Tekhnê

Tecnología al servicio de la sociedad

Universidad Distrital Francisco José de Caldas - Facultad Tecnológica

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- Centro: Type of violence experienced by women in public transport (Delmonte, A., Cubillos, D. and Oyola, P.)
- Inferior izquierda: Percentage of people who say they preferred NOT to take Transmilenio for fear of experiencing some kind of sexual violence (Delmonte, A., Cubillos, D. and Oyola, P.)
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Revista Tekhnê

La revista **Tekhnê** es una publicación institucional de la Facultad Tecnológica de la Universidad Distrital Francisco José de Caldas. Posee un carácter científico, y atiende a la comunidad nacional e internacional especialista en áreas de ingenierías eléctrica, electrónica, mecánica, de sistemas, industrial y civil. Publica resultados de investigación en inglés (artículos originales e inéditos), y está completamente abierta a especialistas de todo el mundo en calidad de autores y/o lectores. Es arbitrada mediante un proceso doble ciego, con rotación continua de árbitros. La periodicidad de la conformación de sus comités Científico y Editorial está sujeta a la publicación de artículos en revistas indexadas internacionalmente por parte de sus respectivos miembros.

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La revista **Tekhnê** tiene como misión divulgar resultados de investigación realizados en el área de la ingeniería, a través de la publicación de artículos originales e inéditos, realizados por académicos y profesionales pertenecientes a instituciones nacionales o extranjeras del orden público o privado. Propende por la difusión de resultados y su acceso abierto y libre.

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- Top left: Simulation, operational amplifier with R1=R2 output voltage and input voltage seen on the oscilloscope (Rendón, A.)
- Top right: Litres of water used in toilets per inhabitant per day (Sánchez, B., Romero, D. and Garzón, N.)
- Middle: Type of violence experienced by women in public transport (Delmonte, A., Cubillos, D. and Oyola, P.)
- Lower left: Percentage of people who say they preferred NOT to take Transmilenio for fear of experiencing some kind of sexual violence (Delmonte, A., Cubillos, D. and Oyola, P.)
- Lower right: Colombian population according to the census and the projection to the year 2017 (Beltrán, L. and Mieles, R.)

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Tekhnê journal is published every six months, coinciding with the academic semesters of the Universidad Distrital. It is published in July and December. The first volume of the journal was published in the first semester of 2003, maintaining its regularity to date.

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The mission of **Tekhnê** journal is to disseminate research results conducted in the area of engineering, through the publication of original and unpublished articles by academics and professionals belonging to national or foreign institutions of public or private order. It aims at the diffusion of results and their open and free access.

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Revista Tekhnê
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Tekhnê Journal
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The editorial board of **Tekhnê** journal is committed to ethics high standards and good practice for knowledge dissemination and transfer, in order to ensure rigour and scientific quality. That is why it has taken as reference the Code of Conduct, which has been established by the Committee on Publication Ethics (COPE) for scientific journal editors; outlining the following:

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• Maintaining the academic integrity of their content.
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Volume 16 - Number 1 - 2019

Index

Articles

Editorial

La ciencia de datos se ha establecido como un nuevo paradigma en ingeniería, con un fuerte impacto tanto a nivel técnico como a nivel empresarial. Ciencia de datos se ha definido como un conjunto de cálculos numéricos (métodos y procesos principalmente) que utilizan herramientas y modelos conocidos desde hace mucho tiempo, pero que en los últimos 10 años han sido de particular interés y ayuda gracias a la existencia y disponibilidad a bajo costo de procesadores de alto desempeño, y unidades de almacenamiento para grandes cantidades de datos (terabytes, principalmente en la nube), que en conjunto con estas herramientas logran producir resultados confiables a un bajo costo.

En ingeniería la ciencia de datos es ampliamente utilizada como herramienta de apoyo en la identificación de patrones de fallo, en el diseño de programas de mantenimiento predictivo, en el control de calidad, estadísticas de consumo y diseño de nuevos equipos/servicios. A nivel técnico suele relacionarse con dispositivos embebidos diseñados a medida con capacidad de comunicación e interconexión (IoT) y procesamiento de alto desempeño. Corresponden a la antesala de la siguiente evolución tecnológica en la cual los individuos se integran con los sistemas artificiales en busca de servicios y conectividad en tiempo real. Como se viene observando en el mercado, la tendencia de la industria no se enfoca en la venta de productos, sino al ofrecimiento de servicios tecnológicos personalizados vinculados a los productos. Esta tendencia bien se observa en Apple Inc. y los servicios en línea ofrecidos con sus productos, o los vehículos Tesla y sus servicios vinculados de navegación y energía. Cabe preguntarse si esta nueva tendencia esta permeando los procesos actuales de formación profesional en Colombia, como claramente si lo está haciendo en el resto del mundo.

Ph.D Prof. Fredy H. Martínez S.
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Editorial

Data science has been established as a new paradigm in engineering, with a strong impact on both technical and business levels. Data science has been defined as a set of numerical calculations (methods and processes mainly) using tools and models known for a long time, but that in the last 10 years have been of particular interest and help thanks to the existence and availability at low cost of high-performance processors, and storage units for large amounts of data (terabytes, mainly in the cloud), which together with these tools manage to produce reliable results at low cost.

In engineering, data science is widely used as a support tool in the identification of failure patterns, in the design of predictive maintenance programs, in quality control, consumption statistics, and design of new equipment/services. At a technical level, it is usually related to custom-designed embedded devices with communication and interconnection (IoT) and high-performance processing capabilities. They correspond to the prelude to the next technological evolution in which individuals are integrated with artificial systems in search of services and connectivity in real-time. As it has been observed in the market, the industry trend is not focused on selling products, but on offering personalized technological services linked to the products. This trend is well observed in Apple Inc. and the online services offered with its products, or Tesla vehicles and their related navigation and power services. It is worth asking if this new trend is permeating the current processes of professional training in Colombia, as it is in the rest of the world.

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How does it affect mining in Guavio (Colombia)?

¿Cómo afecta la minería en el Guavio (Colombia)?

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This article presents true and reliable information about mining in Colombia, particularly concerning Guavio, highlighting the problems generated by mining in that region, to raise awareness among Colombian and foreign mining companies. In the Guavio region, there is a great potential to extract construction materials and immensity of minerals, that is why there is a high level of mining activity. Likewise, there is a great variety of environmental and social problems, such as contamination of water bodies by solid waste, generating deviation in riverbeds, causing overflows and loss of land and crops. Finally, possible alternatives are analyzed to reduce the problems generated by mining in Guavio.

Keywords: Crops, extraction, land, mining, mining companies, water

Este artículo presenta información verídica y confiable sobre la minería en Colombia, particularmente respecto al Guavio, resaltando las problemáticas generadas por la minería en dicha región, con el fin de concientizar a las empresas mineras colombianas y extranjeras. En la región del Guavio se presenta un gran potencial para extraer materiales de construcción e inmensidad de minerales, es por esto que allí se presenta un alto nivel de actividad minera. Así mismo, se presentan una gran variedad de problemas ambientales y sociales, como contaminación de los cuerpos de agua por residuos sólidos, generando desviación en los cauces de los ríos, causando desbordamientos y pérdidas de terreno y cultivos. Finalmente, se analizan posibles alternativas para poder reducir las problemáticas generadas por la minería en el Guavio.

Palabras clave: Agua, cultivos, empresas mineras, extracción, minería, terrenos

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Introduction

Colombia has many natural resources, is the second country with the greatest biodiversity of flora and fauna species in the world, has more than 9,000 endemic species (species whose distribution is restricted to a certain geographical area), in addition to the first in birds and orchids, the second in plants, amphibians, butterflies and freshwater fish, the third in palms and reptiles and the fourth in mammals (Decaëns et al., 2018; SiB Colombia, 2019). Due to the great number of moors in the territory, it can be said that it is a great producer of water; but mining is destroying all these resources since licenses have been granted for environmental protection zones and also for the riverbeds (Gallego, 2018; Morán, Ceballos, Peña, Lorenzo, & López, 2018).

Some areas have said *No to mining*, using the popular consultation, one of them is the municipality of Cajamarca, which through this resource managed to ensure that mining in the territory did not continue to affect the environment in which its inhabitants lived, but achieving this goal is not very easy and making people aware of the great problems that mining brings is even more difficult.

The only ones who know the problems generated by mining are the inhabitants of the areas directly affected by it. Informing the population is the beginning of the awareness process and this will be the purpose of this article.

In the first chapter, we will contextualize the mining wealth in Colombia, its distribution, the regulations that govern it, and some companies that carry out mining operations in the country, and we will discuss illegal mining. The second chapter will focus on mining in the Guavio region, highlighting its water and ecological importance, the materials that are extracted daily, the contamination and consequences generated by mining, the applications, and titles granted, and the territory. The third chapter will deal with the impact, conclusions, and opinions about mining.

Mining in Colombia

Following the Political Constitution, all non-renewable natural resources of the soil and subsoil belong to the Nation in an inalienable and imprescriptible form (Ministerio de Minas y energía, 2018). The mining industry is one of the main economic managers in the country. In recent years this activity has intensified thanks to new technologies that have come from foreign investors (Wikipedia, 2018).

The geological morphology of Colombia allows it to have a great potential of minerals, such as gold, coal, emeralds, nickel, zinc, lead, platinum, etc.; highlighting also the amounts of salt, gravel, sand, asbestos, gypsum, sulfur, phosphoric and ornamental rocks, among others. These are destined for the manufacture of different objects used daily by the entire population.

This richness made the first inhabitants of the country, besides dedicating themselves to hunting and fishing, also dedicate themselves to the manufacture of objects and tools with clay, gold, and platinum (Vanguardia, 2018).

In every Colombian home, there is a mineral product that we may not know about. For example, there is nickel in computer and cell phone batteries, clay in skin masks, or salt in soap, among others. All are included in the classes of minerals (metallic and non-metallic), which are part of the great mining potential of the country.

Gold, coal, and emeralds are the best known. However, the Colombian subsoil gives for much more. It is estimated that in Colombia only 5% of the area that potentially has gold, 1% of the area rich in emeralds, and 8% of the nickel deposits have been explored and exploited. Colombia is in the line of the Pacific belt, considered a strategic strip with copper potential. There is talk of a deposit of 500 million tons of the mineral, which would put the country on the map of large mining. Currently, it imports about 70% of the copper required by the domestic industry, and the national production barely reaches 50,000 tons, according to figures from the ACM (Colombian Association of Mining) and the DANE (National Administrative Department of Statistics). Although in Colombia copper exploration is starting to increase so far, it is believed that in eight or ten years this business will start to shine.

From ANDI (National Association of Businessmen of Colombia) there is a great expectation to take advantage of the investment in infrastructure works and housing plans, two factors that make steel dynamic. According to him, for the works of the first 4G wave, it is estimated that there will be a demand for steel of 939,000 tons, of which 500,000 tons correspond to types of steel produced in the country.

It also estimates that the demand for steel for concrete will have a positive behavior until 2018 since 600,000 tons will be required only for housing projects subsidized by the national government if the 315,000 social interest housing (VIS) are built (Dinero, 2018b).

It is necessary to highlight that Colombia has the largest open-pit mine in the world, El Cerrejón. It is located in the Guajira peninsula with a surface of 69,000 hectares. In 1980, the conditioning works began led by the American company Exxon (Fig. 1).

In the last few decades this problem, along with others, has been deteriorating in a large part of the Wayuu territory. In addition to generating different types of contamination and accidents that not only affect the environment but also the people who live around the mine (Dinero, 2018a).

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Figure 1. Cerrejón coal mine (Contagio Radio, 2018).

Distribution in Colombia

Although many people claim that mining activities in Colombia are concentrated mainly on the northern coast, because large coal companies are located there, the National Mining Agency established through its work of monitoring, control, and control of titles, that mining is not concentrated in one or two areas of the country.

Through three-zone coordinations (Central Zone, Northern Zone, and Western Zone), which in turn group together twelve Regional Attention Points (PAR), the National Mining Agency has been carrying out an inspection work, which after its first phase that ended in December 2014 and in which 100% of the titles in force were inspected, already presents important results about what mining is and where this activity takes place.

Of the 9,602 mining titles in force in Colombia, 17% are in departments that are part of the Nobsa PAR, 16.5% are in departments that are part of the Bogotá PAR, 16% are in the hands of the Governor's Office of Antioquia, 8% are in the Ibagué and Cúcuta PARs, which together account for 65% of the total number of titles. The remaining 35% is distributed among the PAR Bucaramanga 7%, Cartagena 6%, Manizales 5%, Cali 5%, Valledupar 5.5%, Medellín 2%, Pasto 2% and Quibdó 2% (Agencia Nacional de Minería, 2018).

Mining legislation

To promote the formalization of mining in Colombia, as well as the different tools that accompany it, the Directorate of Mining Formalization signed the inter-administrative agreement 094/2013 with the National University of Colombia - Medellin campus; using workshops with mining communities and municipal authorities, it seeks to strengthen the development of this activity by publicizing the existing legal, environmental, social, technical and business tools for the support of small-scale miners to improve mining productivity and competitiveness in the country (Ministerio de Minas y Energía, 2018).

Exploitation in Colombia is regulated directly by the National Mining Agency, Regional Autonomous Corporations, National Environmental Licensing Authority, the Colombian Geological Service, the National Hydrocarbons Agency, the Ministry of Mines and Energy, and the Ministry of Environment and Sustainable Development, and indirectly by the Procuraduría, the Contraloría, the Alcaldías, ONGs (Non-Governmental Organizations) and the community in general (Agencia Nacional de Minería, 2018; El Espectador, 2018).

The 2016 mining policy and the 2018-2025 National Mining Development Plan seek to increase mineral production and establish the basis for future mining (El Espectador, 2018). The extraction of the different materials that exist in the country has produced different consequences, both environmental and social since the territory has been destroyed when obtaining them.

According to the Vice Minister of Mines Carlos Andrés Cante, Colombia will continue to be an attractive country for mining investors because there is enough information to know the material wealth that the country possesses, adding also that the mining titles granted do not exceed 5% of the area of the territory, demonstrating the potential for development and investment opportunities in *well-done mining* projects. It is also important to note that the aim is to reduce the informality of the activity, to be more environmentally friendly, and to improve the image of mining (Vanguardia, 2018).

Companies

Colombia's exports have been positive for three consecutive months, and many sectors have contributed to these figures. This means that foreign sales have been focused on the agro-industrial sector with products such as coffee, palm, sugar, and a significant recovery in the manufacturing sector, without demeriting Colombia's mining companies.

According to the portal Portafolio.com, in January 2017 exports from the "Other Sectors" group registered a variation of 65.5%, thanks to the growth in non-monetary gold exports with 66.3%. All of this despite the difficult times, because the mining industry was affected by issues of legal security, competitiveness, and high volatility in international markets, as affirmed by the Colombian Mining Association (ACM).

The hope and expectations that the sector will grow are placed on the production of coal, nickel, and gold because at the end of 2016 they showed positive numbers.

List of mining companies in Colombia.

• ANGLOGOLD: has been assigned 406 mining titles in the country, distributed in five projects that cover 781 hectares: La Colosa in Tolima, Quebradona and Gramalote

in Antioquia, Salvajina in Cauca, La Llanada in Nariño, Chaparral in Tolima and Rio Dulce in Antioquia.

• MINERALES ANDINOS DE COLOMBIA: they are owners of 111 mining titles and operate in Segovia, Antioquia, and in Marmato, Caldas, where they carry out open-pit operations and coexist with old artisanal mining that exists since the XIX century.

• NEGOCIOS MINEROS S.A.: has 88 titles that comprise 35 thousand hectares in the departments of Antioquia, Chocó, Risaralda, Cauca and Tolima.

• CONTINENTAL GOLD DE COLOMBIA: has been assigned 67 titles distributed in 79 thousand hectares in the municipalities of La Vega and La Sierra in Cauca, Bagadó and Lloró in Chocó, Suratá and Vetan in Santander, Silos and Mutiscua in North Santander and in Antioquia.

• MINEROS S.A.: is a firm with national capital that has been awarded 67 mining titles. Its operations extend over 116 thousand hectares in the municipalities of Bagre, Zaragoza, and Nechí, Bajo Cauca Antioqueño and has an annual production of approximately 120 thousand ounces (Catelli, 2017).

Illegal mining

Illegal or illicit mining has generated the greatest social, environmental, and economic problems since these mining settlements are located in the poorest populations. It is called illegal mining because it is operated without licenses or adequate safety standards to work within them, generating high mortality rates due to landslides, as has already happened on several occasions in the country. Also, the lack of environmental and police control entities in the areas generates problems, since no barrier blocks the processes of this type of mining.

Some of the areas currently affected are Antioquia, Nariño, Chocó, Sur de Bolívar, Córdoba, Caquetá, and Cundinamarca with a problem of contaminated water, deforestation, damage to the soil and subsoil, and the poor progress of the place and the bad life of the thousands of Colombians who are engaged in this activity since most of the people who engage in this type of mining are part of groups outside the law.

This type of mining pollutes the natural resources too much because they use large amounts of mercury and cyanide to separate the metals that are extracted from the soil. For this reason, Antioquia is the department with the most serious problems of contaminated water, due to the presence of large quantities of these compounds in water sources.

Also, the conflict in the country between the FARC-EP (Revolutionary Armed Forces of Colombia - People's Army) and the national government plays a very important role because the strong guerrillas cannot compete against the country's supplies or income, so to continue with the conflict they are forced to enter into illegal processes to finance their activities such as illegal mining which according to Aníbal Fernández de Soto, Vice Minister of Defense has reached such a point that it has overcome the finances of drug trafficking. This activity is carried out without any type of regulations or licenses for the regulation of the environment as reflected in two main cases. The first case in the region of Catatumbo; an area that has had a historical presence of guerrillas of different types, with a tradition of oil exploitation and a great potential for coal extraction. The second case is southern Bolívar (Simití, Santa Rosa del Sur and Montecristo) where gold extraction has been a fundamental activity in the process of its territorial configuration, and where different types of mining take place (formal, informal, traditional, and so-called criminal) that have been carried out directly and indirectly by armed groups (guerrillas and paramilitaries) (Bibliothek der Friedrich-Ebert-Stiftung, 2017).

The following section describes mining in the Guavio region, its aquifer and ecological importance, the materials that are extracted daily, the contamination and consequences generated by mining, the applications and titles granted, and on the territory.

Mining in Guavio

To focus this issue on the region, it is necessary to contextualize it a bit (Fig. 2).

Figure 2. Geographic location of Guavio (Bojacá, Hilarión, & Bojacá, 2018).

The Guavio region is located in the department of Cundinamarca, which borders it:

ISSN 1692-8407

• For the North with: Province of Sabana Centro and Province of Almeidas.

• For the South: Province of Oriente, Province of Medina.

• For the West: Bogotá.

• For the East: Department of Boyacá.

It is composed of eight municipalities: Ubalá, Gachalá, Junín, Gachetá, Guasca, Gama, La Calera, and Guatavita. It has 79,621 inhabitants (3.6% of the department's total). Its area is 2,628 Km2 and represents 11.6% of the total area of the department.

The main economic activities of the region are Agriculture (3.8%), livestock (It has 5.1% of the total heads of livestock in the department), pig farming (It produces 9.52% of pigs in Cundinamarca), and mining (It is characterized by mining operations in almost all municipalities) (Cámara de Comercio, 2017).

Water and ecological importance

It is a province of great importance for its large forest and water reserves such as the Junín Raft, the Chorreras, and Concepción rivers, the San Rafael and El Sapo reservoirs in La Calera, the Sucio river in Gachalá, the Chingaza Natural Park (declared a World Heritage Site under the title of Ramsar Wetlands), the Siecha lagoon in Guasca and the Guatavita lagoon and the Tominé reservoir in Guatavita.

It presents environmental deterioration caused mainly by the contamination of water sources, inadequate management of solid and liquid waste, destruction of forests by indiscriminate logging and burning, and of course mining.

It is an attractive sector for ecological and scientific tourism because it is one of the natural areas with the greatest production of water and unique biodiversity in the world; the Chingaza Natural Park and the Guavio dam are considered the second most important in South America in terms of energy generation. Besides, there are areas rich in medicinal thermal waters (Cámara de Comercio, 2017).

The entity in charge of regulating environmental activities in the region is the Corporación Autónoma Regional del Guavio (CORPOGUAVIO).

Extracted material

Construction. The exploitation of construction materials in the municipality of Guasca has two management plans for environmental recovery and restoration (PMRRA) (Fig. 3). It is an area not compatible with mining according to Resolution 222 of 1994. It is located within the savannah of Bogotá, its moors, waters, surrounding valleys, surrounding hills, and mountain systems were declared by Article 61 of Law 99 of 1993 as being of national ecological interest, whose priority destination is agriculture and forestry (Bazurto & Martínez, 2015; Lasso, Patarroyo, & Martínez, 2015). In these mining titles, the restoration of areas affected by old mining exploitations is being carried out, which are not currently being exploited.

Figure 3. Exploitation of construction materials in the municipality of Guasca.

José Miguel Palencia Cordoba is the owner of the company Agregados de la Sabana Ltda., which exploited construction materials in the municipality of Guasca. He began extracting stones, sand, and clay in the municipality approximately in 1973, according to Bernardo Mancera, an inhabitant of the municipality.

For him, the most relevant consequences have been the loss of the sources, since quite deep excavations are carried out to extract the materials, some sedimentation pools have a depth of 7 meters.

As for the landscape where the exploitation of the materials was carried out, there is no mountain, there is nothing, only the lagoons produced by the machines that carry out the extraction, Don Bernardo tells us. For about 15 years, the company has been covering the lagoons with materials brought from other areas.

He also tells us that for approximately two years there has been no exploitation in the area and that the company transports the materials from other areas of the country.

Precious stones. The municipalities of Gachalá and Ubalá belong to the mining district of Chivor, because it is a strategic zone, with geographical and geological continuity, in which emerald mining is the most interesting economic activity; in this zone, there are more titles and therefore it is the sector where more environmental licenses have been approved, this type of exploitation is done subway because this method generates fewer affectations to the landscape and renewable natural resources (Cámara de Comercio, 2017).

Minerals. There are also two environmental licenses corresponding to iron exploitation, one located in the municipality of Guasca; activity for which the Corporation established corrective management measures, to restore and environmentally recover the area affected by open-pit exploitation, but which is no longer operating.

The second iron exploitation is located in the municipality of Ubalá, a mining project that is subject to continuous

and strict environmental monitoring. Due to this and in the course of acting as an environmental authority since the time the license was granted, 2 closures have been imposed for non-compliance with the environmental management plan, which generated that this company will take action on the environmental part and begin to comply with the approved measures, to the extent that it currently has environmental compliance of over 85%. Considering the importance of this mining project for the region, the corporation asked the Attorney General's Office to create a special agency and as of 2011, it has the support of Dr. Oscar Ramirez Marion, Environmental and Agrarian Attorney, who constantly participates in the monitoring and everything concerning this license (Cámara de Comercio, 2017).

Contamination

Mining is a very destructive extraction activity in its process, it can become a very worrying factor in terms of how contaminated it can become audibly and environmentally.

A notorious discomfort lies on the beds of the Guavio and El Salinero rivers. There, the mining companies have the machines to crush the material that is dragged along, which generates a deafening noise.

In 2005, a judge indicated that, although the failures in their housing could be due to vehicle traffic, they were also a product of the irregular terrain where it is built. However, as far as noise is concerned, the Municipal Court of Appeals agreed: it ordered the owner of the sandpit to shut down his crushing plant and plant a tree barrier to reduce the noise (Fig. 4) (Guerrero, 2017).

Figure 4. Environmental pollution (Periodico Nueva Región, 2017).

According to a study by the National Institute of Natural Resources (Inderena), the environmental impact of mining is great. The transformations that they cause to the environment affect the hydric, geologic, biological, atmospheric, and socioeconomic resources. Some of these consequences are preventable, but others cannot be avoided.

In water resources, open-pit mining, for example, causes contamination of water bodies by solid waste and domestic and industrial discharges related to mining activity (Jacinto, Martínez, & Martínez, 2015). As a result, sediment content increases, and riverbeds are diverted, leading to flooding, landscape transformation, and crop loss.

In the geological field, topographical and geomorphological changes occur due to the removal of surface layers of the land. The instability of the land by leaving the rock formations exposed can cause the triggering of erosive phenomena.

In the biological field, the impact on natural forests and water pollution cause the loss of resources and endangered species (El Tiempo, 1995).

Consequences

Unfortunately, because of mining in Guavio, there is a problem in its municipalities, since its inhabitants and the environment are being affected in different ways by this practice. Landslides, strong odors due to the poor condition of the sewage system, big noises generated by the machines, and pollution are some of the consequences that this entails.

Some of the inhabitants of the region have told of the consequences they suffered because of mining; below are some of them: *What used to be a green place with crystalline waters, is now just gravel, and a river occupied by crushers*.

Miguel Solaque says that after living two years near a mining site, not only did he lose his peace of mind, he also lost his hearing; since the crushers and dump trucks full of a material pass in front of his house, causing many cracks in his house and significant damage to his ears since the noise is unbearable, he is not the only one affected by this problem, of this same fact several inhabitants complain.

Carlos Duarte, a farmer, claims to have lost a large part of his farm, due to several landslides that have occurred. Thanks to mining extraction, the land is already very fragile and they fear a great tragedy because the over-exploitation of the Guavio River is causing landslides not only in his home but in several places in this region.

Another big consequence that has occurred is the infections from the sewage that overflows on the roads because the machinery used by the mining companies has damaged the sewage system, the inhabitants have to leave with boots, mouth covers and have to take firm steps to avoid falling into the wells that are formed and to avoid serious accidents (Guerrero, 2017).

Environmental. About the environmental impacts generated by mining, the transformations caused in the moors, water, geological, biological, and atmospheric resources are highlighted.

