Tekhnê

Tecnología al servicio de la sociedad

Universidad Distrital Francisco José de Caldas - Facultad Tecnológica

Universidad Distrital Francisco José de Caldas
Facultad Tecnológica

Vol. 14 No. 2
July - December 2017
ISSN 1692-8407

Tekhnê

Tecnología al servicio de la sociedad

Universidad Distrital Francisco José de Caldas - Facultad Tecnológica

Volumen 14 - Número 2 - 2017
ISSN 1692-8407

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS
FACULTAD TECNOLÓGICA

Cubierta: Monumento a Alfonso XII, Parque del Buen Retiro, Madrid (España)
Autor: Fredy H. Martínez S.

Contracubierta:
• Superior izquierda: Differences between types of knowledge (Merchán, J.)
• Superior derecha: Characteristics of empirical knowledge (Merchán, J.)
• Centro: Water table (López, F., Maca, K. and Gordillo, L.)
Inferior izquierda: Terrain profile (Jiménez, E., Alfonso, B. and Suárez, L.)
• Inferior derecha: Tunnel radiography (Jiménez, E., Alfonso, B. and Suárez, L.)

Corrección de estilo español
Angélica Viviana Rendón Calderón

Corrección de estilo inglés
Fredy H. Martínez S.

Impresión
Imprenta Universidad Distrital Francisco José de Caldas
Formato 21.5 × 28 cm
Papel Bond 75 g
Tiraje de 70 ejemplares

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.

Periodicidad

La revista Tekhnê posee una periodicidad semestral, coincidente con los semestres académicos de la Universidad Distrital. La publicación se realiza los meses de julio y diciembre. El primer volumen de la revista se publicó el primer semestre de 2003, manteniendo su regularidad hasta la fecha.

Misión

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.

Público objetivo

La revista está dirigida a docentes, investigadores, estudiantes y profesionales interesados en la actualización permanente de sus conocimientos y el seguimiento de los procesos de investigación científica en el campo de la ingeniería.

Forma de adquisición

La revista Tekhnê se puede adquirir a través de compra o canje.

Reproducción

Dirección postal

Prof. Fredy H. Martínez S.
Editor y director revista Tekhnê
Sala de Revistas, Bloque 5, Oficina 301
Facultad Tecnológica
Universidad Distrital Francisco José de Caldas
Transversal 70B No. 73A-35 sur
Teléfono: (571) 3238400 Ext. 5003
Celular: (57) 3005585481
Bogotá D.C., Colombia
E-Mail: fhmartinezs@udistrital.edu.co
Url: https://revistas.udistrital.edu.co/index.php/tekhne

Tekhnê

Tecnología al servicio de la sociedad

Universidad Distrital Francisco José de Caldas - Facultad Tecnológica

Volume 14 - Number 2 - 2017
ISSN 1692-8407

UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS
FACULTAD TECNOLÓGICA

Cover picture: Monument to Alfonso XII, Park of the Pleasant Retreat, Madrid (Spain)
Author: Fredy H. Martínez S.

Back cover picture:
- Top left: Differences between types of knowledge (Merchán, J.)
- Top right: Characteristics of empirical knowledge (Merchán, J.)
- Middle: Water table (López, F., Maca, K. and Gordillo, L.)

Lower left: Terrain profile (Jiménez, E., Alfonso, B. and Suárez, L.)

- Lower right: Tunnel radiography (Jiménez, E., Alfonso, B. and Suárez, L.)

Style correction in spanish
Angélica Viviana Rendón Calderón

Style correction in english
Fredy H. Martínez S.

Printed by
Imprenta Universidad Distrital Francisco José de Caldas
Format: 21.5 × 28 cm
Paper: Bond 75 g
Printing: 70 copies

Tekhnê Journal

Tekhnê journal is an institutional publication of the Facultad Tecnológica of the Universidad Distrital Francisco José de Caldas. It has a scientific character and serves the national and international community specialized in the areas of electrical, electronic, mechanical, systems, industrial and civil engineering. It publishes research results in English (original and unpublished articles), and is completely open to specialists from around the world as authors and/or readers. It is arbitrated through a double-blind process, with continuous rotation of arbitrators. The periodicity of the formation of its Scientific and Editorial Committees is subject to the publication of articles in internationally indexed journals by their respective members.

Periodicity

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.

Mission

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.

Target audience

The journal is aimed at professors, researchers, students, and professionals interested in permanently updating their knowledge and monitoring scientific research processes in the field of engineering.

Form of adquisition

Tekhnê journal can be purchased, or exchanged.

Reproduction

Mailing address

Prof. Fredy H. Martínez S.
Editor and director Tekhnê Journal
Sala de Revistas, Bloque 5, Oficina 301
Facultad Tecnológica
Universidad Distrital Francisco José de Caldas
Transversal 70B No. 73A-35 sur
Phone: (571) 3238400 Ext. 5003
Cell phone: (57) 3005585481
Bogotá D.C., Colombia
E-Mail: fhmartinezs@udistrital.edu.co
Url: https://revistas.udistrital.edu.co/index.php/tekhne

Declaración de ética y buenas prácticas

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

Revista Tekhnê
Universidad Distrital Francisco José de Caldas
Facultad Tecnológica

El comité editorial de la revista Tekhnê está comprometido con altos estándares de ética y buenas prácticas en la difusión y transferencia del conocimiento, para garantizar el rigor y la calidad científica. Es por ello que ha adoptado como referencia el Código de Conducta que, para editores de revistas científicas, ha establecido el Comité de Ética de Publicaciones (COPE: Committee on Publication Ethics) dentro de los cuales se destaca:

Obligaciones y responsabilidades generales del equipo editorial

En su calidad de máximos responsables de la revista, el comité y el equipo editorial de Tekhnê se comprometen a:

- Aunar esfuerzos para satisfacer las necesidades de los lectores y autores.
- Propender por el mejoramiento continuo de la revista.
- Asegurar la calidad del material que se publica.
- Velar por la libertad de expresión.
- Mantener la integridad académica de su contenido.
- Impedir que intereses comerciales comprometan los criterios intelectuales.
- Publicar correcciones, aclaraciones, retractaciones y disculpas cuando sea necesario.

Relaciones con los lectores

Los lectores estarán informados acerca de quién ha financiado la investigación y sobre su papel en la investigación.

Relaciones con los autores

Tekhnê se compromete a asegurar la calidad del material que publica, informando sobre los objetivos y normas de la revista. Las decisiones de los editores para aceptar o rechazar un documento para su publicación se basan únicamente en la relevancia del trabajo, su originalidad y la pertinencia del estudio con relación a la línea editorial de la revista.

La revista incluye una descripción de los procesos seguidos en la evaluación por pares de cada trabajo recibido. Cuenta con una guía de autores en la que se presenta esta información. Dicha guía se actualiza regularmente y contiene un vínculo a la presente declaración ética. Se reconoce el derecho de los autores a apelar las decisiones editoriales.

Los editores no modificarán su decisión en la aceptación de envíos, a menos que se detecten irregularidades o situaciones extraordinarias. Cualquier cambio en los miembros del equipo editorial no afectará las decisiones ya tomadas, salvo casos excepcionales en los que confluyan graves circunstancias.

Relaciones con los evaluadores

Tekhnê pone a disposición de los evaluadores una guía acerca de lo que se espera de ellos. La identidad de los evaluadores se encuentra en todo momento protegida, garantizando su anonimato.

Proceso de evaluación por pares

Tekhnê garantiza que el material remitido para su publicación será considerado como materia reservada y confidencial mientras que se evalúa (doble ciego).

Reclamaciones

Tekhnê se compromete responder con rapidez a las quejas recibidas y a velar para que los demandantes insatisfechos puedan tramitar todas sus quejas. En cualquier caso, si los interesados no consiguen satisfacer sus reclamaciones, se considera que están en su derecho de elevar sus protestas a otras instancias.

Fomento de la integridad académica

Tekhnê asegura que el material que publica se ajusta a las normas éticas internacionalmente aceptadas.

Protección de datos individuales

Tekhnê garantiza la confidencialidad de la información individual (por ejemplo, de los profesores y/o alumnos participantes como colaboradores o sujetos de estudio en las investigaciones presentadas).

Seguimiento de malas prácticas

Tekhnê asume su obligación para actuar en consecuencia en caso de sospecha de malas prácticas o conductas inadecuadas. Esta obligación se extiende tanto a los documentos publicados como a los no publicados. Los editores no sólo rechazarán los manuscritos que planteen dudas sobre una posible mala conducta, sino que se consideran éticamente obligados a denunciar los supuestos casos de mala conducta. Desde la revista se realizarán todos los esfuerzos razonables para asegurar que los trabajos sometidos a evaluación sean rigurosos y éticamente adecuados.

Integridad y rigor académico

Cada vez que se tenga constancia de que algún trabajo publicado contiene inexactitudes importantes, declaraciones engañosas o distorsionadas, debe ser corregido de forma inmediata.

En caso de detectarse algún trabajo cuyo contenido sea fraudulento, será retirado tan pronto como se conozca, informando inmediatamente tanto a los lectores como a los sistemas de indexación.

Se consideran prácticas inadmisibles, y como tal se denunciarán las siguientes: el envío simultáneo de un mismo trabajo a varias revistas, la publicación duplicada o con cambios irrelevantes o parafraseo del mismo trabajo, o la fragmentación artificial de un trabajo en varios artículos.