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In the water resource, mining causes pollution in the bodies of water by altering the course of their rivers generating the overflow of the same and with this the loss of land and crops, also, there are topographic and geomorphological changes due to the removal of surface layers of land, also, the impact on natural forests and water pollution causes the loss of resources and species in danger of extinction.

Besides, among the conditions that occur in workers exposed to these toxic substances, the most common are those of the respiratory system, which include pneumoconiosis, chronic obstructive pulmonary disease, industrial bronchitis, and lung cancer that causes temporary or permanent disability.

Social. Mining activity not only produces an environmental impact but also produces what is called a socio-economic impact, that is, an alteration in the lifestyles of the people affected by this activity and the economy of the region where it is implemented, which can be positive in some cases and negative in others (Vera, 2013).

On the social level, in any mining area, there is an increase in the demand for services, a massive migration of population, change in economic and social activities, and therefore the abandonment of the countryside (El Tiempo, 1995).

The inhabitants suffer the consequences of this activity due to the factors that influence their daily lives.

Licenses

The cartographic images show the mining applications and titles in the area of jurisdiction (Fig. 5).

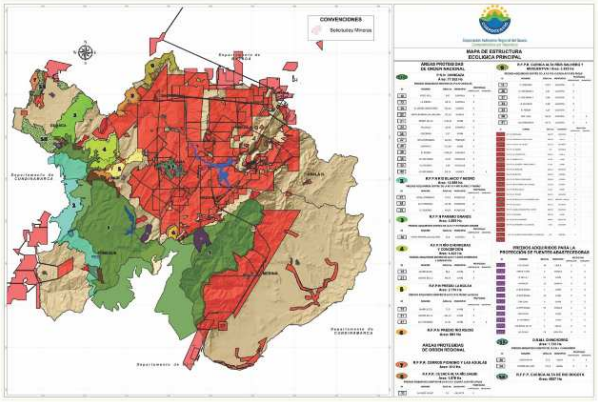

Figure 5. Applications and mining titles in Guavio.

Of the 103 mining titles, 23 have environmental authorization, distributed as follows:

- 16 environmental licenses.
- 5 environmental management plans.
- 2 management plans for environmental recovery and restoration.

This data is equivalent to 22.3% of the total of these. In addition to the above, 20 environmental licenses have been requested for mining operations, representing 19.4% of the total titles in force. Of these applications, 6 were denied due to different circumstances, among which are the affectation of ecologically important areas and management measures that did not comply with the principle of preventing, mitigating, correcting, and/or compensating for the impacts generated, 11 of these applications were withdrawn, given that the environmental impact studies were not complemented with the requirements requested by this authority, and the remaining 3 applications are currently under evaluation.

Currently, the corporation carries out the environmental follow up of 9 emerald titles, 7 dragging material titles, 2 iron titles, 2 construction materials titles, 1 quartz title, 1 receipt title, and 1 salt title (Periodico Nueva Región, 2017).

The following section describes prevention measures that can be implemented by those affected and by those who carry out this activity.

Impact

Mining is taking over more and more of the territory, but what is worrying is that this is being accentuated on water sources such as moors, rivers, and streams; this means that not only is the water resource diminished due to the greenhouse effect, pollution, massive cattle raising, the cutting down of trees and the reduction of the areas in charge of storing it, but it is also affected by the mining that is carried out on it since it contaminates a great part of the vegetable cover that is in charge of storing and providing the resource to the beings of the area (Figs. 6, 7 and 8).

Figure 6. Diagrama OSPF con sus respectivas áreas.

Although mining not only causes repercussions on water sources but also on the native fauna and flora of the areas affected by this type of extraction of minerals from the soil; when the water that feeds these beings is contaminated, a process of fauna migration and soil erosion begins, which generates a disappearance of the flora of the exploited area.

Figure 7. Diagrama OSPF con sus respectivas áreas.

Figure 8. Diagrama OSPF con sus respectivas áreas.

Also affected are the populations that inhabit the areas surrounding the areas of exploitation, the people who live in these areas because they are suffering from various complications and endure various types of pollution, such as acoustic, thermal, soil, etc. There are current cases of people who have lost some of their senses because of these contaminations or people who have had to leave their homes because they can no longer stand the exploitation.

Workers are also at risk due to landslides caused by mining, as has already happened on some occasions in the region.

It is almost impossible to talk about seeking non-polluting mining techniques because the sustainable development of the mining industry is given in the large-scale production, but it is feasible to find a way to cope with the situation with certain preventive measures both for those affected and the companies that practice this activity.

In both subway and open-pit mining, technical or environmental prevention measures aim to avoid the production of dust or to reduce the amount of respirable dust as much as possible, which is achieved with technical prevention alternatives:

1. Adequate ventilation of the workstations.
2. Use of dust extraction mechanisms.
3. Humidification of the materials through the use of tools provided with water injection, watering of the materials, and use of hygroscopic salts, burn a certain degree of humidity and prevent the suspension of the dust.
4. Insulation of vehicle cabins and machine control stations in installations.
5. Use of individual protection masks of proven efficiency.
6. Separation of personnel from the source of the dust, through the use of remote control.
7. Use of appropriate technologies in the various departments and mineral processing plants to minimize the emission of pollutants to the workplace and the community.

Social prevention alternatives:

1. Increase the training of management and workers of the companies in the management of the impacts of mineral dust and its consequences on human health.
2. To develop a system of environmental education among the different factors of the company aimed at the formation of awareness on the management of the protection and safety means, individual and collective, as the most direct way of immediate protection of the directly exposed worker.
3. To train the Legal Department of the producing companies in the treatment of those who do not comply with the established legislation and on the need for new resolutions aimed at raising the demand in the treatment of technological indisciplines.
4. Guarantee the existence of a system for the treatment, in case of disasters, of those affected, including the training of medical and paramedical personnel and the maintenance of material resources to provide first aid.
5. Carrying out specialized medical examinations, taking into account the recommendations of international and national health institutions (Vera, 2013).

A solution could be sought to improve the problems generated by mining, following in the footsteps of some municipalities in the country, such as Cajamarca in Tolima, Cabrera in Cundinamarca, Cumaral in Meta, among others; but when making one of these decisions, alternatives must be sought to replace it, that is, when saying *no* to mining, one must say *yes* to another activity.

On many occasions, we have heard it said that popular consultations are not legal, but according to article 8 of Law 134 of 1994, the popular consultation is the institution through which a question of a general nature on a matter of national, departmental, municipal, district or local importance is submitted by the President of the Republic, the governor or the mayor, as the case may be, for the consideration of the people so that they can formally pronounce themselves on the matter.

In all cases, the decision of the people is obligatory. When the consultation refers to the convenience of calling a constituent assembly, the questions will be submitted to the people's consideration using a law approved by the Congress of the Republic (Registraduría Nacional del Estado Civil, 2017).

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One of the municipalities that we can take as a reference and a sign that it is possible to avoid mining exploitation in a territory is Cajamarca, located in the department of Tolima; after much effort and even a change of governors, its inhabitants managed to get a popular consultation on the acceptance of mining in the area approved. Of the 6241 voters, only 76 said yes, that is, 97.92% of the population, did not want the company AngloGold Ashanti to carry out an open-pit gold mining project called La Colosa (Dinero, 2017).

It should be added that by 2013, the cities and municipalities could not prohibit mining in their territories, since the regulation of the use of the subsoil was considered to be the responsibility of the central government (Dinero, 2017).

Conclusions

Mining is one of the most profitable businesses in Colombia due to the wealth the country has in different minerals since it has a great extension along with the territory and it is something very well paid for the sale of the extracted minerals, but what is criticized of this activity is that a great part of it is illegal, which does not have the authorization of the state and does not protect the environment, Besides this, it does not leave any profit or give any benefit to the regions where this practice is carried out, the only thing that it leaves are devastated regions, considering this way the business that more affects environmentally our country and this can be seen in the region of the Guavio, located in Cundinamarca since the purpose of this illegal activity is to extract the natural resources without environmental permits and without conscience of the damages that they cause.

The Guavio region has been highly affected by this activity since there is an immense variety of mining potential there that has generated contamination in its water sources due to inadequate management of solid waste, landslides, due to the weakness of the soil generated by the heavy machinery that works daily, the destruction of its forests by indiscriminate slashing and burning, bad odors due to the damage to the sewage system that has caused the extraction of some minerals and hearing diseases in its inhabitants in addition to causing them to lose their land and crops. This is devastating for the people who have been living in this region for years and see how everything is getting worse every day because of this practice that has not had an end so far.

The lack of commitment of the companies that exploit the territory, the irresponsibility of the control bodies, the lack of knowledge of the prevention measures that should be carried out, and the rules that have been broken are all causes of the devastation caused by mining daily.

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Conserving water is conserving your life

Conservar el agua es conservar tu vida

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This article was written to raise awareness among people about the use of water in the home throughout the daily tasks, proposing consumption alternatives, and tips. The first part deals with the problem of the number of resources available and the importance of water for human beings. The second part presents some of the instruments that are being developed at the national and international level to save water. It also indicates some savings figures related to these tools and feasibility analysis for their implementation in Colombian households. Finally, in the last section, advice and alternatives are presented to facilitate the identification of waste sources and improve household consumption habits, habits that go hand in hand with saving money and caring for the environment.

Keywords: Care, culture, saving, shortage, vital, waste, water

Este artículo se realizó con el fin de crear conciencia en las personas respecto al uso que se le da al agua en el hogar a lo largo de las labores cotidianas, proponiendo alternativas de consumo, y consejos. En la primera parte se trata la problemática respecto a la cantidad de recurso disponible, y la importancia que tiene el agua para el ser humano. En la segunda parte se expone algunos de los instrumentos que se están desarrollando a nivel nacional e internacional para el ahorro de agua. También se indican algunas cifras de ahorro relacionadas con estas herramientas, y análisis de viabilidad para su implementación en los hogares colombianos. Para concluir, en la última sección, se presentan consejos y alternativas para facilitar la identificación de las fuentes de desperdicio, y mejorar los hábitos de consumo en el hogar, hábitos que van de la mano con el ahorro de dinero, y el cuidado del medio ambiente.

Palabras clave: Agua, ahorro, cuidado, cultura, desperdicio, escasez, vital

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Introduction

The fundamental base of this article is the water resource, considered as a finite resource, essential for life and its development (Boretti & Rosa, 2019; Wang et al., 2018). However, this resource is considered vulnerable, largely as a result of its current use (Cai, Varis, & Yin, 2017; Cavalcante, Vasconcelos, da Silva, & de Azevedo, 2019). Therefore, at a global level, the good use of water has become a transcendental necessity for its sustainability (Good & VanBriesen, 2017; Megdal, 2018).

For this reason, it is required through different methodologies to create an awareness of savings in homes, schools, and industry. It is necessary to create this conscience in all people because everyone is responsible for taking care of water (Martínez & Martínez, 2014; Wada et al., 2016).

It is opportune to take advantage of this means to aim at this objective. In this same sense, the content of this article seeks to highlight the importance of water resources, its current waste, and contamination, as well as some future consequences resulting from continued bad habits, and finally, advice on how to put it into practice and thus contribute to water conservation (Cosgrove & Loucks, 2015; Mancosu, Snyder, Kyriakakis, & Spano, 2015).

Let's talk about water

Water, as well as oxygen, is essential for plants, animals and human beings to exist. It is also one of the elements that have to do with the development of different forms of life. Ancient civilizations considered water to be synonymous with life. Water represents, in general, 70% of the human body, a little more in men than in women, depending also on the body size. The brain is composed of 95% water, the lungs of 90%, and the blood 82%. Therefore, the importance of water for life in general and human beings, in particular, is evident (Nizel & Nazrul, 2015).

According to the United States Geological Survey (USGS), the surface of our planet is made up of three-quarters of water, or 71%. Of this percentage, 96% are oceans and seas, while the rest, called freshwater, exists in the environment as water vapor, in rivers, lakes, the poles, glaciers, soil moisture and aquifers, and even in living beings. As can be seen, water is a liquid element that is found in many parts of the planet Earth in different forms. In the particular case of the human being, water is important to be consumed and for the organism to continue working correctly.

Although water is essential for the proper functioning of the human body, for the different organisms, plants, and animals, it also plays a very important role in other areas of daily life, such as domestic, industry, agriculture, among others. In this way, it is possible to affirm that the value and transcendence of this resource, water, is unquestionable. As was rightly believed in antiquity, water is synonymous with life.

Water is essential for life, but for many millions of people around the world, it is a scarce resource. That's why these people struggle daily to get water that is suitable for consumption and to meet their basic needs. Millions of children still die every year from waterborne diseases. Water-related natural disasters, such as floods, tropical storms, and tsunamis, take a heavy toll on human life and suffering. And too often, drought ravages some of the world's poorest countries and exacerbates hunger and malnutrition.

Considering the finite nature of freshwater resources, and the increasing demand, it is essential to protect and properly manage water resources. Water shortages force people to consume contaminated disease-carrying water. In 2005, 500 million people lived in countries defined as water-critical or water-scarce.

Why is there a water shortage? That is the question we all ask ourselves when we need to know why there are often not enough water resources for the entire population. This is a very important factor when thinking about the not too distant future. In Colombia, water sources are not protected, and water is not treated as a strategic resource. The extractivist model seriously threatens the páramos (alpine tundra ecosystems), rivers, lagoons, and subway water throughout the country. The petroleum and mining multinationals have received all kinds of benefits, among them flexibility in environmental regulations. At the same time, investments in reservoirs and aqueducts, as well as the purchase of land for the protection of water sources, are insufficient.

There should be no shortage of water in Colombia (García, Piñeros, Bernal, & Ardila, 2012). We are one of the most water-rich countries in the world. Our surface water supply is six times above the world average, and three times above the average of Latin America. Groundwater potential represents 74.5% of the national territory and covers 683 municipalities, although of the 61 aquifer systems identified, 73% lack sufficient knowledge for their use. We have 1065 lakes that cover 6,814 Hectares located in different páramos, and six large areas of glaciers that favor the balance of the hydrological cycle but lose 3% of their mass per year (Fig. 1).

In the face of this scarcity, we must face up to both the population (Fig. 2), and the government itself, which has the resources to invest in different alternatives, so that we can turn off the tap to continue conserving this vital resource.

It is no mystery to anyone that pollution is a key factor that is affecting our entire environment, and it influences water as well. Many things are involved in the contamination of water in Colombia. According to the Ministry of the Environment, it is estimated that half of the water resources have quality problems. It is estimated that the industry, the

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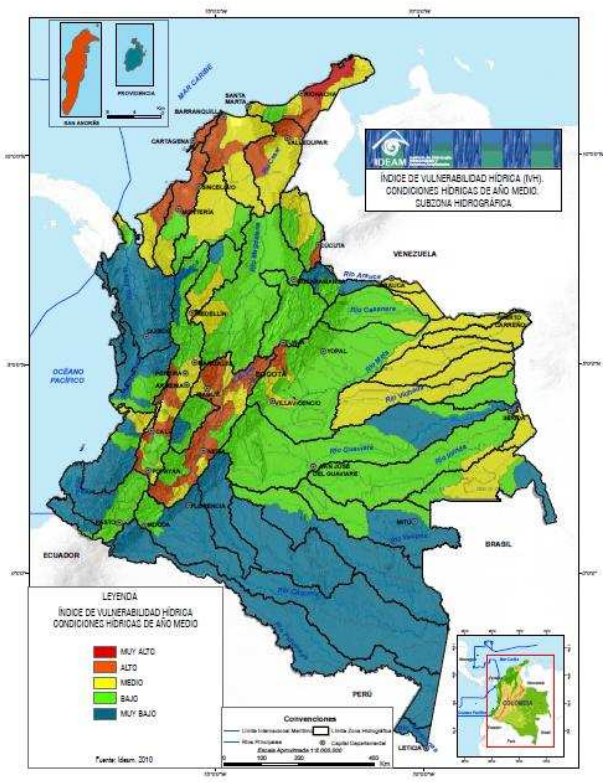

Figure 1. Water Vulnerability Index (IVH). Average year water conditions. Colombia. (IDEAM, 2010).

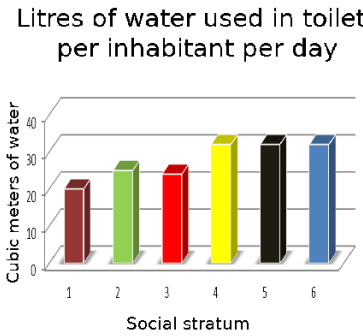

Figure 2. Liters of water used in toilets per inhabitant per day (Alarcón, Barrera, & Castro, 2015).

agricultural sector, and domestic water generate 9,000 tons of contaminating organic materials.

One of the reports states that almost 4,500,000 m^3 of domestic and industrial wastewater is discharged into the natural environment, and most municipalities do not have plants for its treatment. Cities at the level of Barranquilla only have oxidation ponds available before the water is discharged, while the capital, Bogotá, has a treatment plant that only processes 20% of what the inhabitants produce. According to the National Water Study (2010), conducted every four years by the Institute of Hydrology, Meteorology and Environmental Studies (Ideam), most of Colombia's Andean water system has been altered due to the transport of sediments and toxic substances, with a marked incidence of the industrial corridors located in the basins of the Bogotá-Soacha, Medellín-Itagüí, Cali-Yumbo, Sogamoso-Duitama-Nobsa, Barranquilla-Soledad, and Cartagena-Mamonal corridors, which seriously affects the quality of the liquid in the Magdalena, Medellín, Bogotá, and Cauca rivers.

Everything has been influenced so that the levels of contamination generated are taken as a warning. These mustn't continue affecting, not only the water resources but the environment in general, which comprises a balance.

97.5% of the planet's water is found in the oceans and seas, this is not suitable for consumption, agriculture, and industry in general. The remaining 2.5% is freshwater, almost all of it in the polar caps, subway reservoirs, or difficult to use. Therefore, 0.26% of the total mass of water in the world that is easily exploitable for human use remains, which is in reservoirs, lakes, rivers, and accessible wells.

Much of the water that can be used is increasingly contaminated. Also, 70% of the water we use goes to irrigate crops, which are often not appropriate, causing waste. The average consumption of water per person per day in developed countries is more than double that which is strictly necessary.

The most common forms of water waste are a poorly closed tap, excessively long baths, unused connected hoses, road washing, excessive vehicle cleaning, among other practices. However, that is not the only cause of the problem in question. A considerable part of the waste is carried out in the transport of water to the consumer, which is the result of old or damaged public pipes, poorly executed works, as well as clandestine water redirections. This happens in all countries, however, there are certain places that have a low rate of water waste. An example of this is Japan, which wastes 10% of its water, or Germany, which loses 9%, following the average of European countries.

Therefore, the waste of water is one of the main causes of the lack of it in several places in the world (Fig. 3). Combating this problem is the duty of the citizen, of the businessmen, and the State.

The University of La Sabana reveals some disturbing numbers. The country wastes 43% of its water resources. One of the causes of this is the failure of the infrastructure of the aqueducts that carry it. For this reason alone, they lose more than 40% of the liquid they administer.

On the other hand, water is wasted by the population in some regions of Colombia due to certain annual customs or other factors. For example, in Valledupar, as well as in Manizales and Ibagué, there is the so-called hydraulic sweeping (cleaning of sidewalks, gardens, and streets with hoses). This high consumption increases the expenses in the

Figure 3. Soil, water and air pollution (Antón, 2008).

production and treatment processes of the wastewater. In Cali the levels of savings have been increasing, however, the waste continues because of the enormous theft of water that occurs in the areas of the Cali hillside, there the consumption is not measured or charged. On average, out of every 10 liters of water, four are lost due to overflowing or leaking tanks, deterioration of networks, illegal connections, and measurement errors. Bogotá, according to the University, has one of the highest indicators of water loss, at 38 percent.

But these are not the only problems that put the country's water at risk. According to the institution, each year more than 756,945 tons of organic waste are thrown into the rivers, such as food, fecal matter, rotten plants, among others. In addition to this, more than 918,670 tons of non-biodegradable organic matter, such as plastics, rubber, and other industrial waste, are also dumped annually. It is clear how waste or loss of water due to contamination is materialized in Colombia, and particularly in the capital. This shows the lack of culture and responsibility of citizens concerning water.

Although Colombia has large water sources, it has some deficiencies in managing them. About 80% of the population, and economic activities, are located in places where the resource is scarce. This is a major problem because the entities responsible for maintaining, caring for, and distributing water do not take responsibility for the direction they should take.

Ricardo José Lozano, director of IDEAM, added that the aqueduct infrastructure that allows water to reach homes is not strategically built, since many of the aqueducts are built-in high-risk sites vulnerable to winter. When there is no rain, the flow of rivers drops, and the aqueduct intakes are left without the resource. And when there is excess rainfall and the levels rise, there is the destruction of the infrastructure in the municipalities.

On the other hand, the fraud is also materialized by the citizens towards the aqueduct, manipulating the water meters (registers) thus managing to alter the real measurement. The Bogotá water and sewage company estimates that 10 percent of the 494.41 million cubic meters of water produced annually in the city is stolen.

Therefore, not only do those in charge of water administration commit water fraud, whether it is due to corruption, lack of planning, or disinterest, but the citizens themselves do it. It is clear then the failure and insufficiency of values, which allows the waste of this vital resource, regardless or perhaps without thinking about what may happen in the future with the scarcity of it. It is everyone's responsibility to take proper care of the water today that will serve the citizens of tomorrow.

Because of the abundance of this natural heritage in Colombia, culturally it has not been given the value, sense, and meaning it should have. It is conceived as an inexhaustible and free resource whose cycles are ignored. It is available without taking into account the parameters of quality and flow regulation. It is not known that it is a limited resource and that for its conservation all Colombians must take measures to transform this culture of waste, to begin to treat and manage water resources in a rational manner, with collective responsibility, making sustainable use of it, and improving practices in daily activities.

Not taking action in the face of the possible risk of losing this vital resource for our lives, could lead to several consequences that either in the short or long term end up altering our ecosystem, and could be the end of many things. Some of these consequences are:

- **Lack of drinking water**. The shortage will affect a third of the population, and this degree of drought can destroy all kinds of crops, and kill living beings.
- **Loss of biodiversity**. They represent an extremely important factor for the balance of the environment, and this has been decreasing due to the lack of water. This leads to the extinction of many species and gradually puts the planet at risk.
- **Diseases**. Contaminated water is a way of transmitting diseases. Scarcity and poor access to drinking water force communities to consume contaminated water, and it is responsible for 80% of the diseases that occur in developing countries.
- **Water pollution**. Cities and their large factories are the main water polluters. However, they are not the only ones, livestock also contaminate through animal feces, and agriculture through fertilizers.
- **Acid rain**. Smoke from industries and cars is also one of the biggest polluters. These go up into the clouds and stay there until the moment it rains. Therefore, the rain falls acidly on rivers, lakes, and seas, increasing their acidity and killing aquatic animals and plants.

ISSN 1692-8407

The Ministry of Housing suggests 15 concrete actions to citizens to save water in their homes:

- Examine outdoor faucets, pipes, and tubing for leaks. Drop by drop the water runs out.
- Make use of the rainwater collection systems in the houses, which can be used for washing clothes, cleaning houses, and sanitary facilities.
- Water plants and gardens only twice a week, in the evening or early morning, preferably using drip irrigation systems.
- When washing dishes by hand, use a tub for washing and another for rinsing. Never under the jet of the open faucet.
- Take short showers, and turn off the faucet while soaping.
- Use a glass of water to brush your teeth. Do not leave the tap open.
- Close the tap while shaving. Use a container or the stopper of the sink to shave.
- Wash vehicles in a designated area. If you wash at home, use only a bucket of water.
- Teach children not to waste water.
- Periodically check that the toilet float is working properly.
- Install low-consumption toilets.
- Check key gaskets at least twice a year.
- Collect water from the shower while waiting for it to heat up to use it for plants or toilets.
- Use the washing machine for full loads avoiding its use for few clothes.
- Avoid the use of hoses because of the waste of water.

Tools or techniques for saving water

As discussed in the previous section, water is important and must be cared for, thus avoiding future shortage problems, which could even cost lives. For this reason, it is significant that the population is aware of some methods, tools, products, or even inventions under development that can be used to reduce consumption. In general, it is possible to use the current technology to improve the quality of life of the human being, developing customized solutions (Garcia, Osuna, & Martinez, 2018).

Although only approximately 10% of total water is used for domestic purposes, this is where advice should be initiated and implemented to make water use more efficient, as the behavior of each of its members has a potential impact.

Currently, around the world, there are researchers and people without the theoretical knowledge of the problem of water, who develop objects for the same purpose: to save water in the home. Because water scarcity is a phenomenon that affects 1200 million people, equivalent to one-fifth of the world's population, who suffer from physical water shortages, while a quarter of the population faces economic shortages.

In Latin America, universities like the National University of Colombia (UNAL) and the Autonomous University of Querétaro, (UAQ), are developing two quite interesting proposals, and although they are similar, they would benefit all social classes, because they affect a practice that occurs throughout society, the shower.

In Colombia, a person spends between 40 and 50 liters of water bathing once a day, in a shower of between 3 and 15 minutes. In hot weather, this number goes up, because people are used to taking a bath twice a day with similar duration. Besides, the consumption generated by the toilets is similar, because a discharge can consume from 3 to 5 liters, and if this operation is done on average 3 to 5 times a day, the value would go from 30 to 48 liters per day.

Given this situation, students from the Universidad Nacional de Colombia, in the Mechatronics Engineering and Mechanical Engineering careers, designed a prototype to contribute to savings in the home and reduce service costs (Fig. 4). The device consists of a rectangular base that collects the water that falls during the shower so that it can be used later in the toilet flushes. The components of the device are a water collector in the shape of a platform, a filter for solids (hair, rings, soap, etc.), and a pump that drives the collected water to the collection tank. The energy consumption of this device is 20 W, so it is also energy efficient. The energy consumption of this product would increase the cost of the energy bill by 500 Colombian pesos, which is considerably less than the savings on the water bill, which can be as much as 14,000 Colombian pesos a month.

Figure 4. Home water saving device (Universidad Nacional de Colombia, 2010).

The model that was developed in Mexico differs from the Colombian prototype in that it is composed of four modular cells, which make it possible to reuse 90% of the water it collects (Fig. 5). Also, it has no electrical components. Each cell can hold 10 liters, which is equivalent to an average bucket. According to the calculations made by its inventor,

it can save about 80 liters of water per day in an average household, so in a country like Colombia with 50 million inhabitants, it could be possible to save 1.5 million liters of water per day.

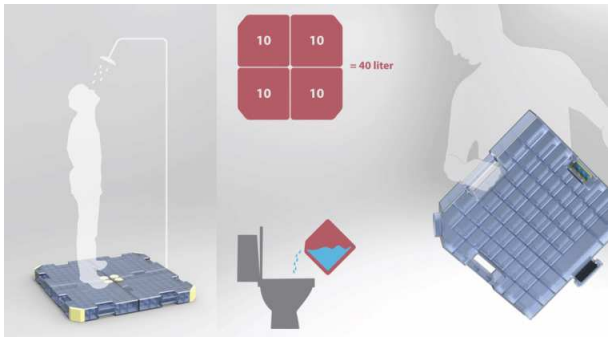

Figure 5. A young Hungarian-Colombian developed a system that allows the reuse of shower water (design, 2016).

Besides, the Universidad Autónoma de Querétaro is developing a pedal, which besides saving water, helps to prevent the spread of diseases by contact with the taps of the sinks (Fig. 6). This works thanks to the action of a pedal, which pumps the liquid into the cistern. This idea came up in 2009 and its main objective is to save water without having to use electrical sources and taking advantage of mechanical strength. The objectives of its developers were to avoid direct contact with the device, due to the germs and infections that live in the bathrooms and are transmitted through the sink. Also, to avoid the spread of pandemics such as influenza A/H1N1, because one of the sources of spread was the handling of water taps.

On the other hand, Mexican engineers are developing an alternative, which, although it cannot be considered an invention, is quite useful: to save rainwater (Fig. 7). According to the calculations of Mexican engineer Jesús Hiram García Velázquez, the roof of a 40 square meter house could capture 100,000 liters of water in six months, although this amount depends on the weather conditions. Rainwater harvesting is an abundant, free, sustainable, good quality source of water that goes directly to the homes, and even cheaper than the traditional ways used by the government to supply us publicly. A good example of companies that have adopted this measure is Mexico City's international airport, which collects 400,000 liters per year. In existing structures, it is possible to use digital tools to facilitate the efficient and economical design (Martinez, Montiel, & Martínez, 2018).

Another alternative to reuse water is to collect the water that comes out of the washing machine when it finishes its cycle because an average washing machine with a capacity of 7 kg of clothes consumes between 42 and 62 liters of water, which is an exorbitant amount considering that it can be used to clean some areas of the home such as the patio.

Figure 6. Pedal-operated wash basin (BRUNOTICIAS, 2017).

Figure 7. Rainwater harvesting (iAgua, 2017).

It is not only in Mexico that initiatives are being carried out to make better use of the liquid. In Colombia, private sector companies such as Corona are designing and selling their products with international standards for water flow, all in the interest of conserving the resource. Toilets more than 10 years old require an average water consumption of 18 liters, while those less than 6 years old with variable discharge only consume 6 liters for solids, and 4.8 liters for liquids. The new variable flush system contributes to saving an average of 210 liters of water, compared to toilets that do not have this system.

In the 21st century, we must be aware that in the age of technology we must look for alternatives to solve the water

ISSN 1692-8407

shortage and how to save this resource as much as possible. This is where the different products with which we have been innovating to achieve maximum savings in water resources come into play, providing multiple alternatives so that it is not wasted and is easily accessible to everyone.

Many products currently exist for these purposes, but some of which are commercially available in Colombia are the following.

Ecological urinals (Fig. 8)

Figure 8. Urimat, ecological urinal without water consumption (EcoInventos, 2017).

One of the benefits generated by this product is that it does not require the use of water-saving about 30 thousand liters of water per year. It does not require the use of chemicals in addition to being practical because its cleaning is organic.

Energy-saving faucets (Fig. 9)

Figure 9. Push water taps (Commercial Washroom, 2019).

These water-saving faucets dose the water, making us use the necessary amount, avoiding waste, and saving up to 80% of water. These can be of the push type with a water pressure output of 5 to 7 seconds or in other cases there are sensor faucets that can be graduated to the point that when you approach your hands they open and when they are removed they close, but they can also be adapted as the push type from 5 to 7 seconds, giving this an estimated time and sufficient for proper handwashing.

Organic cleaners (Fig. 10)

Figure 10. Organic cleaners (Camargo, 2019).

They are used as an alternative for the water since they have different uses for the cleaning as the services of cleanliness like those of the bath, soils, kitchen, etc, avoiding this way the use of water and managing to be very efficient at the moment of realizing the above-mentioned offices.

Aerators for faucets (Fig. 11)

These are inexpensive products that are placed in the taps, these mix the water with the air reducing its flow but giving the impression that it falls with the same amount. They allow you to save up to 50% of water.

Eco-stop systems (Fig. 12)

These products allow you to stop the flow of water with just a gesture or a button. In the case of the showers, they allow the water not to be wasted when soaping up, so that the tap is open, which is very useful since a normal shower can consume from 16 to 24 liters, while this system has a consumption of up to five liters.

Figure 11. Aerators for faucets (EcoInventos, 2017).

Figure 12. Eco-stop systems (EcoInventos, 2017).

Thermostatic faucets (Fig. 13)

These will be of great help when it comes to saving water as energy, given that when looking for the desired temperature, either in a shower or in a tap, eight liters of water can be wasted. On the other hand, with one of these, the temperature can be predefined reducing up to two liters of consumption.

There is an infinite number of products that can also considerably reduce water waste, here are some of them.

Figure 13. Thermostatic faucets (EcoInventos, 2017).

Figure 14. AQUS® System, water recycling system (EcoInventos, 2017).

Water recycling system (Fig. 14)

This system collects water from the sink and, after filtering and disinfecting it, uses it to fill the toilet tank.

Dual discharge systems (Fig. 15)

Figure 15. Dual discharge systems (CLUXTER, 2015).

ISSN 1692-8407

The idea of this product is to be able to choose between two different types of flushes when using the toilet.

Nebia shower (Fig. 16)

Figure 16. Nebia, the shower of the future that reduces consumption by 70% (EcoInventos, 2017).

Nebia is a shower system that splits the water into millions of tiny drops that spread over your body, just like an atomizer does. With Nebia the water covers an area 10 times larger than a conventional shower head.

These products give us different alternatives when choosing the savings we want to make in our homes. Also, they tend to be economical and functional for each of the aspects in which we are going to use them in our homes. And this advance will not stop here, every time it will seek to innovate in the market with new products that will aim to have greater savings, and above all that is friendly to the environment. That is why technology has been a fundamental part of the implementation and creation of each of these products that can extend the existence of a water resource that is increasingly seeking to preserve.

Changing habits

Let's start by defining and knowing about the word *habit*. The word *habit* refers to an act that we take for granted and adapt to the environment around us. However, when it comes to the use of water, it is known that many people use it inadequately. This is due to bad habits in daily activities, irresponsible habits of which, it seems, we are not aware. Some of the practices in which there is evidence of waste or excessive application of water are, for example, washing cars, cleaning teeth, washing dishes, lowering the cistern, among others. This speaking from the domestic sphere.

Modify, change, transform, renew, are words that should now remain in our vocabulary. Become aware of the negative consequences that they bring year after year, even if they are not seen at the moment. Not all the population enjoys this resource, in many places, there is no water source. At the same time, in another scenario, people have to walk kilometers to get some of it, while in another area or sector the tap is opened, and what was needed in the other two cases is spent. How ironic, isn't it? And not content with this, as soon as the opportunity arises there is the human being contaminating rivers or lakes within their reach, it seems that a negative attitude towards our environment is expressed (Fig. 17).

Figure 17. Practical tips for saving water (cuencarumiyaco, 2014).

Fig. 17 shows some of the actions that are carried out daily in households. Likewise, the liters of water that can be spent approximately, as can be seen, is in habitual activities, and that besides, are necessary. However, one does not always have good habits to carry them out in the best way. Some tips that could be put into practice are, to replace a bath with a shower that can suppose a saving of about 150 liters, to cut the water while you brush your teeth or shaves can suppose a saving of 10 - 12 liters per minute, to repair the taps that drip, among others.

It is said that great results come from small changes. This is why we start from each household, with each family member, rather than giving a voice to the industry or the agricultural sector. Small changes that can mean great annual savings, adding to it the incentive that we want to create in each person, the transformation starts from home, it goes from the inside out. The solution is in the hands of each person, starting from the family, reforming those bad habits, and valuing water, the source of life. There are many tips, tools, and methods that can be found to reduce consumption, just be aware of the need to apply them today.

Tips to avoid water waste in the home

To begin with, we would like to mention the bad habits that there are in the home regarding the use of water since

we can observe that in Colombian homes. The bad habits are (Fig. 18):

1. Brushing your teeth with the tap turned on.
2. Not to close the faucet of the shower at the time of soaping.
3. To wash the plates with the open faucet.
4. Wash the vehicles with conventional hoses.
5. Clean the garden with a jet of a low-pressure hose.
6. Wash clothes by hand.
7. Do not report a leak in the hydrant.
8. Take long showers.

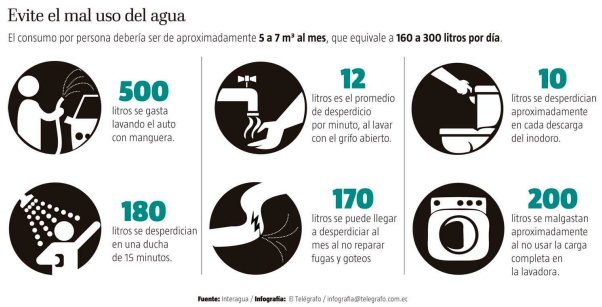

Figure 18. Primary awareness of water use, UASLP experts (Luis, 2018).

In addition to these habits, certain tools in the home also contribute to waste, such as:

- **The garden hose**. It wastes a large amount of water because the pressure it offers is too low, making it more difficult to remove dirt and requiring more water usage.
- **The old washing machines**. They consume a higher percentage of water than modern machines, which even offer an option to re-use the water. While these are less affordable, in terms of savings there is no discussion.
- **The old taps**. The flow of water they carry is greater, so their pressure translates into greater consumption of the liquid.
- **The old toilets**. These do not have an efficient water consumption design, so when compared with a modern one, their consumption is much higher.

The characteristic that all these devices have in common is that they were designed many years ago, without taking into account the need we have today to save water, so it is necessary to be careful when using them to make an adequate consumption. That's why we're going to give you some tips on how to save water.

- Slightly turn off the water tap in your home. By decreasing the flow, you will get fewer liters from the tap per minute. Such a small gesture becomes a very useful measure to save such precious liquid. You will hardly notice the difference every time you open the taps, but your pocket will appreciate it.
- Perform regular maintenance on your home's hydraulic system to check and repair leaks. If the meter *runs* when all your taps are turned off and your appliances are turned off, you probably have a water leak in your system.
- Repair the taps. Prevent them from leaking. You will save 200 liters of water (a drop per second is 30 liters per day).
- Use the remaining water from the food jars and from washing the vegetables to water the plants.
- Wash the car once a month, using a bucket and cloth.
- Don't let your toilets lose water. Check that your toilet doesn't lose water in a very simple way: pour a small amount of colorant into the water tank. Do not use the toilet, and if after 15 minutes you find colored the toilet, it means that your toilet is leaking water and you must repair it.
- Use a cup to rinse your mouth when you brush your teeth. You will save six liters of water per minute.
- Use your dishwasher or washing machine only when they are full. You can save up to a thousand gallons a month.
- Soap all the dishes and then rinse them all together.
- Wash fruits and vegetables in a bowl of water instead of running the tap.
- Designate a glass for drinking water throughout the day or refill a water bottle. This will reduce the number of glasses to be washed each day.
- Don't let the water run to defrost food. Defrost it by leaving the food in the refrigerator.
- Before buying a new washing machine, compare the amount of water you will save with each model. Remember that if you choose well, you will also save energy.
- Use the washing machine only with full loads. That is, when washing clothes, check that the water level corresponds to the size of the clothes.
- If your shower is capable of filling up to a gallon in less than 20 s, replace it with a more efficient model. You can save up to 750 gallons of water per month.
- If you shorten your bathing time by a minute or two, you can save up to 150 gallons of water per month.
- You've always been told to turn off the water when you brush your teeth, but did you know that you can save up to 25 gallons of water if you do?
- In case you need to leave the faucet or shower running to get hot water, put a container or bucket together, and then reuse it in the toilet or for watering plants.
- Decrease the frequency of washing the floors. It is preferable to mop them.
- Turn off the shower while washing your hair to save up to 150 gallons of water per month.
- Turn off the sink while you're shaving to save up to 300 gallons of water a month.
- To save time and money, you can wash your face and teeth while bathing.
- Hidden water leaks are a silent source of wasted liquid. To avoid that situation, read your water meter and don't turn on any faucets for two hours. If the indicator changes after

ISSN 1692-8407

that time, a leak will occur. By the way, check your water meter frequently and check your water bill to see how much water you are using.

- Repair any leaking faucets and be sure to turn off the faucets.
- Report broken pipes to the property owner or water supplier.
- Water your garden with rainwater. Do this once a week.
- Bathe your pets on land that needs watering.
- Instead of a hose, use a broom to clean the sidewalk.
- Opt for an ecological car wash, which can be done with products offered by the market to clean and shine the car, without using a drop of water. You can also do without the hose and use a bucket of water.
- Avoid toys that require a constant flow of liquid, such as water guns.
- Try to take a bath in a few minutes and prefer to use a water-saving shower.
- Install a low-volume toilet. If your toilet is old, adapt a water-saving device in the cistern that allows partial and total water discharges.
- Do not let the water run while washing the dishes. Remember that you can use water-saving filters in the dishwasher or use a dishwasher. The dishwasher is a mechanical device that saves 30 liters of water daily.
- Prefer to soak your pots and pans to clean them and not waste water while removing dirt.
- If you prepare a tea, pour the amount of water it will require into the pot. It is also recommended to cook food in the least amount of water possible.
- Wash fruits and vegetables in a container with water and do not clean them under the tap.
- Throw accidentally falling ice cubes at a plant. You can also pour the water left over after cooking into a plant. Do not use the water to defrost the food, better use the refrigerator.

Conclusions

The problem that was developed during the article was the use of water in the home, looking for alternatives to achieve savings of this resource. For this reason, we talked about the importance of water in our ecosystem as a first step, raising different arguments about possible situations that can arise if we do not take care of the water resource. Within the proposed solution, the content was based on the writing of advice that could be made at home to achieve the preservation of water for much longer, relying on the different products that may offer the market or actions that could be supportive in helping against this problem. Finally, with this article, we seek to create awareness in society, on this issue that is not a mystery but a reality that is already lived in many countries where scarcity abounds, so the importance of being involved and achieve not only preserve this vital resource for us but future generations.

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A critical look at the women-only wagons in Transmilenio

Una mirada crítica a la medida de los vagones exclusivos para mujeres en Transmilenio

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Given that the problem of sexual violence in Colombia has increased unusually, the government entities, together with the Secretary of Women, have adopted measures to reduce these facts, such as the wagons for exclusive use by women in Transmilenio. However, these have not been efficient, so it is essential to seek a real strategy that does not bring consequences in the coexistence.

Keywords: Civil engineering, culture, inequality, mobility, segregation, sexual harassment

Dado que la problemática de violencia sexual en Colombia se ha incrementado de una manera insólita, los entes gubernamentales, junto con la secretaria de la mujer, han adoptado medidas para reducir estos hechos, como los vagones de uso exclusivo para mujeres en Transmilenio. Sin embargo, estas no han sido eficientes, de manera que es indispensable buscar una verdadera estrategia que no traiga consecuencias en la convivencia.

Palabras clave: Acoso sexual, cultura, desigualdad, ingeniería civil, movilidad, segregación

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Introduction

Mass public transport in Bogotá, Colombia was initially proposed as a solution to mobility in this city (Lecompte & Bocarejo, 2017; Lemoine et al., 2016; Mosquera et al., 2012). The inhabitants were surprised and rewarded with this innovation, which consists of an articulated bus with two or three cars and several stations within the city (Cesafsky, 2017). However, what was initially the salvation to mobility, today has become one of the problems that most affect the inhabitants (Hunt, 2017; Vecchio, 2017).

The constant increase of population in the capital of the country, the sexual harassment against women, the lack of culture in the society, are reasons for which we want to achieve that the reader takes into account from a critical look the factors that are related to this transport and some proposals that have been wanted to adopt (Bastomski & Smith, 2017; Gekoski, Gray, Adler, & Horvath, 2017; Gekoski et al., 2015; Whitzman, Legacy, & Andrew, 2013).

This article is structured as follows. In the following section, we consider sexual violence in the public transportation system in Bogotá, the reasons for not implementing wagons for the exclusive use of women, and alternatives to combat sexual violence in Transmilenio. In the end, we present our conclusions.

Sexual violence in public transport in Bogotá

During the sixties in the city of Bogotá, it was possible to appreciate a considerably comfortable life in several aspects. The city had a population that barely exceeded one million people, a territorial extension of around 8000 hectares, and a transportation system capable of satisfying the demand of that time without caring that this service was private. But this lifestyle would deteriorate over the years, the capital of Colombia presented a huge population growth due to migration from the countryside to the city, generating a huge disorder at the territorial level, environmental problems, and mobility within the city.

In the last years of the 20th century, the crisis that was being experienced was unsustainable since the city lacked a massive public transportation system that was capable of meeting the demand, generating comfort, tranquility, and efficiency. There was the additional problem that the city did not have an adequate road infrastructure for the time that reached every part of the capital.

It was then that the idea of possible solutions to this problem began to be considered during the mandates of Mayors Andrés Pastrana, Jaime Castro, Antanas Mockus, and Enrique Peñalosa. However, these alternatives presented some limitations, such as the implementation of the subway, which was not considered a short-term response, and its construction was quite costly.

And so it was decided to use the implementation of the Transmilenio system which is: "*a massive transportation system that uses trunks with exclusive lanes, large capacity buses, and exclusive stations with prepaid systems that were put into service in the city of Bogotá at the end of 2000, as a solution to the problem of vehicular chaos that occurred daily in the capital*", and is based on four pillars (Andina, 2001):

1. "*Respect for life, represented in a comfortable, safe, and modern service.*
2. *Respect for people's time, with a transportation system that meets minimum quality standards in terms of itineraries and travel time.*
3. *Respect for citizen diversity, as it would become a transportation system in which different social classes converge without preferences of any kind and, on the contrary, equal treatment.*
4. *International quality, complying with the minimum requirements indicated by the transport engineering for the provision of a comfortable, safe, and effective service"* (Transmilenio, 2013).

The first three trunks delivered to the population were Autonorte, Calle 80, and Caracas which are expected to mobilize close to 660,000 users per day. The first route used by the system had 14 buses, and the route was between Calle 80 and Calle Sexta along the Caracas trunk line. This project, with an ambitious outlook, expected to have by 2016 around 22 trunk lines with stations and yards by, with sufficient resources provided by the government and the district. However, currently, the system has 112.9 km of track in operation, 11 trunks in operation, 134 stations, 9 portals, and 9 patio garages (Transmilenio, 2013).

Although the implementation of this system provided citizens with a solution regarding mobility, it also brought about not only changes at the infrastructure level but also economic, social, cultural changes, and an increase in the quality of life of Bogota's people. But over time this solution would bring more problems to Bogota's society than just those related to displacement within the capital.

At present, the problem within Transmilenio is becoming greater and greater. Insecurity, crime, sexual harassment, and many other events affect all users, but the most frequent victims are women. These crimes are part of the daily routine at the stations of this system, especially on Avenida Jiménez, Calle 76, Calle 40 Sur, Santa Lucía, Ricaurte, Portal del Norte, Calle 100, Calle 72, Flores, Calle 63, Marly, Restrepo, Portal del Tunal, Portal de las Américas, and Banderas, which are largely in the Troncales del Norte, Caracas, and the Americas (El Espectador, 2015).

Sexual harassment is a form of gender discrimination, and most victims are women. Emotional stress, humiliation,

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anxiety, depression, anger, impotence, or fatigue are some of the serious effects suffered by victims of this type of harassment. Sexual harassment is an attack on the dignity and physical and psychological health of women. It causes the loss of freedom to say NO, emotional, physical, and moral damage.

Sexual harassment is in all areas, it can be in the street, at work, on public transportation, at school, on social networks (cyber-bullying), and it can even be in the family. If it is not addressed initially it could turn into sexual violence, something that neither Colombia nor other countries have been able to end. Every day women are exposed to uncomfortable situations such as penetrating glances, insinuations, gestures that are too much, and even transgressions of personal space. These situations are very frequent, so much so that today they have become naturalized in such a way that people make *funny* comments regardless of whether they affect anyone.

There are too many victims, but too few women who dare to report, since most believe that this is an unnecessary, time-wasting process with no results. In most cases of sexual harassment, there is a witness, but he does not do anything about it, since he does not know what to do or how to intervene, thus giving the harasser the freedom to continue with his bad actions. Women should know that it is better to denounce than to do nothing about it, nothing is lost by trying.

The UN, in General Assembly Resolution 48/104 on the Declaration on the Elimination of Violence against Women, defines violence against women, including sexual harassment, as prohibited at work, in educational institutions and elsewhere (Article 2.b), and encourages criminal, civil and other administrative penalties and preventive approaches to eliminate violence against women (Article 4.d-f) (Espectador, 2016).

The District Women's Secretariat, in alliance with the Bogotá Metropolitan Police and the Transmilenio system, continues to work to prevent this type of incident and to improve the safety conditions of women on public transportation. In this sense, campaigns to prevent violence against women in the system will be strengthened, with the aim of increasing social sanctions against sexual harassment and promoting solidarity and co-responsibility among users (ONU, 2017a).

Some important worldwide numbers that should be taken into account to better understand this topic are:

- According to a survey conducted in 2016, more than 1 in 4 women in Washington D.C. (United States) have experienced some form of sexual harassment on public transportation (SDMujer, 2017).
- One in 10 women in the European Union reports having been cyberbullied since the age of 15, including receiving unwanted, sexually explicit, and offensive emails or SMS messages, or inappropriate and offensive attempts on social networks. Young women between the ages of 18 and 29 are most at risk (ONU, 2017b).

The World Bank worked on a pilot program to find effective ways to combat the problem of sexual harassment at public transportation units and stops in Latin America. From this, the following characteristics were found:

- Reporting is not easy. There is a general feeling that it is not worthwhile to report events because it is complicated and there are rarely results.
- There is no solidarity among strangers. If there were a greater sense of community, people would dare to raise their voices when an incident occurs and would be more supportive of the victims.
- Segregation is not a sufficient solution. Some saw it as another way of victimizing women, suggesting that women *choose* to submit to abuse if they do not go in the women's compartment (Unión Europea, 2014).

Sexual harassment is a very broad problem, and countries close to Colombia have also experienced problems in public transportation-related to this issue. Although with some campaigns that have been proposed in the country it is proposed to improve, the truth is that this is a more cultural issue, therefore, there must be more corrective measures in this regard. Colombia is a country that has very uneducated citizens.

As can be seen in Fig. 1 and Fig. 2, the number of women who suffer violence and sexual harassment in public transport daily is quite high. A large number of complaints and reports led the Mayor's Office of Bogotá and the Secretary for Women to take extreme measures, and thus implement through the campaign called *Women travel safely on Transmilenio*, wagons exclusively for women in the articulations of the Trasnmilenio mass transit system, starting with a pilot plan on March 7, 2014, on some routes in the northwest of the city, which lasted a month, showing positive results, so the implementation of the strategy was extended and expanded on the most used routes throughout the city for approximately two years.

This strategy emerged in the city after its implementation in other countries such as:

1. **Brazil**. Since 2006, the Rio de Janeiro subway has a car marked with pink signs for women that operates during rush hour, and public buses in the city of Goiânia also use this media, which operates there all day.
2. **Egypt**. Since the '90s, exclusive wagons for women have been implemented in the Cairo subway, which is marked by the color pink (Banco Mundial, 2014).
3. **India**. Since this is a country with a great number of sexual harassment, Indian authorities implement train services only for women, being equally popular with the cab services by women.

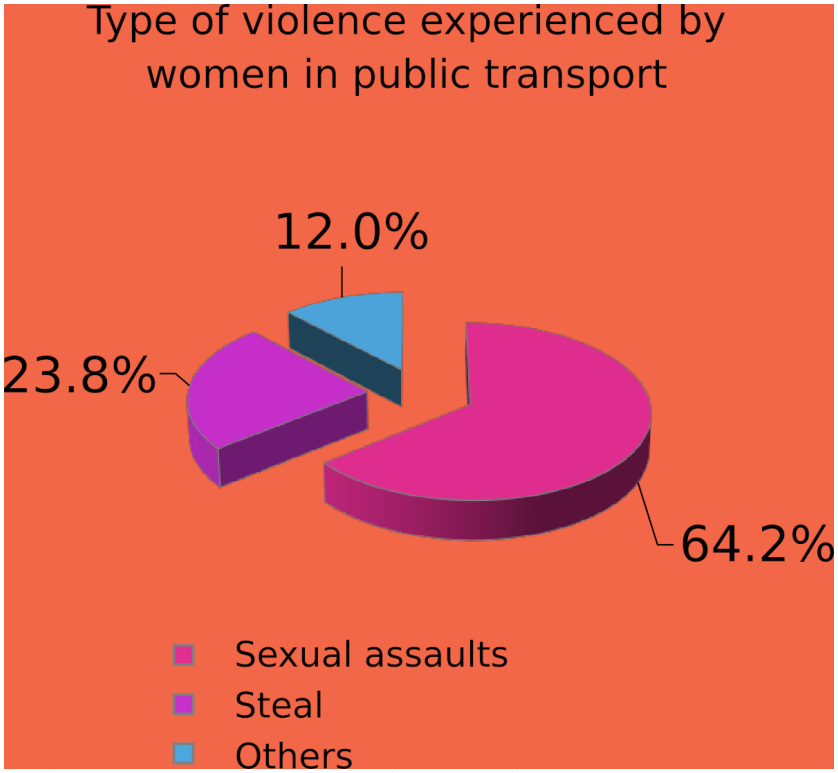

Figure 1. Violence suffered by women on public transportation (SDMujer, 2014).

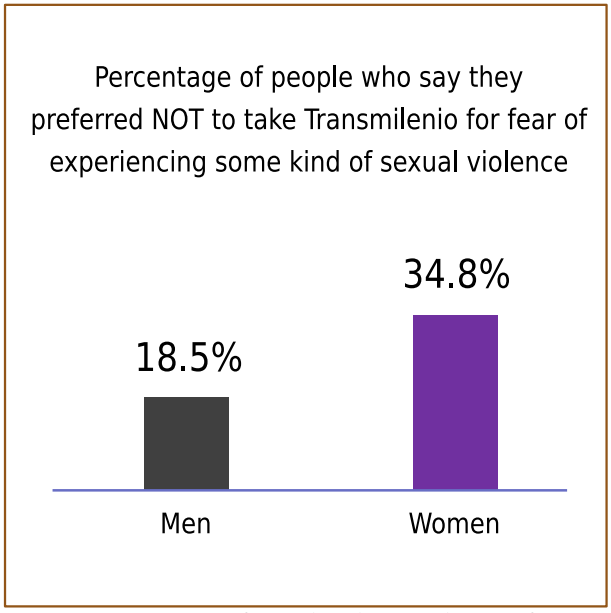

Figure 2. Percentage of people who say they prefer not to take Transmilenio for fear of suffering some kind of sexual violence (SDMujer, 2014).

4. **Indonesia**. The first women-only carriages were implemented in August 2010 in the Jakarta metropolitan area, while in 2012 a train was created on which men cannot travel (La Prensa, 2014).

5. **Israel**. The private sector implemented a service in which part of the bus is exclusively for women, an idea that was driven by religious sensitivities of ultra-conservative sectors of the Israeli population.

6. **Japan**. The Japanese capital's subway has wagons for the exclusive use of women, a measure that was created in 1912 and that currently provides service from Monday to Friday, some during the service's peak hours and others throughout the day, which are easy to distinguish because they are a different color. There is also a special service of cabs driven by women at night.

7. **Malaysia**. There are women-only carriages on trains throughout the country since 2010. That same year, exclusive buses were implemented in the capital Kuala Lumpur, while a year later an exclusive cab service was created, driven by women (La Prensa, 2014).

8. **Mexico**. Since 2008, through the campaign *we travel safe*, urban trucks and subway cars are used in Mexico City only for women, complemented by the installation of video cameras and special groupings within the system.

9. **Taiwan**. The women-only subway cars were implemented in the Taiwanese subways, however, they only operate during rush hours.

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Once the pilot plan was carried out in the city, the Women's Secretariat decided to survey Transmilenio users to see how it had progressed. Although most of the people surveyed were aware of the measure, most of them also considered that this measure would not contribute much to preventing violence against women in this means of transport, as can be seen in Fig. 3.

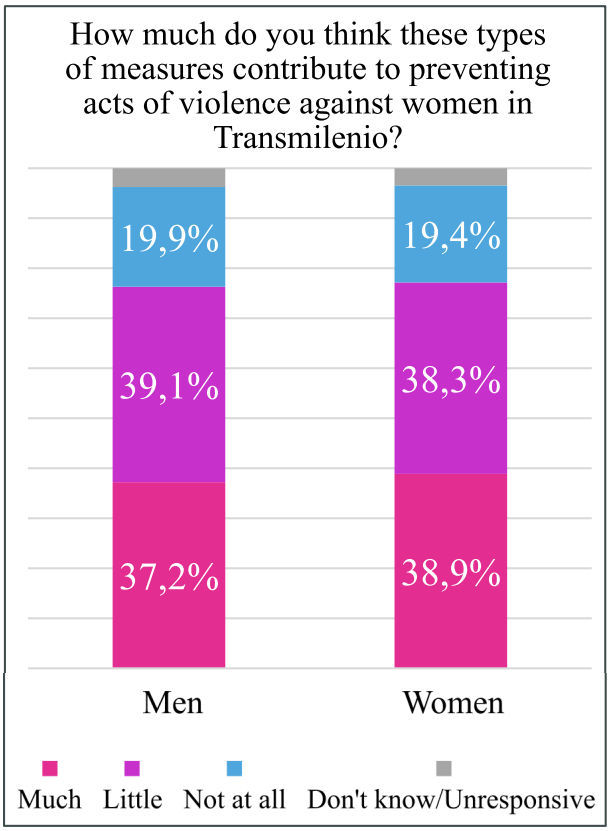

Figure 3. Community perception of the effectiveness of restriction in Transmilenio (SDMujer, 2014).

Even so, it was decided to implement this measure. However, as its popularity grew over time, so did user dissatisfaction. It seems that the contribution of such a measure is very small, because, although it seems to have a good purpose, it does not seem to be relevant for the transport system that is being developed in the city. This can be explained by the lack of culture and tolerance among users, much less if what is wanted is to achieve equity and good coexistence in society. After two years of its implementation, it was decided by the mayor's office not to continue using this strategy; it took this time for the administration to deduce that the results were less and less favorable.

Well, in a consultation made by Caracol Radio in March of this year to the secretary of Women's Affairs of the current administration, Cristina Velez, to know what happened with the measure, she said that the city that has implemented more extensively the policy of exclusive cars is Mexico City, with unflattering results that have not changed the violence in public transport, so it is not a measure that we will continue in Bogota (La Prensa, 2014). It was a very bad strategy, leaving the Secretary of Women alone to deal with a public transportation issue. This allows for the resolution of a situational problem, but not the structural one. It prevents harassment because it separates men and women, but it doesn't solve the underlying issue, which is how we treat each other in public space (Espectador, 2016).

Therefore, this is not a measure that should be implemented in the city. The fact that it is no longer in operation is a relief since it also rules out the problems that this measure contracts with, such as segregation, secondary victimization of women, greater congestion in the system, and the reproaches that men would most likely make to women. But it is also important to bear in mind that the problem is not solved because women represent 53% of the almost 2'600.000 passengers that travel daily in the system (Caracol Radio, 2017), who must travel daily by this means of transportation to reach their workplaces, studies, and homes, going through really difficult times when they are harassed by men without any respect for them and without support from other people, who in many cases do not pay attention to what is happening around them.

Thus, the Women's Secretariat seems to be continuing to look for suitable strategies according to the Secretary's statement that we are working with data from the World Economic Forum to take long-term action. We are studying rapid reporting points to identify the lines where there are more incidents so that we can reinforce the presence of authorities, whether they are police or authorities of coexistence (Espectador, 2016). But it is very unrewarding to see long-term measures taken and not think about doing something now, at the moment when this type of violence is growing so rapidly and with so few repercussions for the perpetrators, so it continues to be the daily bread of a large number of users of the system and the satisfaction of many of the perverts who enjoy violating them.

Reasons not to implement women-only wagons

The most popular strategy that has been observed to combat the problem of sexual aggression in the Transmilenio mass system seemed to be the real solution, and the expectation of the users was great to the point that their deficiencies would be noticed. There were many doubts and questions about the real functioning of the women's wagons and the repercussions that these would bring. Its consequences are so serious that instead of being an advance for society it seems to be a step backward, a direct pass to the old society that lacked aspects such as gender equality, tolerance, and citizen culture, which have been sought lately and would be lost immediately with such an absurd measure.

By implementing methodologies such as the above to provide a safer environment for all users of the mass transit system, especially women who are most affected by the countless cases of abuse and mistreatment within the system, not only are they ineffective, but they also generate a greater number of problems for the entire female gender.

1. **Gender Inequality**. Gender equality is understood as giving women and men equal value and real enjoyment of rights and opportunities, thus ending discrimination (El Espectador, 2017a). By making these measures effective, women are being given a position of weakness or fragility with the male gender, thus reversing all the efforts that women have made in their history to be valued and recognized as equals to men. Although much progress has been made in achieving this goal, even in this modern society women are often seen as equals, especially in the workplace. In Bogotá, according to DANE figures, for example, it has been found that women continue to earn up to 20% less than men despite having the same academic level and experience. Also, they spend nine and a half hours in unpaid work compared to two and a half hours for men and, as if that were not enough, they continue to be the main victims of domestic and sexual abuse (Unicef, 2017).

2. **Lack of civic culture**. Culture is the set of forms and expressions that will characterize a given society in time. By the set of forms and expressions is understood and includes the customs, beliefs, common practices, rules, standards, codes, clothing, religion, rituals, and ways of being that predominate in the common people who integrate it. The term culture has a very wide meaning and multiple meanings. The same happens with words like science, knowledge, or faith, concrete words with different values and meanings (Definición ABC, 2017). In Bogotá, in addition to mobility problems and insecurity in the mass transportation system, the lack of culture in Bogotá is also reflected. Before, it was not common to see people getting on the buses selling products or singing, while now there is a different vendor at each station. Justifications and permissiveness have helped to strengthen this phenomenon. On the other hand, in the year 2015 in Transmilenio about 67,000 users snuck in or entered without paying the fare, which corresponds to $41 billion per year in losses, which are replaced with taxes from all Bogota's citizens, that is to say, because of the sneakers, public money is no longer invested in other matters of vital importance such as health, education, etc. A rather thorny issue is the frequent acts of intolerance generated by not giving up a chair, by pushing or not letting the bus doors close or open. Symptoms of a lack of social awareness and social culture (Grandas, 2015). Colombia as a whole is not uneducated, because if we take as a reference other cities like Medellin, a city quite organized and educated, then why Bogota which is the capital of the country is not, if, with more reasons this should be an example for all other cities, it is a question of customs, if a person from Bogota goes to Medellin is going to notice a big change and therefore will also behave like the inhabitants of this city. Another factor that is aggravated by the implementation of this type of measure in the Transmilenio transport system is the citizen's culture. What is evident in the current society of Bogota is the custom and tradition of individualism, where only each person matters, seeking the advantage over others and the most important thing within the system is to obtain a seat at all costs during their journey, leaving aside the value and quality of being civilized people only thinking about entering the articulated *as you can* in a society which lives its day to day to the efforts characteristic of a city that is constantly growing. But given this problem of the lack of citizen culture in several areas that affect the system, measures have been taken to generate awareness and a possible solution to so many discontents that harm the quality of this service. This is the initiative *Todos pagamos el pato* (We all pay the price), which consists of embodying in a character the insecurity, the atmosphere of disorder, and the discontent that those who avoid the passage symbolize. The call to personify that discontent will be a yellow duck that, from now on, will roam the different stations and portals of Transmilenio, leading all those behaviors that not only worry and bother users but also put them in danger and generate more occupation on the buses (El Espectador, 2017b). But even so, many more strategies are needed to improve the coexistence and citizen culture of all users of the mass transit system.

3. **Segregation**. An important aspect that would manifest itself during the execution of measures of this type is the gender or sexual segregation in which the woman would be in a situation of isolation because she considers herself to be weak concerning the other gender, seeking her protection by separating herself from the other users of the system as a measure to avoid further aggravating this problem. But it would be showing a society which is unable to take conscience and acquire a citizen culture based on respect and tolerance that can overcome the potholes of bad habits and customs and prefer to solve them in an easy and retrograde way damaging the image and the concept of the woman at present. A fundamental concept in social groups is the interaction between individuals, restricting this interaction breaks the balance of the system, and this is as true as in artificial systems (Penagos, Pacheco, & Martínez, 2018; Rendón, Arbulú, & Martínez, 2018).

Victimization of women

Many authors agree that secondary victimization is the negative psychological, social, legal, and economic consequences of the victim's relationship with the criminal justice system and that it represents a frustrating clash between the victim's legitimate expectations and the institutional reality, involving a loss of understanding of the

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psychological and physical suffering caused by the crime, leaving them desolate and insecure, and generating a loss of faith in the ability of the community, professionals, and institutions to respond to their needs. It is also understood as a second victimization experience that results in some frequency being more negative than the primary one and can lead to an increase in the damage caused by the crime with others of a psychological or patrimonial dimension (Gutiérrez, Coronel, & Pérez, 2009).

Some of the factors that influence the development of an abusive and revictimizing environment in a judicial environment are:

- Lack of information to the victim of the rites and procedural times.
- The frustration of their expectations when the sentence is not reached.
- The victim must give the version of the facts in the presence of the victimizer.
- The subjectivity of the professionals themselves and their working conditions.
- Rationalization by some professionals of the victim's situation ("I would be doing something to make what happened to her happen!").
- How crimes are typified in the criminal codes and the definition of the passive subject of the crime.
- Iatrogenic interventions, in which the personnel in charge of caring for the victims, with their intervention, produce more harm than the criminal act itself.
- Giving priority to the search for the reality of the criminal event by forgetting to care for the victim or depersonalizing his treatment.
- The lack of information about the evolution of the process, about the sentence, and about the fate of the offender.
- The lack of an environment of privacy and protection.
- Excessive legal technicalities.
- Ignorance of professional roles on the part of the victim.
- The excessive slowness of the judicial process and its interference with the victim's recovery and rehabilitation process.
- The oral trial: the narration of the crime, the questioning of its credibility, and the feeling of guilt are important inducers of tension.
- The behavior developed by the victim during the trial.
- The costs of victimization.
- The duration of the crime (Gutiérrez et al., 2009).

This is how it becomes more difficult to deal with sexual violence in the city and even in the country. The negligence of Colombian judicial authorities in many of the reported cases is quite clear, either because of a simple *lack of evidence*, lack of attention, or simply because they do not believe in the women who report.

Given that in many cases the people who attend to these complaints are men, there is a greater negative response on their part, affecting the women who have been raped even more with their comments. Also, the interrogations carried out by the authorities and even the trials themselves can make the victims feel guilty about what happened to them, without taking into account the possible evidence that may be requested by the judicial entities and that may lead the victims to go through uncomfortable and difficult moments that bring with them psychological and emotional effects accompanied by the accusations that other people may also make. And since the authorities are the main cause of this damage, the victims do not know who to turn to.

Therefore, it is pertinent to make a call for attention. If in cases where the aggression seems so evident, severe secondary victimization is observed, as it could be in the middle of the reporting of cases that occur in public transportation. This is the main reason for women not to report, as many consider the harm they may suffer by doing so or simply consider that they will not achieve anything by reporting.

In this way, to denounce, encouraged by the campaign of the wagons for women, is not very convenient while the judicial entities, continue acting and judging the victims in this way and while the laws are not hard enough with all that sexual aggressor so that it was enough reason not to want to commit a crime of this type.

Signposting of women from victim to victimizer

It's no secret that today's society is still very macho. So it would be something very delicate the role that would be taken by women who sometimes could not manage to use the wagons exclusively for women. All these women would be presented with a sign because as many people see, they would not have to be present in the mixed wagons, but this is possible given the flaws in the system since it is a large number of women who transit and use this means of transport daily, and very possibly they would not fit in a single wagon per joint and with the delays and delays of the buses it would not be possible to afford to wait for another one, because it would also be the delay of people in their places of work, study or whatever their destination.

It is almost obvious that with the only option of taking the mixed wagon because the women's wagon is full, it is pointed out by the men that if these women are attacked it is their fault since they are in the mixed wagon. The women who are victims of such a horrible experience every day would become the victimizers because they are in the area where men are possibly lurking to feed their morbidity.

But, then it is even more important to think about cases in which it is difficult to make use of these wagons, such as women with cars, because there is no place for them in the women-only wagon, people with some kind of disability

who are accompanied in many cases by people of another sex, including the illogical separation of families or groups of people who may go together and are forced to separate when they get into the articulate.

Thus, it would be very exclusive this measure that would become a big problem with which very possibly all users would be against, because it is unacceptable to want to achieve a really good and healthy coexistence among citizens, separating them into groups.

Consequences on mobility

Public transportation in Bogotá has generated several inconveniences, and the massive transportation system was believed to be the solution to these problems, however, today it has become a major problem since as all cities and countries in the world have constant population growth, Bogotá did not take that into account and that is why this system cannot meet its demand.

This *salvation* in the issue of mobility has lost its charm in Bogota, mainly because of the issue of security, since despite the measures taken by the police and the system, thefts do not stop, 83 percent of users, according to a survey by the Chamber and Commerce of Bogota, say they feel unsafe in the Transmilenio. Also, on the other hand, there is time, Bogota is a Latin American city where citizens spend more time on their journeys (about 97 minutes daily) people must get up very early if they want to get to work on time, many with 2 hours notice, adding that the delivery of the articles to the stations is not continuous, therefore there is an accumulation of people and when it comes to entering these buses, many get hurt.

Another important problem that affects the mass transportation system is the routes since it has a rather complicated route system, which involves congestion in the stations, the price of tickets, and the inefficiency of the system.

As the years go by, citizens realize that they must demand a decent means of transport because the city will continue to grow, so measures must be taken in terms of mobility and mass transport as soon as possible, because if it is currently chaos, at a prospective level, it will be catastrophic (Fig. 4). There is a need to research and develop quality, high capacity mass transit schemes with technologies that can replicate low energy, high-performance strategies (Gordillo & Martinez, 2018).

The initiative to implement wagons exclusively for women in the mass transport system would complicate the situation, both in terms of congestion and mobility, since the number of people who need to be transported is increasing. It is logical that with the lack of citizen culture in Bogotá, this measure would not work; in fact, there would be more aggression against women, and in the case that some of them do not comply with this alternative due to time, eagerness, etc. men could take advantage of this situation, causing women to re-victimize themselves. Also, the problem of providing supplies for all stations would be more complicated, since if now that the wagons are mixed they do not give enough, with the segregation it would be Dantean.

Alternatives to combat sexual violence in Transmilenio

New ideas

To try to find a solution to the problem that half of the women who use TransMilenio feel unsafe during the trip and one in three say they have not used this mass transport system for fear of suffering some kind of sexual violence, Bancolombia, and the Silla Vacía decided once again to ally to generate a scenario in which possible solutions to city problems were developed, to generate proposals for action. This is why experts from the Cachaca Network were called to a brainstorming session (a hackathon) from which these ten ideas were taken by Cristina Vélez, the district Secretary for Women, to eventually include some of them in her plan of action within UN Women's *"Safe Cities"* program of which the city is a part.

1. **TransmitRecording**. Through the sound systems that already exist in Transmilenio, reproduce messages that with figures or cases of recent harassment warn about the consequences of being a harasser.

2. **Panic button**. Locate easily accessible panic buttons along the buses so that people who are feeling harassed can generate an alarm and expose the harassers.

3. **High Fire**. In the same way that people yell *"Fire!"* when there is a fire, you want to establish a keyword for users to yell if they see a woman being harassed. This will generate an alert and draw the attention of the other passengers to make the stalker stop.

4. **Look into my eyes, not my tits**. The organization of space on TransMilenio buses can be a determining factor in discouraging forms of harassment such as rubbing or uncomfortable glances. This idea seeks to make the organization of the space so that users have to be face to face, looking at each other's faces. In addition to the physical organization, it seeks to accompany the idea with a strong communication strategy so that men look at women's eyes, and not at their tits.

5. **Superpowered women**. To train women in self-defense (in non-violent ways) to empower women from a young age, and to give them tools with which they feel safe in the different environments of their lives.

6. **Life in the Mile**. *"The last mile,"* the last stretch that women travel from bus stations to their final destination, is a place where women feel very unsafe. The idea, then, is to fill these stretches with life, hiring artists and musicians to make that last stretch safer, more lively, and cleaner. It was

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Figure 4. Total daily travel time dinero2016.

also proposed that the Transmilenio and last-mile bridges could be *"adopted"* by companies or foundations, who would be able to make interventions to beautify them, improve them, and increase safety. The idea is that on the bridges or under them there will be music, exhibitions, or even English *'classes'*, to change the imaginary about these places that are generally synonymous with insecurity.

7. **The mile group**. In the same sense as the previous idea, this exercise proposes to create WhatsApp groups so that the neighbors can do the equivalent of a *'car pool'* with different schedules to walk together that last route. At the same time, it seeks to alert neighbors to be aware of these groups from their homes and stores.

8. **Torni penis**. The turnstile, which is the first barrier to enter the system, would also be the first barrier against harassment. The idea is that the tourniquet is shaped like a penis to generate repulsion in the user, making him feel empathy with the victim. The idea is that male users put themselves in women's shoes and empathize with them. The idea seeks to document in video the moment in which people crash with the tourniquet penis, to make a campaign in media and social networks to convey the message.

9. **Positive hands**. This campaign seeks to show the positive things that men can do with their hands: painting, carpentry, fixing a bicycle, etc. The idea is to send a message to make bullies feel bad that the best thing they can do with their hands is to commit a crime like sexual harassment.

10. **Transmit Angel**. The idea is to create a network of volunteers within TransMilenio to take care of the women on the bus routes and in the *"last mile"*. The *"Tu Llave"* cards, which already have the possibility of being personalized, would allow the Transmi Angels to be identified (La Silla Vacia, 2017).

Some of the ideas seem to be pertinent, as well as others somewhat inappropriate, but according to this position to deal with, the most appropriate solutions would be those in which methods of warning are proposed in the articles that give the impression that there is a harasser exposing him to the public, and also sentencing him to heavy penalties since it would be appropriate to accompany these methods with great legal repercussions.

Penal solutions

Given the countless cases of sexual harassment within the Colombian public transportation system, the control agencies are trying to provide a more direct solution to the constant abuses that women suffer during their journeys to carry out their daily activities.

1. **Law project number 112 of 2014**. The Senate of the Republic has chosen to propose more drastic measures to minimize this problem that affects a large part of the population since it is already getting out of hand. Through Law Project number 112 of 2014, the Colombian Congress decreed the crimes of Sexual Harassment in Public Transportation. Anyone who makes unexpected touches on intimate parts of another person's body, without his or her consent, taking advantage of the circumstances of the means of access and use of public transportation, will incur a prison term of two (2) to four (4) years (Guerra, 2014). This will be contemplated in Title IV of the Crimes against the Freedom,

Integrity, and Sexual Formation of the Colombian Criminal Code. The origin of this project is the great deterioration of the behavior of citizens in public spaces, in addition to the appearance of new phenomena of intolerance and conduct of a sexual nature (Guerra, 2014).

2. **Law Project 145 of 2015**. Another measure or proposal given by the Colombian Senate is Law Project 145 of 2015, where the Congress of the Republic decreed the inclusion in the National Code of Police, the special contravention of Sexual abuse in Public Transportation, as conduct that seriously affects the coexistence, the sexual rights and the integrity of the citizens, as well as the adequate use of the spaces and means destined to public transportation. For all the effects of the law, the special contravention of sexual abuse in public transportation is created. In this sense, anyone who, taking advantage of the circumstances of access, congestion, and use of public transport, makes unexpected touches on intimate parts of a person's body, without their consent, or performs obscene acts, or infringes by any means upon the sexual rights and/or moral integrity of another person, shall incur an arrest of three (3) to nine (9) months and a fine of one (1) to (6) SMLV Minimum Legal Wages, without prejudice to any compensation that may be due to the victims for such conduct (Guerra, 2014).

The implementation or formulation of such laws was really necessary because the current laws were not very effective in bringing a concrete charge before a judge for abusers or attackers within the transportation systems, since such laws could not be fully enforced due to certain determining requirements such as violence for these sexual harassment cases. For example *"Violent Sexual Act"*, which is enshrined in Article 206 of the Criminal Code, and specifies that whoever performs on another person a sexual act related to carnal access using violence, will incur a prison term of eight (8) to sixteen (16) years (Guerra, 2014). Or *"Injury by Fact"*, is included in the Criminal Code in Article 226, Title V, Crimes against Moral Integrity, Single Chapter, and applies as a modality of the crime of Injury and Slander, which establishes that whoever makes dishonorable accusations to another person, will incur in prison from one (1) to three years, and a fine of ten (10) to one thousand (1000) monthly legal minimum wages in force (Guerra, 2014).

With the implementation of these laws, the victims of this type of harassment in the transportation systems will have more courage and enough basis to be able to safely report such abuses, with the confidence that their case will not be forgotten, their aggressor will not be released in a matter of hours and will be treated with the weight of the law for the fault he committed.

Conclusions

The problem that has become evident daily on the streets of Bogotá, due to the massive Tranmilenio public transportation system, where, although measures have been taken to mitigate incidents such as sexual harassment, the problem has not diminished, and more and more people are complaining about the system. The most appropriate solutions would be those in which methods of warning are proposed in the articles that give the impression that there is a harasser, exposing him to the public and also sentencing him to heavy penalties, as it would be appropriate to accompany these methods with great legal repercussions.

One of the proposals that have been most considered is the exclusive use of wagons for women. However, this option would complicate the situation, both in terms of congestion and mobility, since, if now that the wagons are mixed they cannot cope, with segregation it would be a Dantean problem. Also, Bogotanos are not prepared for this type of segregation, the lack of culture has made these measures almost impossible because at the time of implementing them, society generates a great rejection. Therefore, it is not acceptable to want to achieve a truly good and healthy coexistence among citizens, separating them into groups.

It is expected that citizens are aware of the situation with the system and that they do not let themselves be convinced by proposals that apparently can be salvation, but in the end, they are not, because it is necessary to take into account the background of these facts in the city, and how the inhabitants have reacted, so that in this way we know if it could be a possible solution or not.

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Correlation between birth and national mortality

Correlación entre natalidad y mortalidad nacional

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This article aims to raise a correlation between birth and death rates in Colombia. According to public data, it seeks to make known the meaning of the numbers, their possible interrelationship, and the various statistics obtained by the different sources of demographic data. The related data in the national census and civil registry platforms will be valuable since these sources provide the necessary material for in-depth research on population changes.

Keywords: Birth rate, colombian population, demographic impulse, life expectancy, mortality rate, overpopulation, social development

Este artículo tiene como objetivo plantear una correlación entre los índices de natalidad y mortalidad en Colombia. De acuerdo a los datos públicos, se busca dar a conocer el significado de las cifras, su posible interrelación, y las diversas estadísticas obtenidas por las diferentes fuentes de datos demográficos. Serán de utilidad los datos relacionados en las plataformas de los censos nacionales y el registro civil, ya que estas fuentes proporcionan el material necesario para la investigación profunda sobre los cambios de población.

Palabras clave: Desarrollo social, expectativa de vida, impulso demográfico, índice de mortalidad, índice de natalidad, población colombiana, sobrepoblación

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Introduction

The birth rate refers to the number of births that occur in a specific place and time, also relating the amount of fertile population (Reshadat et al., 2018; Song, Ahn, Lee, & Roh, 2018; You, Symonds, Rühli, & Henneberg, 2018). These studies are reflected in different statistics made by entities that indicate various sectors of the country, and dates where these births occurred. On the other hand, the mortality rate, as its name indicates, refers to the number of deaths that occur in a time, bearing in mind that death refers to the permanent disappearance of the vital functions of a human being (Dwyer-Lindgren et al., 2016; Ebmeier et al., 2017; Sidney et al., 2016). Throughout this article, different types and causes of mortality can be observed, based on studies carried out at the national level by the corresponding entities in each case.

The population census is in charge of collecting, compiling, evaluating, analyzing, and publishing the demographic, economic, and social data related to the inhabitants of a country or a certain area of it (Balcells & Steele, 2016; Dobbs, Hernández-Moreno, Reyes-Paecke, & Miranda, 2018). The civil registry is the continuous counting of births, deaths, migrations, marriages, and divorces (Estrada, Restrepo, Ceballos, & Mardones, 2016; Pachón, Carroll, & Barragán, 2017). Both databases are based on information that will help in the development and planning of a country, and in this research, they function as a primary source for analysis (Rendón, Guevara, & Martínez, 2017; Sanchez-Serra, 2016). In the study of each of the positions, the existing correlation can be identified (Delnord, Blondel, & Zeitlin, 2015; Dharmarajan et al., 2017).

Colombian demography

The Colombian population is concentrated in the Andean areas and on the Atlantic coast where the demographic nuclei of the savannah of Bogota can be seen, formed by Bogota and Soacha, in the Aburra Valley, which includes Medellin, Bello, and Itagüi, in the Cauca Valley, composed by Cali and Palmira. Also the Atlantic Coast, Cartagena, Barranquilla, and Santa Marta. As well as in the area of the Santanderes comprising Bucaramanga and Cúcuta and in the coffee axis Huila and Tolima.

Colombia is the third most populated country in Latin America after Brazil and Mexico according to information revealed for 2017 (Wikipedia, 2017). Colombia has experienced rapid population growth like other countries in the region, with a slight decline in recent years. This is despite the number of people living abroad, which is around three million, some because of the armed conflict and others by choice. In recent years the population in Colombia has increased disproportionately due to the number of immigrants who have arrived in the country.

Demographic index

We're going to start by talking about what the demographic index is, also called the population growth rate. This index expresses the increase or decrease of the population in a given territory during a defined time, expressed as a percentage at the beginning of each period.

The demographic index is defined by certain fundamental variables. In the first part is the entry of the population, which is made up of the number of born and the number of immigrants. The other fundamental variable that must be taken into account when determining the variation in the growth rate is the population outflow, which refers to the number of deaths and emigrants over time and in the defined territory. This data is obtained by subtracting the number of deaths and immigrants from the number of deaths and emigrations. The formula used to find the population growth rate is (*Birth rate* - *Mortality rate*) + (*Immigration* - *Migration*).

A population growth rate can be positive. This indicates that the population is growing (more births and immigrants). If the growth rate is negative, it indicates that the population has decreased (more deaths and migrations). However, there is also a constant population rate that indicates that there was no change in the number of people in both times, which means that the number of births and immigrants was equal to the number of deaths and emigrations. The latter indicates that there was not a net difference, and a point of equilibrium was achieved despite changes in some variables, but the effect is compensated by the others (Wikipedia, 2019b). In this way, for the development of this article, we will take into account these two fundamental variables, as well as all the demographic factors and indicators that give us a better idea and better result of the exercise (Fig. 1).

Birth rate

The birth rate is a measure of the quantification of fertility. It refers to the relationship that exists between the number of births that occur in a certain period and the total number of effective in that same period. The normal time established to be able to calculate the crude birth rate is one year, and it is read as the number of births in a population per thousand inhabitants. This unit represents the number of individuals in a population born alive per unit of time (Wikipedia, 2019a).

Knowing this, and relating it to our particular case, Colombia, the study data are selected (table 1). These data from these statistics are collected in the country by the National Administrative Department of Statistics (DANE). This entity is responsible for planning, organizing, processing, analyzing, and disseminating all official statistics in Colombia. With the help of this entity, we will try to

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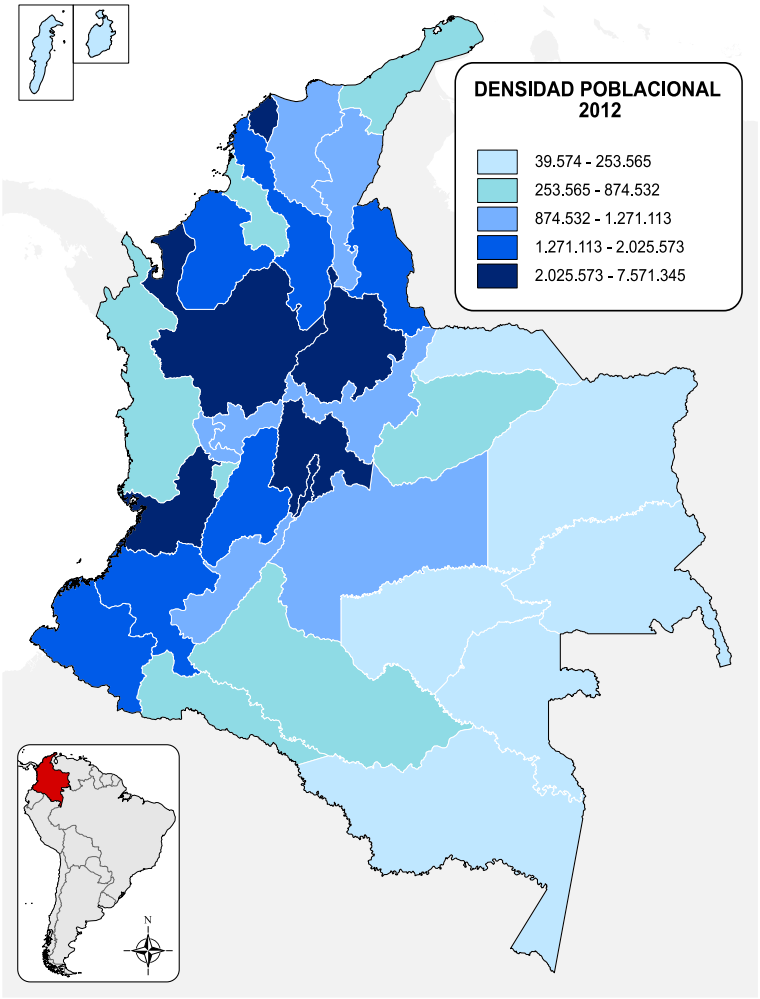

Figure 1. Population density in Colombia (Shadowxfox, 2015).

provide a solution and a real look at the problem raised in this article (Cardona, 2017).

Table 1
Birth information table (Paipa, 2016).

Date	Births	Male births	Female births	Birth rate	Fertility rate
2014	-	-	-	15.77%	1.90
2013	649742	333299	316443	16.08%	1.92
2012	676471	346890	329581	16.39%	1.95
2011	665499	341406	324093	16.73%	1.98
2010	654627	337025	317602	17.08%	2.01
2009	699775	360578	339197	17.45%	2.04
2008	715453	369752	345701	17.84%	2.08
2007	709253	364352	344901	18.25%	2.12
2006	714450	366728	347722	18.66%	2.16
2005	719968	370628	349340	19.08%	2.20
2004	723099	371229	351870	19.48%	2.24
2003	710702	364795	345795	19.87%	2.27
2002	700455	359315	341140	20.23%	2.31
2001	724319	371846	352473	20.59%	2.35
2000	752319	387020	365814	20.96%	2.39
1999	746194	382606	363588	21.36%	2.43
1998	720984	369378	351606	21.80%	2.48

Mortality rate

Mortality is considered to be the process of disappearance of life in a population in a given time. It is studied using flow charts, various statistics that help to interpret the information more effectively. This phenomenon is analyzed through the registration of deaths, not only taking into account the number of deaths but also age, causes, socio-economic characteristics, among others.

The mortality statistic is identified as different between men and women, as there has been over-mortality in men throughout their lives. Mortality has an important influence on various social and economic factors. The study of mortality by cause of death has been grouped into two major categories:

- Mortality due to endogenous or biological causes, which will have greater weight in the first month of life, as well as in advanced ages as a result of the aging that the population is suffering.

• Mortality by exogenous causes, as the result of the action of some means that will prevail in the childhood and young adults, although it is present in all ages (infectious diseases and accidents).

With the passing of time and the evolution of medicine, it is evident that mortality from endogenous causes is beginning to be more important and to receive more attention, while the second group turns out to be more controllable with hygienic and preventive measures (Fig. 2) (EcuRed, 2019).

Changes in Colombian demographics

In this section we will talk about the changes that have occurred in the Colombian population during the last few years, taking into account numbers and data provided by the different organizations and institutions involved, knowing that both national and world demographics have increased significantly and disproportionately.

Demographic statistics

Taking into account that in our country a national census was made in 2005, and to date, no other has been carried out, the statistical data obtained are valid. However, according to data obtained by the DANE, another national census is planned for 2018, which will begin in January and will have its first results in May, to obtain data about the population in the country, and thus know the reality of the increase in Colombian demography and the impact that this increase may have on the political, social and economic (Fig. 3).

In Colombia, the relative growth of the potentially active population continues with normal growth. This is between 15 and 64 years of age, which is 65.7% compared to the inactive population, which is made up of those under 15 and over 64, with a percentage of 34 percent. This is what Pro Familia tells us through the National Demographic and Health Survey (ENDS), which is conducted every five years with the collaboration of the Ministry of Health and Social Protection. In this survey, an analysis was made with the figures shown in the demographic changes that have occurred in the country. In the results obtained, the reduction in fertility is noted, which has led to the transformation of the structure by age of the population, in the same way, it is clear the decrease in infant mortality and the different changes in the size and composition of Colombian households.

This organization has been doing important work in education and in guaranteeing sexual and reproductive rights. Thus, throughout these years it has managed to reduce the fertility rate in the country. According to the ENDS, the fertility rate by area fell. They went from 2.8% to 2.6% in the rural area, and from 2% to 1.8% in the urban area. Another issue worked by the organization is the indicators of infant mortality, which continues to fall, this was reduced by half from the period 1990-1995 until today.

Although the country is ethnically and culturally diverse, there is still a high level of discrimination against these groups (Fig. 4). This discrimination is perceived in their levels of poverty, exclusion, and marginalization. Concerning ethnic groups, the survey shows that 14.4 percent of the country's population recognized that they belong to an indigenous or Afro-descendant population. The indigenous population is distributed with a greater geographical concentration in the Orinoquia, Amazon, Pacific, and Atlantic regions.

Among other results obtained in this survey is the marked decrease in the size of households, which is a common phenomenon among other Latin American countries. There was an increase in single-person households from 9.4% to 11.1%, while at the same time there was a decrease in households made up of more than four people. Similarly, there has been a continuous increase in the number of women heads of household, which stands out in urban areas with 36.4% and in rural areas with 25.5%.

Another important indicator taken from this survey is the percentage of children in the country who are not registered and are exposed to the risk of being excluded from the benefits and services indispensable for the good development of their physical, intellectual, and emotional capacities. The 1.4% of children who are under five years old were not registered, this percentage is higher in the rural area 2.5% than in the urban area 0.9%.

The data presented by the ENDS shows how the country has lived and is living an accentuated process of demographic transition which has implied some significant changes in the roles, behaviors, and demographic trends in the country (Marcas, 2017).

Causes of population growth

The population in Colombia has increased considerably and disproportionately in recent years. Among the causes of this phenomenon is:

• **The decrease in mortality**. This has occurred due to the sanitary, economic and technological advances that made possible the disappearance of epidemics and the diffusion of new industrial techniques. Similarly, the different processes carried out in the country such as the peace process and by which since the ceasefire has decreased mortality in the most affected areas.

• **Life expectancy**. It refers to the increase of the time of life, on average in Colombia the men live 72 years and the women reach 78 years while in 1950 the men were not reaching 50 years and the women 52 years. This phenomenon of continuing to increase can lead to massive and uncontrollable overpopulation for the country's leaders (Tiempo, 2005).

• Demographic momentum. The population tends to continue growing with a decrease in mortality and the

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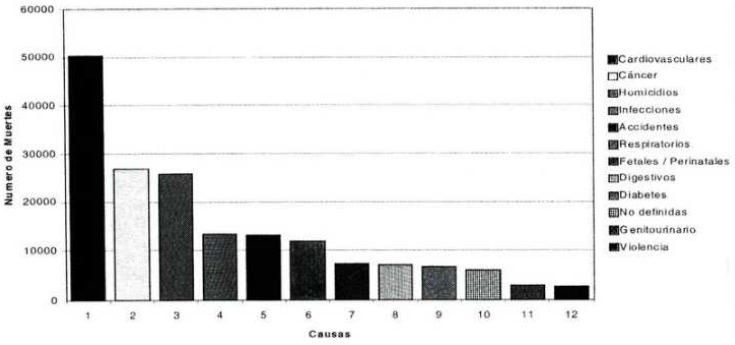


Figure 2. Mortality rate notability (Zambrano & Camacho, 2002).

Figure 3. Overcrowding in Bogotá (Colombia) (Soncas, 2015).

Figure 4. Ethnic minorities in Colombia (Aida, 2017).

absence of migration. Taking into account the age structure reveals a young population that will soon enter the reproductive age the largest generation of adolescents in history, overall there will be more than enough births to maintain population growth in the coming decades (Glosarios, 2015).

- **Immigration**. It is the phenomenon that most affects our country today. The great entrance of foreigners to our country, especially Venezuelans and Colombians with dual nationality who, due to the hard political, economic and social situation in the neighboring country, decide to cross the border in search of better work opportunities and a better quality of life. The number of people from the neighboring country who have entered during the year can only be known after next year's census; however, the possibility of people continuing to enter in the following years without any decrease is not foreseen. To this phenomenon, we must add that due to internal processes such as the peace process and its ceasefire and the restitution of land it is very likely that these affected people will take the initiative to create a home and have children by increasing the birth rate of the country (Figs. 5 to 10) (Dinero, 2017).

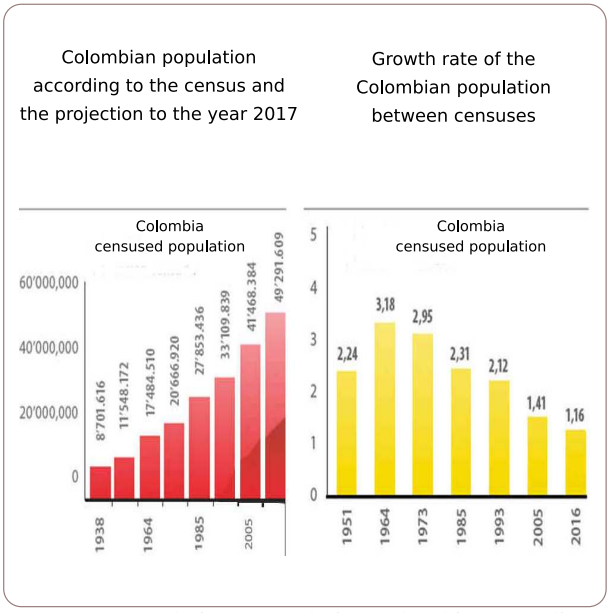
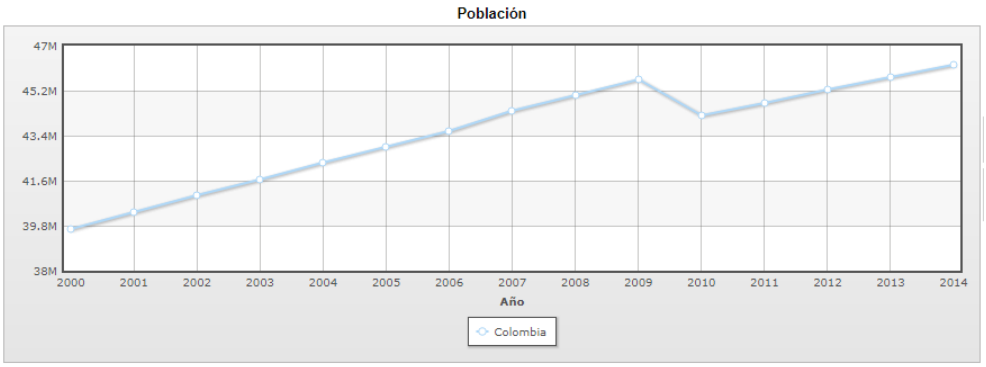


Figure 5. Population growth in Colombia according to national census (Dinero, 2017).

What to do about overpopulation in Colombia?

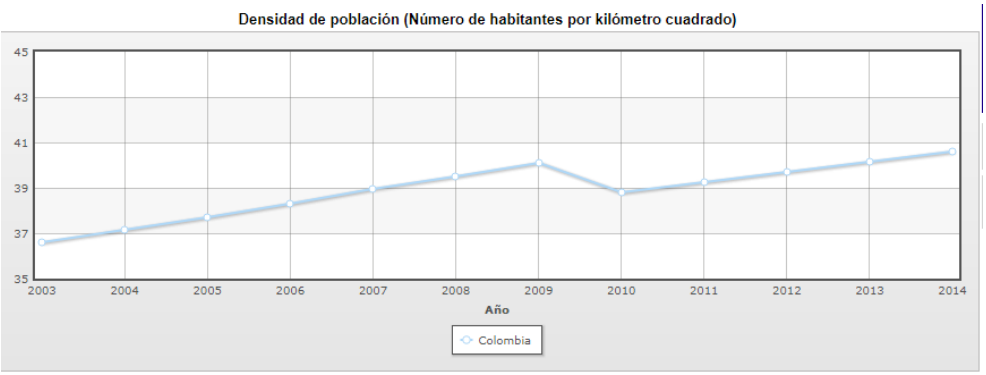
Taking into account that overpopulation is a phenomenon that not only affects Latin American countries but also occurs worldwide, it is evident that it affects various aspects such as the economy, politics, and the environment in a negative way. The population in Colombia has multiplied disproportionately, this phenomenon is not



Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Colombia	39.685.660	40.349.390	41.008.230	41.662.070	42.310.780	42.954.280	43.593.040	44.379.600	45.013.670	45.644.020	44.205.2

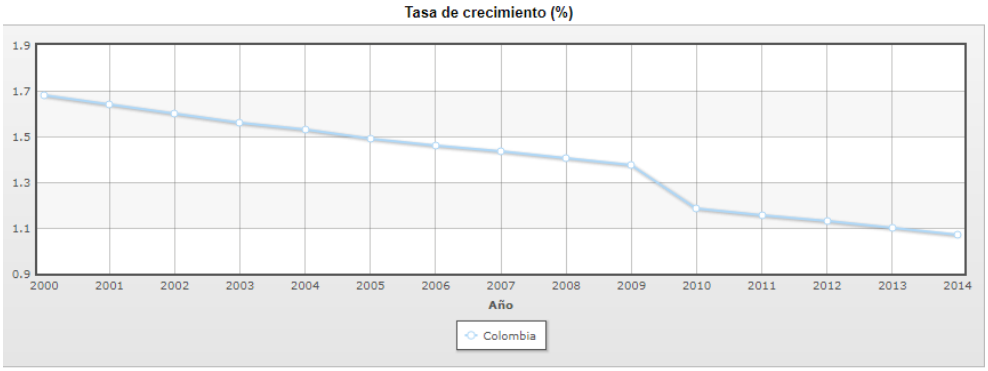
2010	2011	2012	2013	2014
44.205.290	44.725.540	45.239.080	45.745.780	46.245.300

Figure 6. Historical behavior of population density in Colombia (Index, 2014).



Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Colombia	36,58	37,15	37,72	38,28	38,97	39,52	40,08	38,81	39,27	39,72	40,17	40,6

Figure 7. Population density in Colombia (number of inhabitants per square kilometer) (Index, 2014).



Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Colombia	1,68	1,64	1,6	1,56	1,53	1,49	1,46	1,43	1,41	1,38	1,18	1,16	1,13	1,1	1,07

Figure 8. Historical growth rate in percentage (Index, 2014).

evident in developed countries, because the birth rates are counterbalanced by the death rates, while in Colombia the opposite is the case, while there are more births, there are fewer deaths and also, the large number of immigrants who enter our country daily.

The problem is more serious than is thought since the number of inhabitants has almost reached fifty million

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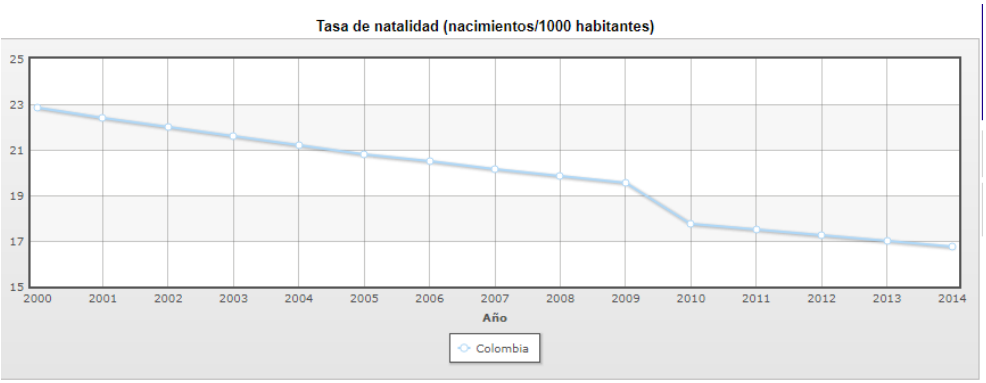
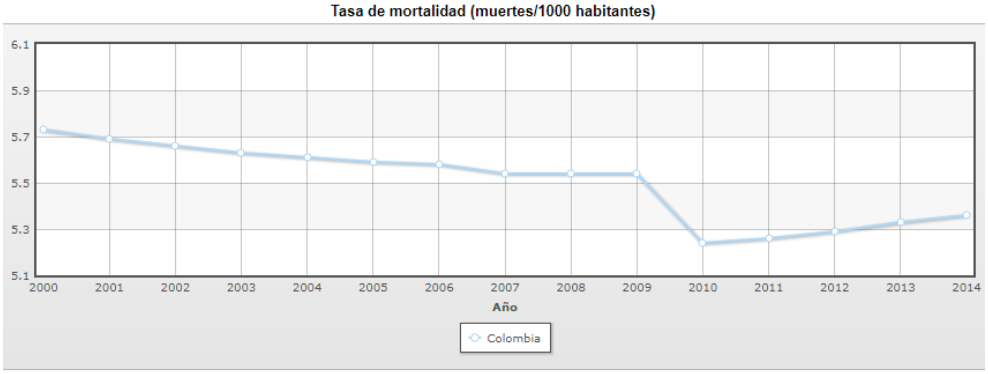


Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Colombia	22,85	22,41	21,99	21,59	21,19	20,82	20,48	20,16	19,86	19,57	17,76	17,49	17,23	16,98	16,73

Figure 9. Historical birth rate (births per 1000 population) (Index, 2014).



Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Colombia	5,73	5,69	5,66	5,63	5,61	5,59	5,58	5,54	5,54	5,54	5,24	5,26	5,29	5,33	5,36

Figure 10. Historical mortality rate (deaths per 1000 population) (Index, 2014).

(50,000,000), a number that will be surpassed in a certain time. One of the most important problems derived from overpopulation is unemployment, the rate of unemployed increases significantly, generating a higher level of poverty and directly affecting the country's economy.

It can be concluded that this problem has no real solution. It is difficult, almost impossible to prevent humanity from continuing to reproduce itself despite the existence of an infinite number of contraceptive methods and different organizations that are responsible for generating protection campaigns to lower the birth rate and prevent disproportionate population growth.

Contraceptive solution

Any method or device that prevents pregnancy. Several contraceptive methods have the same objective, but different levels of effectiveness. At least, sterilization is one of the most effective methods, through vasectomy in men and tubal ligation in women. Although intrauterine devices, subdermal contraceptives, hormonal contraceptives, and barrier methods can also be considered (Semana, 2017).

- **Intrauterine (IUD)**. A method of contraception that prevents pregnancy by killing the man's sperm, or preventing it from entering the woman's uterus (staff, 2000).
- **Subdermal (IS)**. A device made up of one or two matchstick-sized rods that are inserted under the skin of a woman's arm and release a progestin that acts as a contraceptive (Fertilab, 2019).
- **Hormonal**. This method is based on the consumption of hormone products whose administration is by different routes, causes an inhibition of ovulation, which therefore prevents fertilization and pregnancy (Metodoss, 2016).
- **Barrier methods of contraception**. They have the same function as the above-mentioned contraceptives, although they must be used adequately in every sexual relationship since they not only prevent pregnancies, but also diverse sexually transmitted diseases (Figs. 11 to 14).

Figure 11. Male condoms (Infogen, 2016).

Figure 12. Female diaphragm (Verywell, 2019).

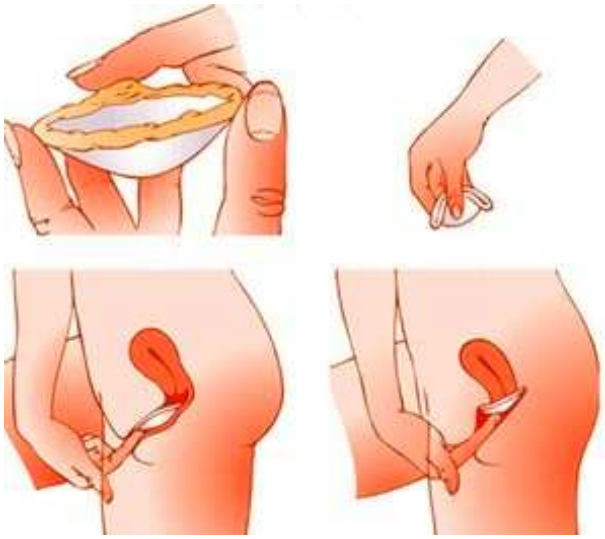


Figure 13. How to use the diaphragm (Anticonceptivas, 2019).

Family planning organizations

At the national level the most important organizations are:

- Pro Familia.
- WHO (World Health Organization).
- Contraception - Ministry of Health and Social Protection.

Figure 14. Vaginal sponges (Hoy, 2016).

- FUDEN - Foundation for the development of nursing.

Conclusions

This paper highlights through national statistics the sustainable increase of the population density in Colombia. Specific numbers are shown for factors that influence this population growth such as cultural, educational, migratory, and recent changes in the internal armed conflict. As an alternative to a social solution, some proposals are made that can help reduce the rate of growth, reducing the social and economic burden of the country.

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Operational amplifier performance practices in linear applications

Practicas de desempeño del amplificador operacional en aplicaciones lineales

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In applications that require signal conditioning, i.e., the coupling of electrical signals in which there are no reductions or distortions due to a low impedance circuit, both in analog and digital signals, the operational amplifier (OpAmp, or Op-Amp) is widely used. These integrated circuits are direct-coupled amplifiers with high gain, which in linear applications require feedback through passive elements. This feedback determines the transfer function of the circuit, which is characterized by the elements used and their connection. In this article, we analyze by simulation the theoretical behavior of the OpAmp in basic signal conditioning configurations, including inverting amplifier, non-inverting amplifier, and voltage follower, as well as circuits coupled with these configurations.

Keywords: Feedback, high impedance, operational amplifier, reversing amplifier, signal coupling

En aplicaciones que requieren el acondicionamiento de señales, es decir, el acople de señales eléctricas en las cuales no se presenten reducciones o distorsiones a causa de un circuito de baja impedancia, tanto en señales análogas como digitales, se utiliza ampliamente el amplificador operacional (OpAmp, o Op-Amp). Estos circuitos integrados son amplificadores de acoplamiento directo con alta ganancia, que en aplicaciones lineales requiere realimentación mediante elementos pasivos. Esta realimentación determina la función de transferencia del circuito, la cual está caracterizada por los elementos utilizados y su conexión. En este artículo se analiza mediante simulación el comportamiento teórico del OpAmp en configuraciones básicas de acondicionamiento de señales, incluyendo amplificador inversor, amplificador no inversor, y seguidor de voltaje, así como circuitos acoplados con estas configuraciones.

Palabras clave: Acople de señales, alta impedancia, amplificador inversor, amplificador operacional, realimentación

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Introduction

The operational amplifier is an active electronic circuit composed of multiple devices that produce a system that can be connected to an electrical circuit, capable of behaving as a high input impedance element, and a transfer function dependent on the passive elements that are connected to its terminals (Martínez, Martinez, & Montiel, 2017; Wang et al., 2010). Without these passive elements, the output of the OpAmp corresponds to the difference of the signal applied to its two inputs multiplied with a gain factor that depends on the construction of the OpAmp, and whose value is of the order of 10^5.

The OpAmp is used as a coupling circuit between circuits due to its high input impedance and signal gain (Montiel, Martínez, & Martínez, 2019). This high input impedance allows connections to be made between circuits, reducing signal loss and distortion. In this type of application, it is normal to control the open-loop gain of the OpAmp using a feedback loop (feedback to the negative terminal of the OpAmp) which, on the one hand, controls the gain of the circuit, and on the other hand, allows the operation of the OpAmp to be linearized, which facilitates the analysis of circuits that contain it (Tammam, Hayatleh, Ben-Esmael, Terzopoulos, & Sebu, 2014). The elements used to feed the OpAmp have stable and known values, so the transfer function of the OpAmp is also stable and known. Much of the work with the OpAmp lies in the design of circuits with certain transfer functions, i.e., the design of the feedback circuit.

Originally the OpAmp was used on analog computers. In these computers, they formed circuits for operations such as sums, derivatives, and integrals. However, these systems required costly and continuous adjustments, and are currently surpassed in performance by digital systems. Currently, they are widely used in instrumentation, specifically in the coupling of circuits (Chi & Cauwenberghs, 2010). It is for this reason that its study and design is fundamental in the programs of Electrical Engineering and related (García et al., 2014). However, for students new to their study, circuit analysis with OpAmp is complex due to its natural non-linear behavior, compared to the rules of linear circuit analysis traditionally taught and used in these programs (Wong & Ng, 2016).

The design strategies of electronic systems, or of those integrated systems that involve electronic circuits are in continuous change (Martinez, Martínez, & Hernandez, 2017; Martínez, Montiel, & Martínez, 2017). However, some basic circuits, such as those implementable with OpAmp, are still critical in most real implementations (Valbuena, Perdomo, & Martinez, 2017). This is the reason for the continuous development of new tools and strategies that support specific training in the design of electronic systems (Martínez, Rendón, & Guevara, 2017).

Inverter amplifier review

For the first study case, we are going to consider the inverse configuration of the operational amplifier with gain (Fig. 1). In this scheme, the OpAmp uses resistance as output feedback to its negative input (R_2). The input signal is fed by the positive input pin through another resistor (R_1). These two resistors are the only necessary passive elements in the circuit, and determine the behavior of the output signal (V_0) to the input voltage (V_{s1}).

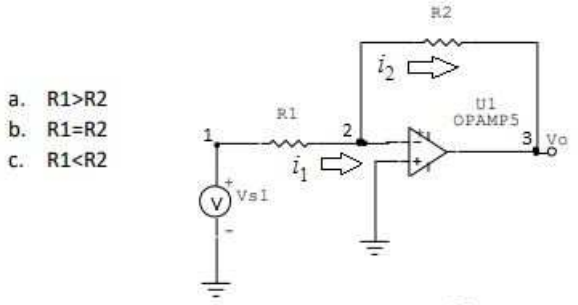

Figure 1. Inverter amplifier with 100 mV input at 1 kHz.

According to the possible values of resistance, the circuit has three possible behaviors determined by the relationship between the magnitudes of the resistors.

- $R_1 > R_2$
- $R_1 = R_2$
- $R_1 < R_2$

Under the inverter amplifier configuration (Fig. 1), the current i_1 is approximately equal to the current i_2 due to the high input impedance of the OpAmp, that is:

$$i_1 \simeq i_2 \tag{1}$$

Therefore, according to the assumed direction of the currents, the following equation can be written to relate these two currents:

$$\frac{v_1 - v_2}{R_1} = \frac{v_2 - v_3}{R_2} \tag{2}$$

As a result of the virtual zero the voltage drop between the two inputs of the OpAmp is zero, ie $V_2 = 0$, so the equation becomes:

$$\frac{v_{s1} - 0}{R_1} = \frac{0 - v_0}{R_2} \tag{3}$$

Or with general circuit input and output expressions:

$$\frac{v_{in} - 0}{R_1} = \frac{0 - v_{out}}{R_2} \tag{4}$$

Clearing the output voltage:

$$\frac{-v_{out}}{R_2} = \frac{v_{in}}{R_1} \tag{5}$$

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$$v_{out} = -v_{in}\frac{R_2}{R_1} \tag{6}$$

As can be seen, the gain at the output is negative (hence the name of the circuit), and depends on the relationship between the two resistors. The three behaviors of the circuit are detailed in table 1.

First case: Inverter voltage follower ($R_1 = R_2$)

To evaluate the performance of the inverter amplifier we will use the following test data:

- v_{in}: 100 mV peak at a frequency of 1 kHz.
- The operational amplifier is supplied with a dual voltage of ±12 V.
- $R_1 = R_2 = 10$ kΩ.
- The ideal model of operational amplifier is used.

According to equation 6, the output voltage is defined as:

$$v_{out}(t) = -0.1\ sin(2\pi ft)\frac{10000}{10000}\ V \tag{7}$$

$$v_{out}(t) = -0.1\ sin(2000\pi t)\ V \tag{8}$$

This means that the output voltage is also a sinusoid signal at the same frequency and with the same amplitude, but out of phase concerning the input voltage by 180 degrees. Both signals (v_{in} and v_{out}) have a period $T = 1$ ms, which means that in a 200 μs/Div oscilloscope configuration a period in five horizontal frames would be observed. This behavior is shown in Fig. 2.

Second case: Inverter with voltage amplification ($R_1 < R_2$)

For this second case we will use the following values for the resistors:

- $R_1 = 5$ kΩ.
- $R_2 = 10$ kΩ.

All other test circuit parameters, including the input signal, remain the same. In this case, the output voltage is given by:

$$v_{out}(t) = -0.1\ sin(2\pi ft)\frac{10000}{5000}\ V \tag{9}$$

$$v_{out}(t) = -0.2\ sin(2000\pi t)\ V \tag{10}$$

The ratio between the two resistors is $R_2/R_1 = 2$, therefore an amplification in the output voltage equivalent to twice the input signal is expected. All other signal characteristics remain the same, i.e., they are still sinusoidal signals at the same frequency out of phase by 180 degrees. This behavior is shown in Fig. 3.

Third case: Inverter with voltage reduction ($R_1 > R_2$)

In this last case, we will use a voltage reduction ratio of 0.5, therefore the resistors used can be of the following values:

- $R_1 = 10$ kΩ.
- $R_2 = 5$ kΩ.

Once again, all other test circuit parameters, including the input signal, remain the same. In this case, the output voltage is given by:

$$v_{out}(t) = -0.1\ sin(2\pi ft)\frac{5000}{10000}\ V \tag{11}$$

$$v_{out}(t) = -0.05\ sin(2000\pi t)\ V \tag{12}$$

That is, the output voltage corresponds to half of the input voltage at all times, again with a negative sign, i.e. a signal 180 degrees off the input. The waveform and its frequency remain the same, only the output amplitude is affected. This behavior is shown in Fig. 4.

Non-inverting amplifier review

The configuration of the OpAmp as a non-inverting amplifier is similar to the configuration as an inverting amplifier. In this circuit again, a resistor is used as output feedback to the OpAmp's negative terminal (R_2), and another resistor R_1 is connected to the same node that allows the circuit current ratios to be defined. However, in this circuit, the input signal (v_{s1}) is not fed to the OpAmp through this resistor but is connected to the positive terminal of the OpAmp (Fig. 5).

Due to the virtual zero between the two terminals of the OpAmp, the voltage at the negative terminal of the OpAmp is the input voltage to the circuit, which radically changes the behavioral equations. As in the inverter amplifier, given the high input impedance of the OpAmp, the two currents indicated in the circuit are practically the same, i.e:

$$i_1 \simeq i_2 \tag{13}$$

Therefore, according to the assumed direction of the currents, the following equation can be written to relate these two currents:

$$\frac{v_1 - v_2}{R_1} = \frac{v_2 - v_3}{R_2} \tag{14}$$

$$\frac{0 - v_{s1}}{R_1} = \frac{v_{s1} - v_0}{R_2} \tag{15}$$

Or with general circuit input and output expressions:

$$\frac{0 - v_{in}}{R_1} = \frac{v_{in} - v_{out}}{R_2} \tag{16}$$

Clearing the output voltage:

Table 1
Possible behavior of the inverter amplifier according to the relationship between the circuit resistors.

$R_1 = R_2$	$R_1 < R_2$	$R_1 > R_2$
$v_{out} = -v_{in}$ The output voltage is equal to the input voltage in magnitude, but with a 180 degree offset.	$1 < \frac{R_2}{R_1}$ The output voltage is equal to R_2/R_1 times the input voltage, but with a 180 degree offset.	$0 < \frac{R_2}{R_1} < 1$ The output voltage is equal to a proportion of the input voltage given by R_2/R_1, but with a 180 degree offset.

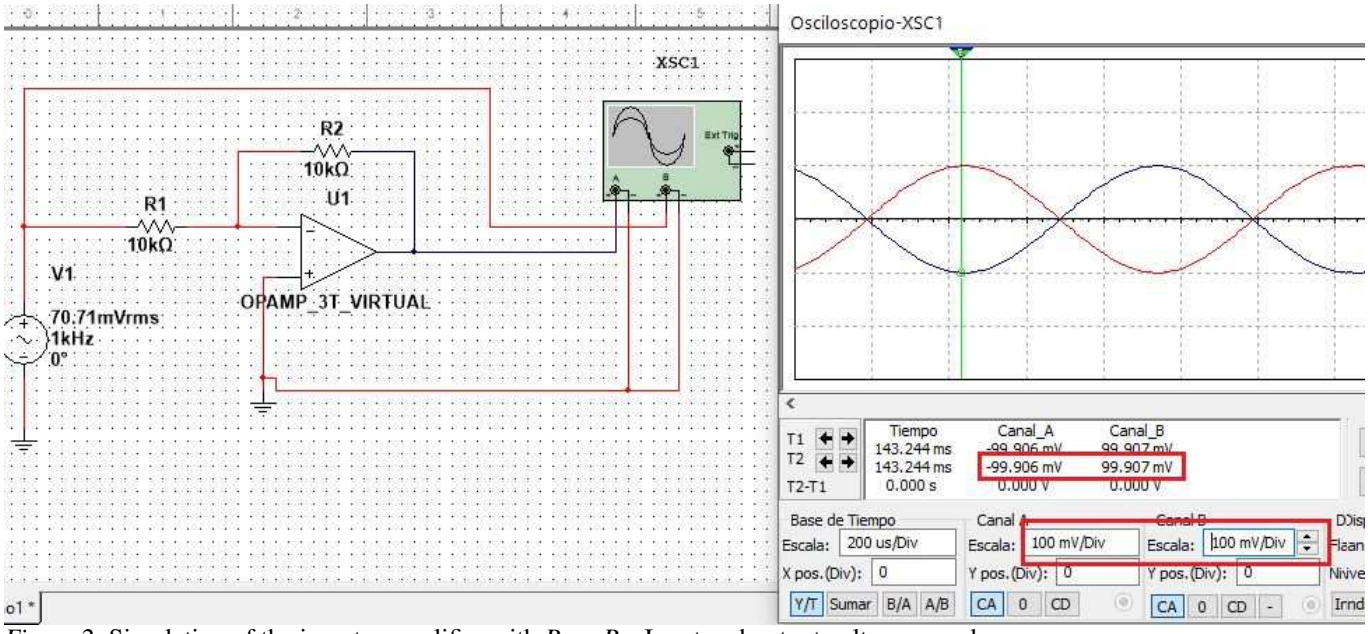

Figure 2. Simulation of the inverter amplifier with $R_1 = R_2$. Input and output voltages are shown.

$$\frac{-v_{in}}{R_1} = \frac{v_{in} - v_{out}}{R_2} \tag{17}$$

$$-v_{in}\frac{R_2}{R_1} = v_{in} - v_{out} \tag{18}$$

$$v_{out} = v_{in} + v_{in}\frac{R_2}{R_1} \tag{19}$$

$$v_{out} = v_{in}\frac{R_1 + R_2}{R_1} \tag{20}$$

In this new circuit again a relationship is established between the output voltage and input voltage, and again this relationship depends on the values of the two resistors. The resistors define the gain value of the circuit, which affects the magnitude at each instant of time, but since the relationship is constant, does not affect the output waveform. Unlike the inverter amplifier, the ratio or gain given by the resistors is positive (the resistors always have a positive value, we are not going to complicate the problem by talking about negative resistors), and again they can produce three behaviors depending on the selected values, these three cases are detailed in table 2.

First case: Voltage doubler ($R_1 = R_2$)

If the two resistors are taken from the same value, the output voltage will correspond to twice the input voltage. This relationship is constant, so as in the previous cases there is no distortion in the output, the waveform and frequency of the input are maintained. To evaluate this circuit we will use the following parameters:

- v_{in}: 200 mV peak at a frequency of 1 kHz.
- The operational amplifier is supplied with a dual voltage of ±15 V.
- $R_1 = R_2 = 10$ kΩ.
- The ideal model of operational amplifier is used.

According to equation 20, the output voltage of the circuit is:

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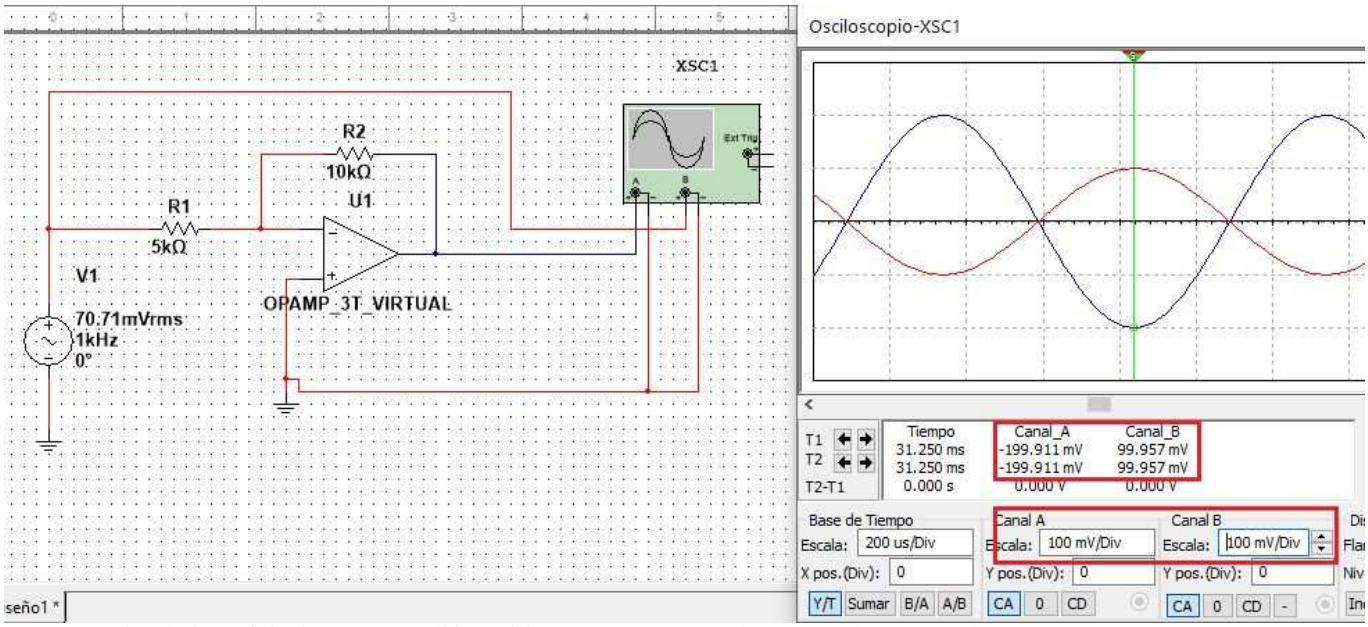

Figure 3. Simulation of the inverter amplifier with $R_1 < R_2$. Input and output voltages are shown.

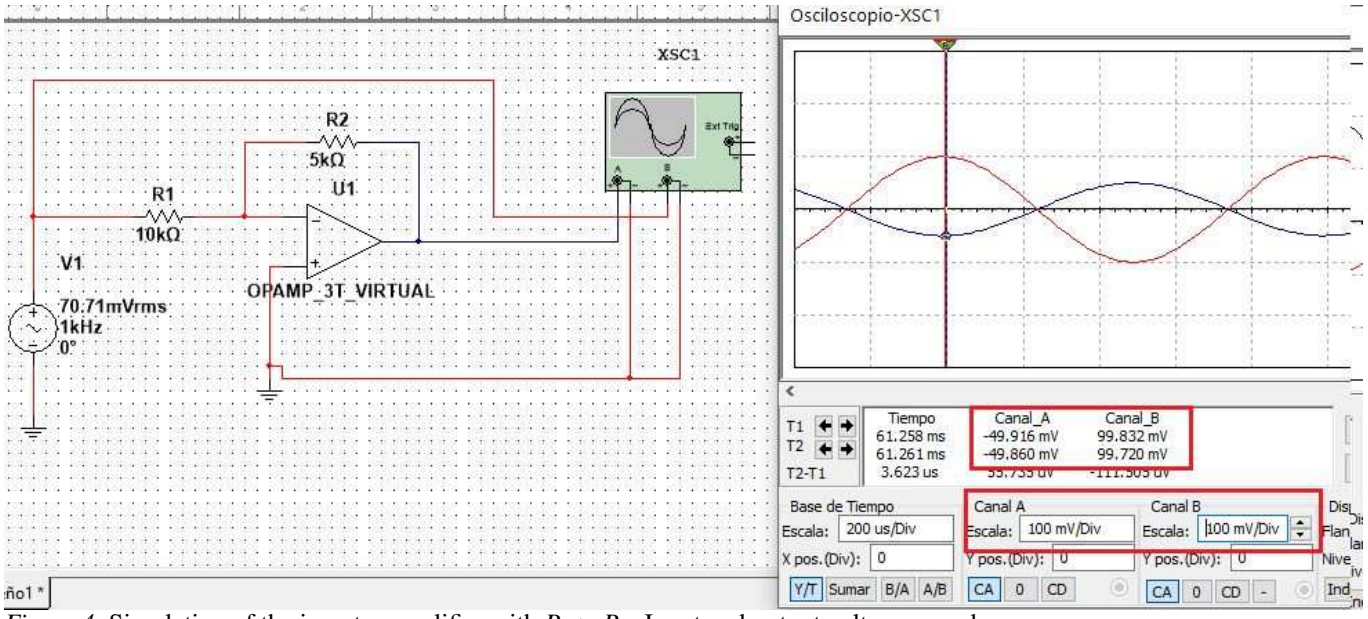

Figure 4. Simulation of the inverter amplifier with $R_1 > R_2$. Input and output voltages are shown.

$$v_{out}(t) = 0.2\ sin(2\pi f t)\ \frac{10000 + 10000}{10000}\ V \tag{21}$$

$$v_{out}(t) = 0.4\ sin(2000\pi t)\ V \tag{22}$$

Therefore, the output voltage has the same sinusoidal waveform as the input, with the same frequency, but its amplitude changes to twice the input value. The output voltage at each instant of time has twice the value of the input voltage and is in phase with it. This behavior can be seen in Fig. 6.

Second case: Voltage follower ($R_1 > R_2$)

To configure the voltage follower we use the following resistance values:

- $R_1 = 10$ kΩ.
- $R_1 = 2$ kΩ.

All other parameters remain the same, including the input signal. According to the resistance ratio, the output voltage is given by:

Table 2
Possible behavior of the non-inverter amplifier according to the relationship between the circuit resistors.

$R_1 = R_2$	$R_1 > R_2$	$R_1 < R_2$
$v_{out} = -2\,v_{in}$ The output voltage is equal to twice the input voltage.	$\frac{R_1+R_2}{R_1} \simeq 1$ The output voltage is very close to the input voltage. Since R_2 is negligible compared to R_1, the relationship between the resistors tends to one.	$\frac{R_1+R_2}{R_1} \simeq \frac{R_2}{R_1}$ $1 < \frac{R_2}{R_1}$ The output voltage is equal to a proportion of the input voltage given by R_2/R_1.

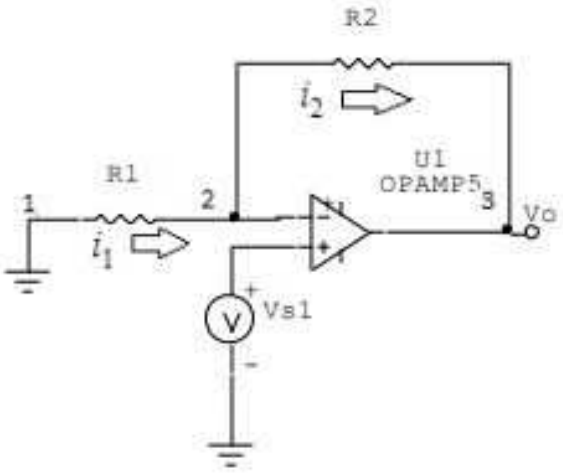

Figure 5. Non-inverting amplifier with 200 mV peak input at 1 kHz.

$$v_{out}\,(t) = 0.2\,sin\,(2\pi f t)\,\frac{10000 + 2000}{10000}\,V \tag{23}$$

$$v_{out}\,(t) = 0.24\,sin\,(2000\pi t)\;V \tag{24}$$

In this case, the gain given by the resistors is $\frac{R_1+R_2}{R_1} = 1.2$, which means that the magnitude of the output signal will have a 20% increase concerning the input signal. Although the circuit is ideally a voltage follower, this behavior will be valid as long as the size of R_1 is much larger than R_2, at least 10 times larger. Thus the value R_2 would have a negligible value against R_1, and the ratio of resistances would approach with negligible error to 1. Fig. 7 shows the ideal behavior of this circuit.

Third case: Voltage amplifier ($R_1 < R_2$)

The last case of this circuit occurs when the resistance R_1 is much lower than R_2, which makes the gain of the circuit tends to R_2/R_1. Again this depends on how big is R_2 concerning R_1, for this relationship to be met the difference must be at least 10 times. If this is not true, the ratio $\frac{R_1+R_2}{R_1}$ must be used to determine the circuit gain. To configure this voltage amplifier we use the following elements:

- R_1 = 3 kΩ.
- R_1 = 20 kΩ.

All other parameters remain the same, including the input signal. According to the resistance ratio, the output voltage is given by:

$$v_{out}\,(t) = 0.2\,sin\,(2\pi f t)\,\frac{3000 + 20000}{3000}\,V \tag{25}$$

$$v_{out}\,(t) = 1.53\,sin\,(2000\pi t)\;V \tag{26}$$

The gain defined by the two resistors is $\frac{R_1+R_2}{R_1} = 7.67$, which means amplification of almost eight times the input signal. Since the resistance R_2 is 6.67 times larger than R_1 ($R_2/R_1 = 6.67$), it is preferable to use the ratio $\frac{R_1+R_2}{R_1}$ to calculate the gain. If the approximate ratio of R_2/R_1 were used, the gain would be 1.33, which produces a considerable difference concerning the real value. Fig. 8 shows the behavior of this circuit.

Review of the voltage follower amplifier

The voltage follower circuit seeks to have an output signal that follows the input signal, isolating this input from the circuit that uses the output signal, mainly to avoid that due to current consumption the processed signal will be different from the one provided, for example, by some sensor. This circuit is implemented by directly feeding the output, without resistance, to the negative input of the OpAmp. The input voltage is fed directly to the positive input of the OpAmp, so this circuit does not use resistance for its configuration (Fig. 9).

According to the circuit, the following nodal relationships can be established:

$$v_1 = v_{s1} = v_2 = v_0 \tag{27}$$

To analyze this circuit we will use the following design parameters:

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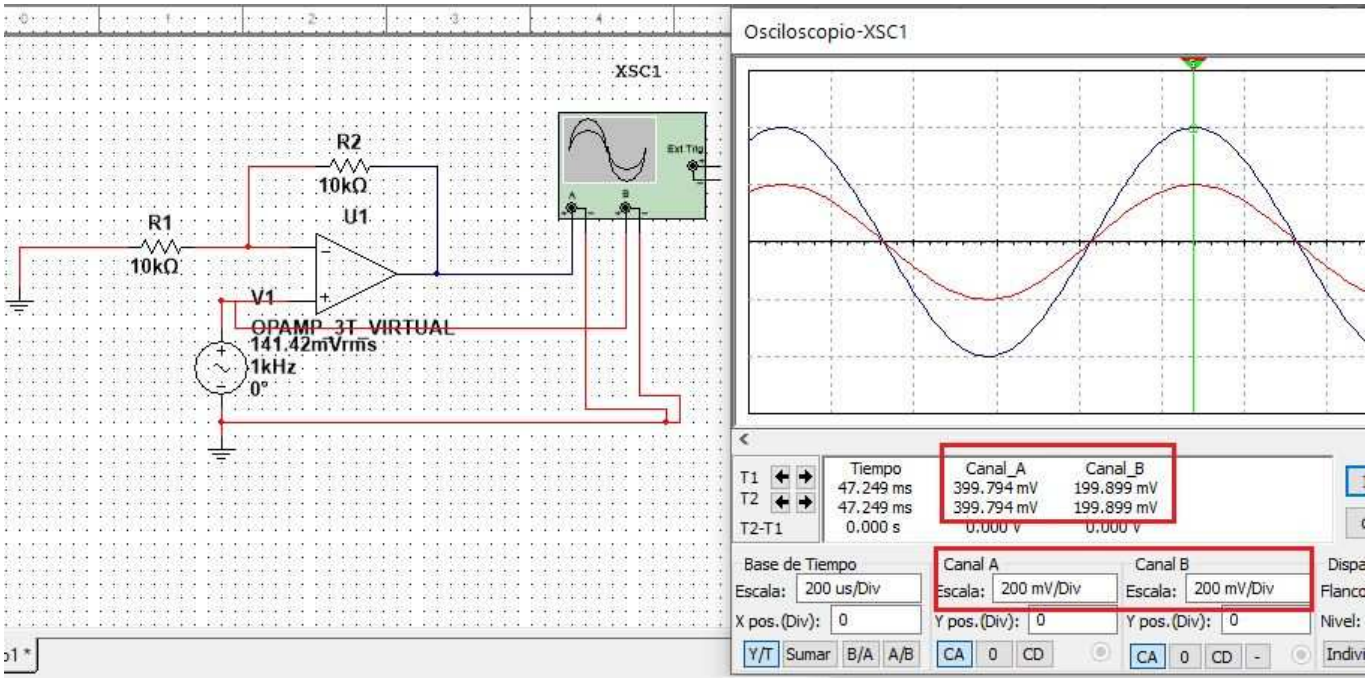

Figure 6. Simulation of the non-inverting amplifier with $R_1 = R_2$. Input and output voltages are shown.

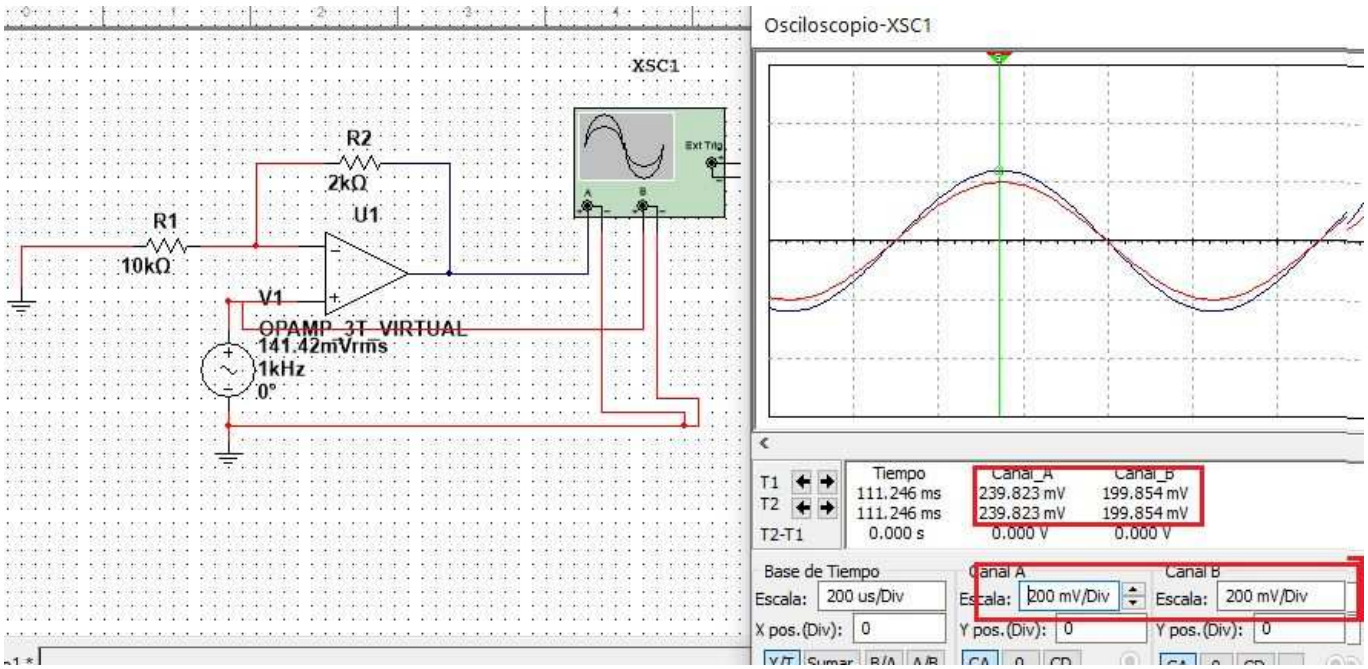

Figure 7. Simulation of the non-inverting amplifier with $R_1 > R_2$. Input and output voltages are shown.

- v_{in}: 1 V peak-to-peak at a frequency of 1 kHz.
- The operational amplifier is supplied with a dual voltage of ±10 V.
- The ideal model of operational amplifier is used.

Therefore, the output voltage of the circuit is given by:

$$v_{out}(t) = v_0(t) = 0.5\ sin(2\pi f t)\ V \tag{28}$$

Fig. 10 shows the behavior of this voltage follower circuit.

Let's now consider the circuit in Fig. 11. In this case, we have the same voltage follower, but we have added resistance in the negative feedback loop (R_1).

From this new configuration we conclude two facts:

1. Due to the high input impedance of the OpAmp, the current through the OpAmp is minimal. Therefore,

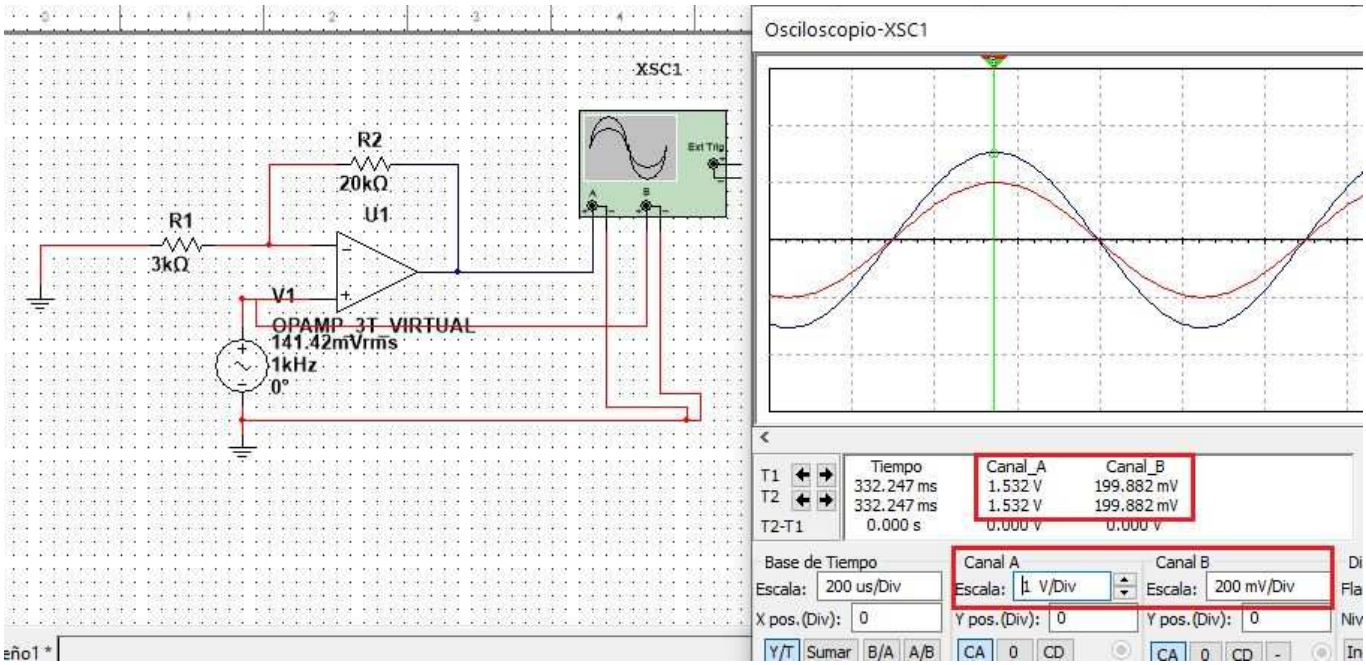

Figure 8. Simulation of the non-inverting amplifier with $R_1 < R_2$. Input and output voltages are shown.

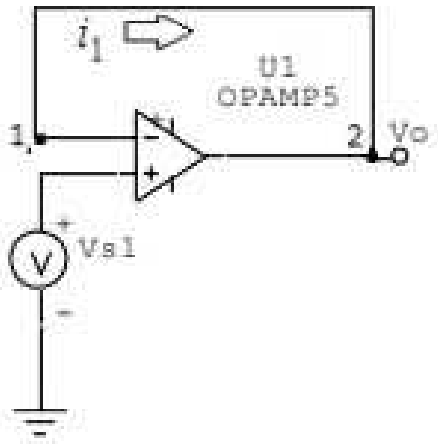

Figure 9. Voltage follower amplifier with 1 V peak-to-peak input.

the voltage drop in the input impedance is almost zero. Consequently, it is valid to assume that $v_{in} \simeq v_1$.

2. Because the current passing through the input impedance is very small, the voltage drop at resistor R1 is minimal and can be assumed that $v_1 \simeq v_{out}$.

Therefore, we can say that:

$$v_{in}(t) = v_{out}(t) \tag{29}$$

$$v_{in}(t) = v_{out}(t) = 0.5\ sin(2\pi f t)\ \ V \tag{30}$$

Inverter amplifier design

It is common to implement an amplifier circuit with an OpAmp under some design restrictions, such as a certain voltage gain value. As an example we design a voltage inverting amplifier with a voltage gain of $A_V = -250$. We will assume that the output voltage of the circuit will be applied over a load resistance of $R_L = 2\,k\Omega$, over which a current amplitude of 2 mA is expected.

The design of such a circuit can be as follows. If a constant and negative voltage gain is requested, the simplest option is to use a reversing amplifier circuit. Also, since the gain is greater than one, then this circuit must have two resistors so that $R_1 > R_2$. Consequently, according to Table 1 and Equation 6, we can set a restriction on the values of the resistors like this:

$$\frac{R_2}{R_1} = -250 \tag{31}$$

Since this is the only functional constraint, to select the resistance values we can pose another current constraint. For example, we can restrict the currents to the order of mA, that is, the resistances should be in the order of $k\Omega$. If for example, we choose:

$$R_1 = 0.5\,k\Omega \tag{32}$$

$$\Rightarrow\ R_2 = 250 \times 0.5\,k\Omega = 125\,k\Omega \tag{33}$$

If a resistor $R_L = 2k\Omega$ is used as the output load, with a current of:

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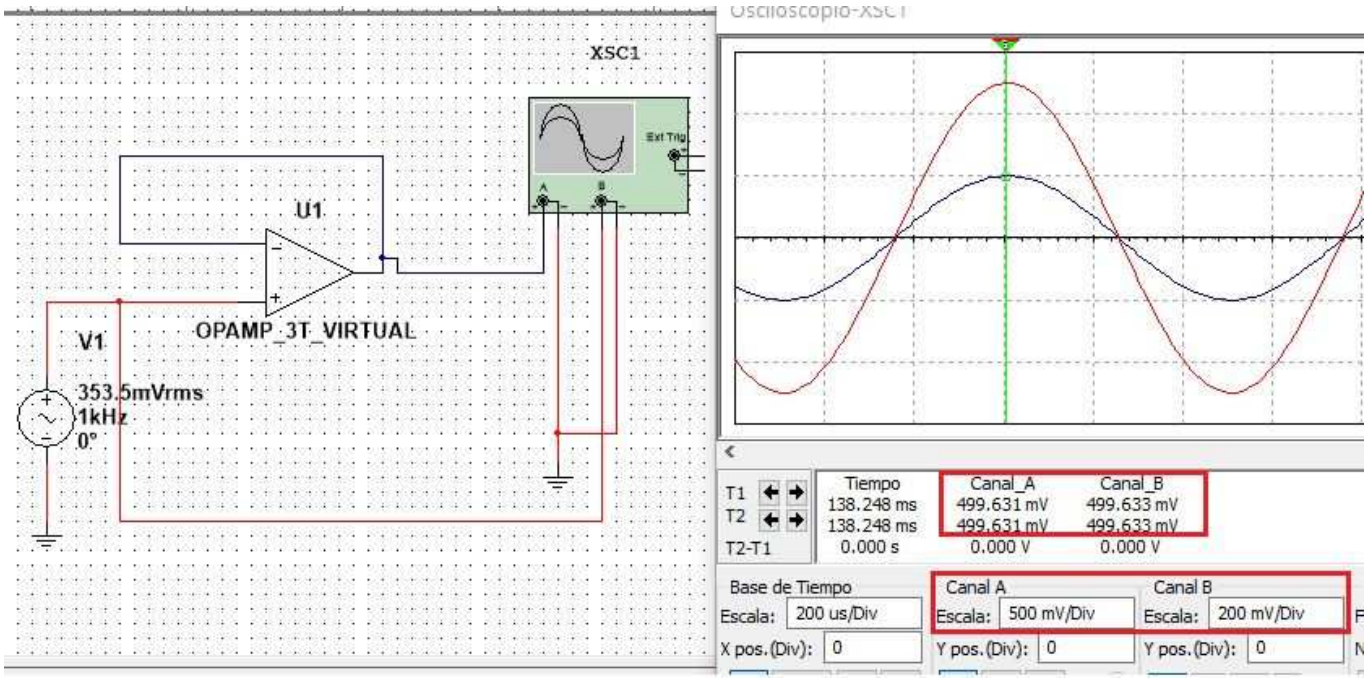

Figure 10. Simulation of the voltage follower amplifier. Input and output voltages are shown.

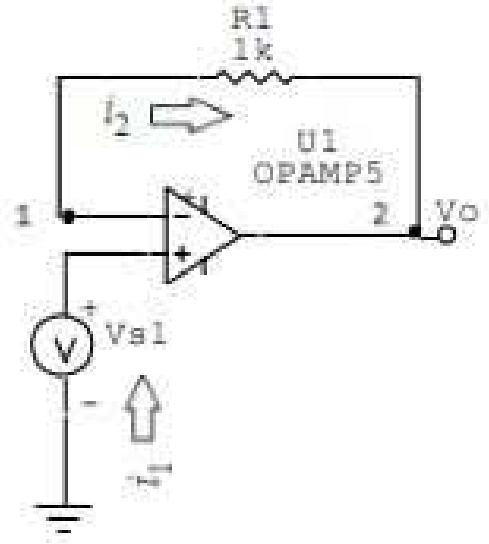

Figure 11. Voltage follower amplifier with feedback resistance.

$$i_L(t) = 2 \times 10^{-3} sin(2\pi ft)\ A \tag{34}$$

$$\Rightarrow\ v_{out}(t) = R_L \times i_L(t) \tag{35}$$

$$v_{out}(t) = (2000) \times \left(2 \times 10^{-3} sin(2\pi ft)\right) \tag{36}$$

$$v_{out}(t) = 4\ sin(2\pi ft)\ V \tag{37}$$

To guarantee this current at the load, with the voltage gain value given by the design, it is necessary to feed the next input voltage:

$$v_{in}(t) = \frac{v_{out}(t)}{250} \tag{38}$$

$$v_{in}(t) = \frac{4}{250} sin(2\pi ft)\ V \tag{39}$$

$$v_{in}(t) = 0.016\ sin(2\pi ft)\ V \tag{40}$$

To finish the design, the resistances must be completely defined. To determine their size (nominal power) we must calculate the currents that circulate through them. In this circuit, the same current circulates through both and is given by:

$$i_{R1,R2} = \frac{v_1 - v_2}{R_1} = \frac{v_{in}}{R_1} \tag{41}$$

Instead of the instantaneous value, we will use the RMS value:

$$I_{R1.R2} = \frac{\frac{0.016}{\sqrt{2}}}{500} = 22.6 \times 10^{-6}\ Arms \tag{42}$$

Therefore, the power that these resistors will dissipate is:

$$P_{R1} = \left(22.6 \times 10^{-6}\right)^2 500 = 255.4 \times 10^{-9}\ W \tag{43}$$

$$P_{R2} = \left(22.6 \times 10^{-6}\right)^2 125000 = 63.8 \times 10^{-6}\ W \tag{44}$$

To configure this circuit the two resistors can be 1/4 watt. As OpAmp it is possible to use, for example, the LM741, which has a maximum output current of 25 mA (it is not necessary to implement a power stage at the output). Fig. 12 shows the behavior of this circuit.

Circuit coupling

In this last section, we will observe the behavior of a circuit formed by the coupling of the three circuits analyzed: an inverting amplifier, a non-inverting amplifier, and a voltage follower. This type of coupling is very common in electronic instrumentation, and it is essential to ensure that the output voltages at each stage are not distorted in the final coupling.

To evaluate the performance of this coupling we will use the following parameters:

- v_{in}: Fed from a DC resistive divider with current values in the order of milliamps. It will simulate a signal from a sensor.
- The operational amplifiers will be supplied with a dual voltage of ±15 V.
- The voltage divider must deliver a voltage of 385 mV from a 10 Vdc source.
- The output of the voltage divider must feed the voltage follower.
- The output of the voltage follower must simultaneously feed the inputs of the inverting amplifier and the non-inverting amplifier.
- The voltage gain of the inverter amplifier should be $A_V = 24$.
- The output voltage of the non-inverting amplifier must be 6 Vdc.
- The ideal model of operational amplifier is used.

According to the restrictions of the voltage divider, two resistors can be selected with the following values.

$$v_{in} = 385\ mV = (10\ V) \times \frac{R_{lower}}{R_{upper} + R_{lower}} \tag{45}$$

A possible combination could be:

$$R_{lower} = 4\ k\Omega \text{ and } R_{upper} = 100\ k\Omega \tag{46}$$

In the case of the inverter amplifier, the requested gain value can be met with the following combination of resistors:

$$A_V = 24 = \frac{120\ k\Omega}{5\ k\Omega} \tag{47}$$

Therefore, the circuit that meets the specifications is the one shown in Fig. 13.

To obtain the 6 Vdc at the output of the non-inverting amplifier, we assume as input the output of the voltage follower amplifier, which follows the 385 mV of the voltage divider. According to the gain of this circuit, the following equation can be written.

$$v_0 = 6\ V = v_{in}\frac{R_5 + R_6}{R_6} \tag{48}$$

$$6\ V = 385\ mV\frac{R_5 + R_6}{R_6} \tag{49}$$

$$\frac{R_5 + R_6}{R_6} = 15.58 \tag{50}$$

A possible combination of resistors that meets these requirements may be:

$$R_5 = 1560\ \Omega \text{ and } R_6 = 100\ \Omega \tag{51}$$

The voltage gain of this non-inverting amplifier is:

$$A_{V2} = \frac{R_5 + R_6}{R_6} \tag{52}$$

$$A_{V2} = \frac{1560 + 100}{100} \tag{53}$$

$$A_{V2} = 16.6 \tag{54}$$

In the case of the inverter amplifier, the output voltage would be:

$$A_{V1} = -24 = \frac{v_0}{v_{in}} = \frac{v_0}{385 \times 10^{-3}} \tag{55}$$

$$\Rightarrow \quad v_0 = -24\left(385 \times 10^{-3}\right) \tag{56}$$

$$v_0 = -9.24\ V \tag{57}$$

Fig. 14 shows the behavior of this circuit.

Conclusions

This paper reviews the design and performance of the OpAmp in three basic linear configurations: inverting amplifier, non-inverting amplifier, and voltage follower. Each of these circuits is analyzed according to the elements used for their configuration. Based on this analysis, their possible behaviors are characterized and supported by simulation. The final part shows an example of design from functional requirements and evaluates a typical scheme of coupling these circuits in a basic signal conditioning system.

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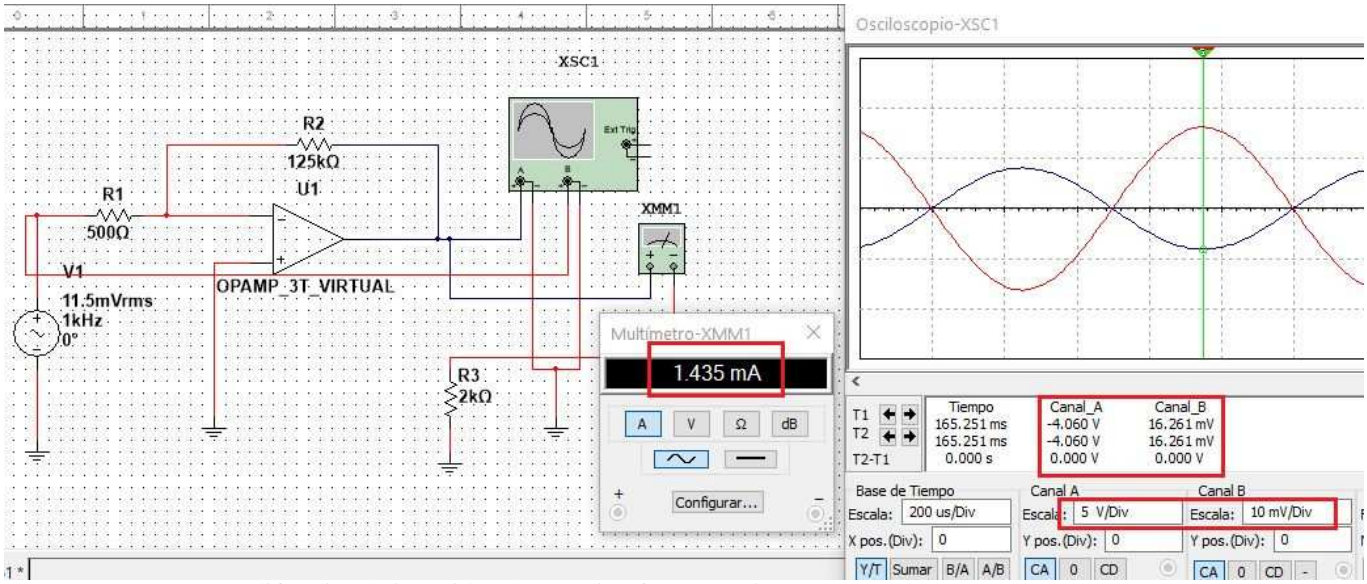

Figure 12. Inverter amplifier simulation with voltage gain of $A_V = -250$.

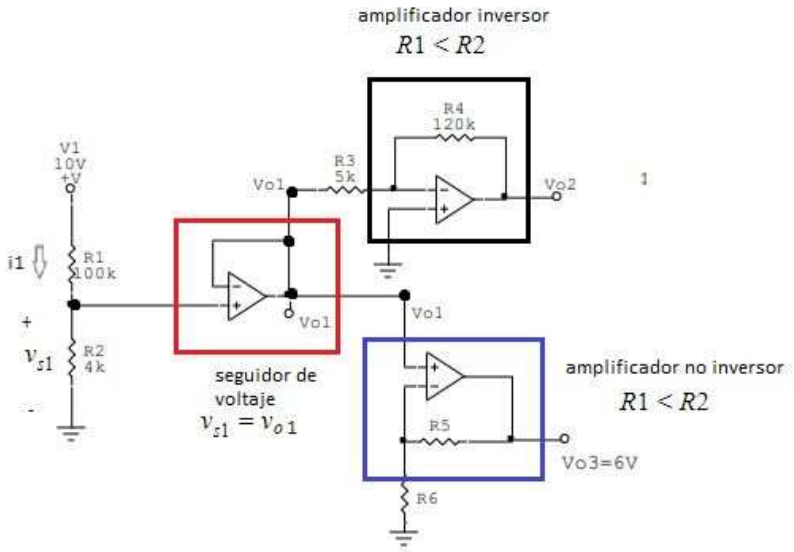

Figure 13. Circuit coupling with operational amplifier: voltage follower amplifier, inverter amplifier, and non-inverter amplifier.

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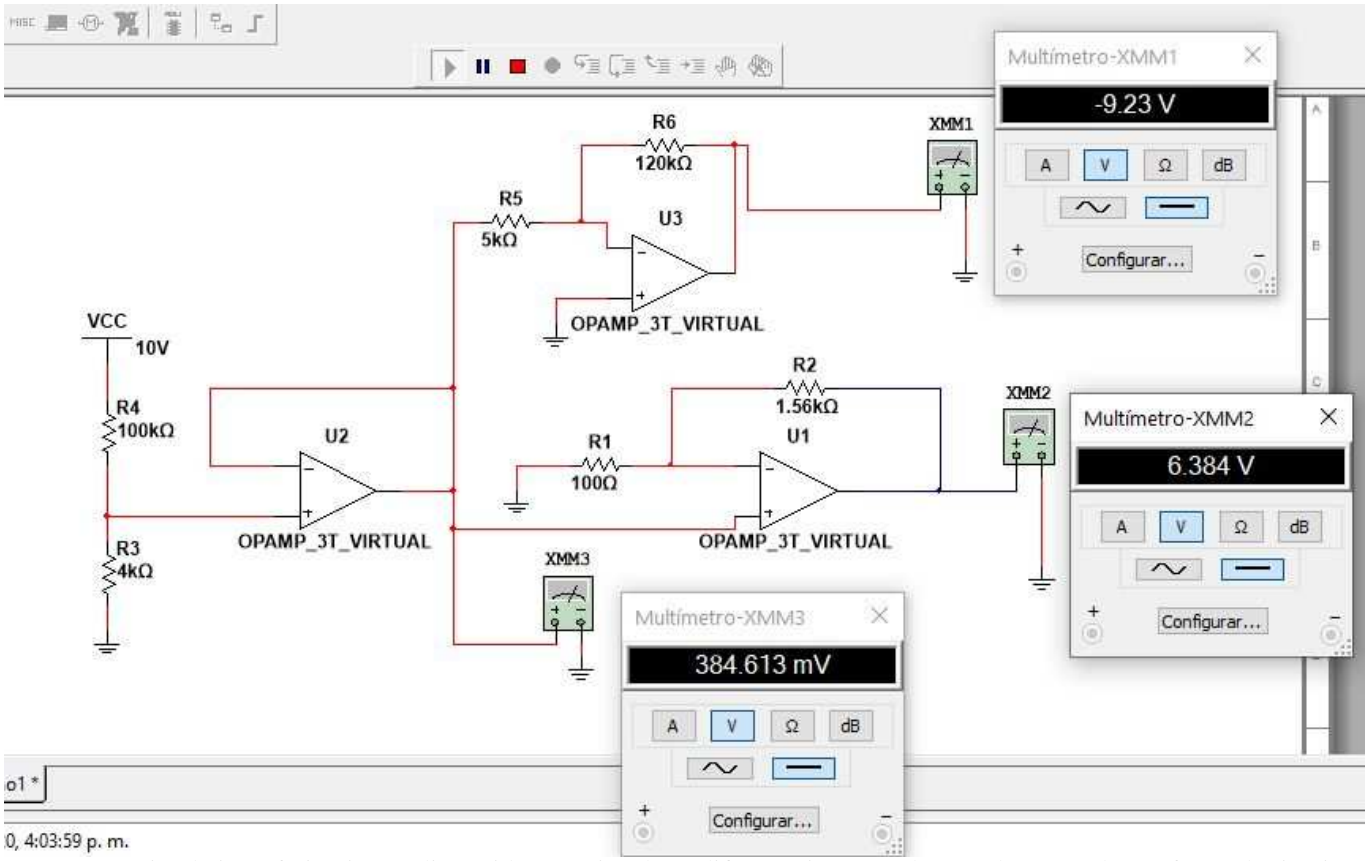

Figure 14. Simulation of circuit coupling with operational amplifier Stationary voltage values are shown for each circuit clamp.

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Instrucciones para los autores

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Alcance y política editorial de la revista

La revista **Tekhnê** es una revista institucional de la Facultad Tecnológica de la Universidad Distrital Francisco José de Caldas (Colombia). Es arbitrada, y acepta trabajos originales en el campo de la ingeniería, la tecnología y las ciencias aplicadas, con la condición de que sean producto de trabajos de investigación. Desde su primer número en el año 2003, la revista ha mantenido su regularidad.

Posee un carácter científico-académico, y atiende a la comunidad nacional e internacional especialista en áreas de ingenierías eléctrica, electrónica, mecánica, de sistemas, industrial y civil. Publica resultados de investigación en inglés (artículos originales e inéditos), y está completamente abierta a especialistas de todo el mundo en calidad de autores y/o lectores. Es arbitrada mediante un proceso doble ciego, con rotación continua de árbitros.

La revista **Tekhnê** posee una periodicidad semestral, coincidente con los semestres académicos de la Universidad Distrital. La publicación se realiza los meses de junio y diciembre de cada año. El proceso de evaluación de los trabajos sometidos para la publicación contempla una etapa de aceptación inicial por parte del Comité Editorial, quien verifica el cumplimiento de los parámetros editoriales, y una evaluación por pares académicos mediante un proceso doble ciego. El tiempo que toma decidir sobre la aceptación de un trabajo nunca supera los seis (6) meses a partir de la fecha de recepción.

La revista **Tekhnê** está comprometida con altos estándares de ética y toma las medidas posibles para evitar las malas prácticas como el fraude y el plagio. Todos los autores deben declarar que sus manuscritos son originales, inéditos y de su autoría, condición necesaria para ser considerados por el Comité Editorial. La revista **Tekhnê** también se compromete a garantizar una justa, objetiva y rápida revisión de los manuscritos tanto por árbitros como por parte del Editor. Los autores reconocen que han dado a conocer cualquier conflicto real o potencial de intereses con su trabajo o de beneficios parciales asociados a través de la cesión de derechos.

La revista **Tekhnê** es financiada por la Universidad Distrital Francisco José de Caldas, razón por la cual NO cobra por procesamiento y/o publicación de artículos (APCs).

Tipos de artículos aceptados

La revista publica exclusivamente artículos de Investigación Científica y Tecnológica (según clasificación del Índice Nacional de Publicaciones Científicas y Tecnológicas Publindex de Colciencias), los cuales se caracterizan por presentar resultados originales de proyectos terminados de investigación, con secciones claramente diferenciadas de introducción, metodología, resultados y conclusiones. Otro tipo de artículos como los denominados de reflexión, revisión, artículos cortos o reportes de casos no son aceptados, y serán rechazados por el Comité Editorial sin surtir proceso alguno de evaluación.

Formato del manuscrito

En cuanto a estructura, deben ser evidentes las secciones de Introducción, Metodología, Resultados, Conclusiones y Referencias. El resto del documento se debe conformar en concordancia con su contenido. La longitud total no debe superar las 25 páginas. En la parte inicial de la primera página se debe incluir: (1) Un título del manuscrito en inglés y español (autores cuya lengua materna sea diferente al español pueden solicitar la traducción al equipo editorial de la revista), corto, descriptivo del contenido y atractivo para el lector. (2) Nombre completo de los autores y detalles de afiliación institucional, incluido correo electrónico. (3) Resumen en inglés y español (autores cuya lengua materna sea diferente al español pueden solicitar la traducción al equipo editorial de la revista) del manuscrito con un tamaño máximo de 150 palabras. (4) Palabras claves, máximo seis, en minúsculas y separadas por comas.

En la Introducción, los autores deben exponer claramente el problema identificado, y del cual se propone una solución. Para este problema se deben plantear los antecedentes, la bibliografía pertinente, las soluciones propuesta a la fecha, la solución propuesta en la investigación y el enfoque propuesto por los autores. Al final se debe indicar la innovación lograda por los autores. La redacción de la Introducción se debe formular de tal forma que sea comprensible para colegas de una amplia gama de disciplinas científicas.

La revisión de la literatura que soporta los antecedentes del problema debe considerar en su mayoría citas de fuentes recientes (máximo cinco años de antigüedad) y de alto impacto (consultar bases de datos SCImago Journal y Scopus), y debe servir para mostrar las diferencias del artículo con investigaciones previas. Para citar una fuente se utiliza la palabra clave asignada dentro del archivo *.bib. Por ejemplo, para la fuente con la palabra clave Caicedo2019 (observe además la preferencia en el uso de cursivas en lugar de subrayado), la citación se realiza como \citep{Caicedo2019}.

Cada párrafo debe comenzar con una oración motivadora, que incite a la lectura, y al mismo tiempo plantee una idea en particular. Esta idea debe

corresponder a elementos claves del problema. El resto del párrafo debe esta compuesto de cuatro a seis oraciones que aporten detalles y aclaraciones a la idea. Las oraciones deben ser simples para facilitar la lectura y no enredar al lector. La introducción puede ser tan larga o corta como lo consideren los autores, pero se recomienda que no exceda la tercera parte de la longitud total del artículo.

En la sección Metodología en primer lugar se detalla la formulación matemática del problema. Si los autores lo consideran necesario debido a la complejidad y extensión, esta formulación del problema puede hacerse en una sección propia. Luego, se explica en forma cronológica la investigación, partiendo del diseño, pasando por los procedimientos (algoritmo, pseudocódigo, etc.), y finalizando con los esquemas de validación y recopilación de datos. Los autores deben suministrar todos los detalles que permitan replicar el trabajo experimental. En la medida que se requiera, el proceso de investigación debe estar respaldado por referencias de calidad.

Las figuras y tablas son soportes que deben ser utilizados. En ambos casos deben estar citadas en el cuerpo del documento, y siempre antes de su aparición (idealmente en el párrafo justo anterior a su inserción). Las imágenes deben ser de alta calidad, y contener información pertinente, no redundante, y claramente comprensible. Si no son desarrolladas por los autores, se debe citar correctamente la fuente en la etiqueta. El tamaño de las imágenes debe ser coherente con el artículo, en todos los casos los textos en imágenes y tablas deben ser claros, y de un tamaño similar al texto del cuerpo del artículo. Las imágenes deben enviarse como parte de los archivos fuente del artículo en formato *.eps. Un ejemplo de inserción de una imagen es como el mostrado en la Fig.~\ref{fig:fig1}. Observe que se hace referencia a la imagen sin indicar que está en el párrafo o página siguiente, se utiliza la numeración.

En cuanto a formato, se solicita a los autores a no forzar ningún estilo diferente al de la clase utilizada en la plantilla Latex. Por ningún motivo se aceptarán artículos que incluyan letras, palabras o símbolos manuscritos en el texto. Si se utilizan líneas o figuras en colores, no se debe utilizar colores claros (amarillos, celestes y similares). El editor se reserva el derecho de eliminar toda figura o tabla que no cumpla las normas. Las referencias deben manejar correcto estilo APA sexta edición. No se deben utilizar notas al pie de página, y usar máximo tres niveles para los títulos. Se puede incluir una sección de Agradecimientos (altamente recomendada) redactada en forma sobria, de no más de cuatro líneas justo después de las Conclusiones.

En la sección Resultados se muestran y se explican los resultados de la investigación. Al mismo tiempo se debe ofrecer un amplio debate sobre los mismos, en particular respecto a resultados de otras investigaciones sobre el mismo problema. Los resultados pueden ser presentados en figuras, diagramas, tablas y cualquier otra estrategia que permita que el lector los entienda. La discusión puede organizarse a lo largo de subsecciones.

La sección Conclusiones debe resumir los datos discutidos en la sección Resultados, mostrando la relevancia del trabajo y cuán diferente es de otras investigaciones. Además, se debe señalar los beneficios y mejoras que supone la solución propuesta en el artículo.

Para todos los casos, los autores deben remitir, junto con las imágenes, un archivo BibTeX (un único archivo *.bib) con todas las referencias utilizadas en el artículo, cada referencia con una key única. Este archivo puede ser generado desde manejadores de referencias como Mendeley y Zotero, o generado con herramientas como JabRef.

En cuanto al lenguaje y estilo de redacción, se deben utilizar oraciones simples y evitar regionalismos. Se debe poner especial cuidado en el correcto uso de la ortografía y redacción, de acuerdo a las reglas del lenguaje.

Formato de publicación

Los manuscritos son publicados siguiendo el estilo APA sexta edición.

Cambios en la edición

El Editor se reserva el derecho, y así lo acepta el(la)(los) autor(a)(es) con el sólo envío del manuscrito, de realizar modificaciones con el objeto de lograr una mejor presentación e impacto del trabajo. Estas modificaciones pueden incluir cambios en el título, resumen, palabras clave, figuras, tablas y texto, entre otros, cambios que no afectan, según el Editor, la esencia del trabajo enviado por los autores. En particular, figuras que no pueden ser bien reproducidas pueden ser eliminadas por el Editor. Las referencias incompletas serán también eliminadas por exigencias de las bases de datos.

Envío de manuscritos

Los autores deben enviar sus artículos a través de la aplicación para tal fin del Open Journal System (http://revistas.udistrital.edu.co/ojs/index.php/tekhne/index) en formato digital, adjuntando carta de cesión de derechos (Copyright Transfer Statement) según formato.

La carta debe estar dirigida al director y editor de la revista, Ing. Fredy H. Martínez S., y debe incluir:

- Solicitud expresa de considerar el artículo para publicarlo en la revista **Tekhnê**.
- Título completo del trabajo.
- Nombres completos de todos los autores, con detalle de entidad a la que se encuentran vinculados, dirección e-mail institucional, títulos académicos, ciudad y país.
- Certificación de la originalidad y el carácter inédito del artículo.
- Exclusividad de su remisión a la revista **Tekhnê**.
- Confirmación de la autoría con la firma de todos los autores.
- Institución que financió o avaló el proyecto.

El proceso de envío consta de tres etapas:

1. Envío del artículo, un único archivo comprimido con las fuentes Latex.
2. Registro de los datos. Se registra en el OJS los datos básicos de los autores y del artículo. Es importante que estos datos sean correctos y completos, ya que ellos serán publicados en el portal de la revista como información del artículo, así como utilizados para la indexación del artículo.
3. Envío del Copyright Transfer Statement como archivo complementario.

Proceso de publicación

El proceso que sigue la revista para la evaluación y publicación de trabajos es el siguiente:

- Recepción del manuscrito (primera versión, convocatoria permanente)
- Verificación de normas por parte de auxiliar de la revista
- Notificación a autores de recepción, solicitud de ajustes de forma y de diligenciamiento de formato de datos de autores
- Recepción de manuscrito (segunda versión) y formato de datos de autores
- Revisión por parte del Comité Editorial
- Notificación a autores de si el manuscrito entra o no a evaluación por parte de pares
- Envío de manuscrito a pares seleccionados
- Recepción de evaluación de pares
- Notificación de evaluación a autores, y solicitud de correcciones si son pertinentes
- Recepción de manuscrito (tercera versión)
- Estudio de manuscrito corregido por parte del Comité Editorial
- Notificación a autores de decisión final de publicación y solicitud de carta de cesión de derechos
- Recepción de carta de cesión de derechos
- Corrección de estilo y diagramación del manuscrito
- Envío de versión final a autores para verificación de errores y aprobación final
- Publicación del artículo
- Notificación a autores de publicación

Contacto

Para cualquier solicitud de información adicional puede comunicarse con:

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Instructions for authors

Tekhnê
Tecnología al servicio de la sociedad
Universidad Distrital Francisco José de Caldas - Facultad Tecnológica

Tekhnê Journal
Universidad Distrital Francisco
José de Caldas

Scope and editorial policy of the journal

The **Tekhnê** journal is an institutional journal of the Technological Faculty of District University Francisco José de Caldas (Colombia). It is arbitrated, and accepts original articles in the field of engineering, technology and applied sciences on the condition that they are the product of research work. Since its first issue in 2003 the journal has maintained its regularity.

It has a scientific-academic nature and attends the specialist national and international community in the areas of electrical, electronics, mechanical, systems, industrial and civil engineering. Publishes research results in English (original and unpublished articles), and is fully open to experts from around the world as authors and/or readers. It is arbitrated by a double-blind process, with continuous rotation of evaluators.

The **Tekhnê** journal has twice a year periodicity, coinciding with the academic semesters of the District University. The publication is made in June and December each year. The evaluation process of the papers submitted for publication includes a stage of initial acceptance by the Editorial Committee, which verifies compliance with the editorial parameters and an evaluation by academic peers through a double blind process. The time taken to decide on the acceptance of a paper never exceeds six (6) months from the date of receipt.

The **Tekhnê** journal is committed to high ethical standards and take possible measures to avoid bad practices such as fraud and plagiarism. All authors must declare that their manuscripts are original, unpublished and of his own, needed condition to be considered by the Editorial Committee. The **Tekhnê** journal also is committed to ensuring a fair, objective and quick review of manuscripts both referees as by the Editor. The authors recognize that they have disclosed any actual or potential conflict of interest with their work or partial benefits associated through the transfer of rights.

The **Tekhnê** journal is funded by the District University Francisco José de Caldas, which is why it does NOT charge for processing and/or publishing articles (APCs).

Types of articles accepted

The journal publishes only Scientific and Technological Research articles (as classified by Publindex, the National Abstracting and Indexing System for Serial Publications in Science, Technology and Innovation of Colciencias), which are characterized by original results of completed research projects with clearly distinct sections of introduction, methodology, results and conclusions. Other articles as called reflection, review, short articles or case reports are not accepted and will be rejected by the Editorial Committee without dispensing any evaluation process.

Manuscript format

In terms of structure, the sections of Introduction, Methodology, Results, Conclusions, and References should be evident. The rest of the document should be arranged according to its content. The total length should not exceed 25 pages. At the beginning of the first page, it should be included: (1) A title of the manuscript in English and Spanish (authors whose mother tongue is different from Spanish can request the translation from the journal's editorial team), short, descriptive of the content and attractive to the reader. (2) Authors' full names and institutional affiliation details, including e-mail. (3) Abstract in English and Spanish (authors whose native language is not Spanish can request the translation to the journal's editorial team) of the manuscript with a maximum size of 150 words. (4) Keywords, maximum six, in lowercase and separated by commas.

In the Introduction, the authors should clearly state the problem identified, and for which a solution is proposed. For this problem, the background, the relevant literature, the solutions proposed to date, the solution proposed in the research, and the approach proposed by the authors should be stated. In the end, the innovation achieved by the authors should be indicated. The wording of the Introduction should be formulated in such a way that it is understandable to colleagues from a wide range of scientific disciplines.

The review of the literature supporting the background of the problem should consider mostly citations from recent (maximum five years old) and high-impact sources (consult SCImago Journal and Scopus databases) and should serve to show the differences of the article with previous research. To cite a source, the assigned keyword within the *.bib file is used. For example, for the source with the keyword \textit{Caicedo2019} (also note the preference in the use of italics instead of underlining), the citation is made as \citep{Caicedo2019}.

Each paragraph should begin with a motivating sentence, which encourages reading, and at the same time raises a particular idea. This idea should correspond to key elements of the problem. The rest of the paragraph should be composed of four to six sentences that provide details and clarification of the idea. The sentences should be simple to facilitate reading and not to entangle the reader. The introduction can be as long or short as the authors consider it, but it is recommended that it does not exceed one-third of the total length of the article.

In the Methodology section, first of all, the mathematical formulation of the

problem is detailed. If the authors consider it necessary due to the complexity and extension, this formulation of the problem can be done in a section of its own. Then, the research is explained in chronological form, starting from the design, going through the procedures (algorithm, pseudocode, etc.), and ending with the schemes of validation and data collection. The authors should provide all details that will allow replication of the experimental work. The research process should be supported by quality references as required.

Figures and tables are supports that should be used. In both cases, they should be cited in the body of the document, and always before their appearance (ideally in the paragraph just before their insertion). The images must be of high quality, and contain relevant, non-redundant, and understandable information. If they are not developed by the authors, the source must be correctly cited on the label. The size of the images should be consistent with the article, in all cases, the text in images and tables should be clear, and of a size similar to the text in the body of the article. Images should be sent as part of the article's source files in *.eps format. An example of inserting an image is as shown in Fig.~\ref{fig:fig1}. Note that the image is referred to without indicating that it is in the next paragraph or page, the numbering is used.

As for formatting, authors are requested not to force any style different from the class used in the Latex template. Under no circumstances will articles that include letters, words, or handwritten symbols in the text be accepted. If colored lines or figures are used, light colors (yellow, light blue, and similar) should not be used. The editor reserves the right to remove any figure or table that does not comply with the rules. References should handle the correct APA Sixth Edition style. Footnotes should not be used, and a maximum of three levels should be used for titles. An Acknowledgements section (highly recommended) written soberly, no more than four lines, may be included immediately after the Conclusions.

In the Results section, the results of the research are shown and explained. At the same time, it should provide a broad discussion of them, particularly concerning the results of other research on the same problem. The results can be presented in figures, diagrams, tables, and any other strategy that allows the reader to understand them. The discussion can be organized along with sub-sections.

The Conclusions section should summarize the data discussed in the Results section, showing the relevance of the work and how it is different from other research. Besides, the benefits and improvements of the solution proposed in the article should be noted.

In all cases, the authors must submit, along with the images, a BibTeX file (a single *.bib file) with all references used, each reference with a single key. This file can be generated from reference managers like Mendeley and Zotero, or generated with tools such as JabRef.

Regarding the language and style of writing, the author must use simple sentences and avoid regionalisms. He must take special care to use the correct spelling and writing, according to the rules of language.

Publication format

The manuscripts are published following the APA style 6th edition.

Editing changes

The Editor reserves the right, and is accepted by the author(s) with the only article shipping, to make changes in order to achieve a better presentation and impact of the work. These modifications may include changes in the title, abstract, keywords, figures, tables and text, among others, changes that do not affect, according to the Editor, the essence of the work submitted by the authors. In particular, figures that can not be well reproduced can be eliminated by the Editor. Incomplete references will also be eliminated by demands of databases.

Sending manuscripts

Authors must submit their articles through the application for the purpose of the Open Journal System (http://revistas.udistrital.edu.co/ojs/index.php/tekhne/index) in digital format, attaching Copyright Transfer Statement (according to format).

The letter should be addressed to the director and editor of the journal Prof. Fredy H. Martínez S., and it should include:
• Express request to consider the article for publication in **Tekhnê** journal.
• Full title of the article.
• Full names of all authors, detailing entity linked, institutional e-mail address, academic degrees, city and country.
• Certification of the originality and novelty of the article.
• Exclusivity of submission to **Tekhnê** journal.
• Confirmation of authorship with the signature of all authors.
• Institution financing the project.

The submission process consists of three stages:

1. Submission of the article, a single zipped file with the Latex sources.
2. Data recording. the basic data of the authors and article are registered in the OJS. It is important that these data are correct and complete, since they will be published on the journal's website as information related to the article, as well as used for indexing the article.
3. Sending the Copyright Transfer Statement as complementary file.

Publishing process

The process followed by the journal for evaluation and publication of articles is as follows:

• Receipt of the manuscript (first version, continuously open call)
• Verification of standards by the assistant of the journal
• Notification to authors of receipt, request for the form adjustments and filling of authors data format
• Receipt of the manuscript (second version) and authors data format
• Review by the Editorial Committee
• Notification to authors if the manuscript is sent or not to evaluation by peers
• Sending the manuscript to selected peers
• Reception peer evaluation
• Notification of evaluation to authors, and request corrections if they are relevant
• Receipt of the manuscript (third version)
• Study of manuscript corrected by the Editorial Committee
• Notification to authors of publication and final decision, and request the

rights transfer letter
• Reception of the rights transfer letter
• Style correction and layout of the manuscript
• Send final version to authors for error checking and final approval
• Publication of the article
• Notification to authors of the publication

Contact

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