Relaciones con los propietarios y editores de revistas

La relación entre editores, editoriales y propietarios estará sujeta al principio de independencia editorial. Tekhnê garantizará siempre que los artículos se publiquen con base en su calidad e idoneidad para los lectores, y no con vistas a un beneficio económico o político. En este sentido, el hecho de que la revista no se rija por intereses económicos, y defienda el ideal de libre acceso al conocimiento universal y gratuito, facilita dicha independencia.

Conflicto de intereses

Tekhnê establecerá los mecanismos necesarios para evitar o resolver los posibles conflictos de intereses entre autores, evaluadores y/o el propio equipo editorial.

Quejas/denuncias

Cualquier autor, lector, evaluador o editor puede remitir sus quejas a los organismos competentes.

Code of ethics and good practice

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

Tekhnê Journal
Universidad Distrital Francisco José de Caldas
Facultad Tecnológica

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:

General duties and responsibilities of the editorial board

As most responsible for the journal, Tekhnê committee and the editorial board are committed to:

- Joining efforts to meet the readers and authors needs.
- Tending to the continuous improvement of the Journal.
- Ensuring quality of published material.
- Ensuring freedom of expression.
- Maintaining the academic integrity of their content.
- Prevent commercial interests compromise intellectual standards.
- Post corrections, clarifications, retractions and apologies when necessary.

Relations with readers

Readers will be informed about who has funded the research and their role in the research.

Relations with authors

Tekhnê is committed to ensuring the quality of published material, informing the goals and standards of the journal. The decisions of publishers to accept or reject a paper for publication are based solely on the relevance of the work, originality and pertinence of the study with journal editorial line.

The journal includes a description of the process for peer evaluation of each received work, and has an authors guide with this information. The guide is regularly updated and contains a link to this code of ethics. The journal recognizes the right of authors to appeal editorial decisions.

Publishers will not change their decision in accepting or rejecting articles, unless extraordinary circumstances or irregularities are detected. Any change in the editorial board members will not affect decisions already made, except for unusual cases where serious circumstances converge.

Relations with evaluators

Tekhnê makes available to reviewers a guide to what is expected from them. Reviewers identity is protected at all times, ensuring anonymity.

Peer review process

Tekhnê ensures that material submitted for publication will be considered private and confidential issue while being reviewed (double blind).

Claims

Tekhnê is committed to respond quickly to complaints and ensure that dissatisfied claimant can process all complaints. In any case, if applicants fail to satisfy their claims, the journal considers that they have the right to raise their protests to other instances.

Promoting academic integrity

Tekhnê ensures that the published material conforms to internationally accepted ethical standards.

Protection of individual data

Tekhnê guarantees the confidentiality of individual information (e.g. participant teachers and/or students as collaborators or subjects of study in the presented research).

Tracking malpractice

Tekhnê accepts the obligation to act accordingly in case of suspected malpractice or misconduct. This obligation extends

both to publish and unpublished documents. The editors not only reject manuscripts with doubts about possible misconduct, but they are considered ethically obligated to report suspected cases of misconduct. From the journal every reasonable effort is made to ensure that works submitted for evaluation are rigorous and ethically appropriate.

Integrity and academic rigour

Whenever evidence that a published work contains significant misstatements, misleading or distorted statements, it must be corrected immediately.

In case of any work with fraudulent content is detected, it will be removed as soon as it is known, and immediately informing both readers and indexing systems.

Practices that are considered unacceptable and as such will be reported: simultaneous sending of the same work to various journals, duplicate publication with irrelevant changes or paraphrase of the same work, or the artificial fragmentation of a work in several articles.

Relations with owners and journal editors

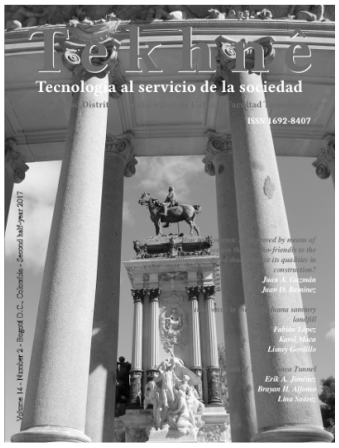
The relation between editors, publishers and owners will be subject to the principle of editorial independence. Tekhnê will ensure that articles are published based on their quality and suitability for readers, and not for an economic or political gain. In this sense, the fact that the journal is not governed by economic interests, and defends the ideal of universal and free access to knowledge, provides that independence.

Conflict of interest

Tekhnê will establish the necessary mechanisms to avoid or resolve potential conflicts of interest between authors, reviewers and/or the editorial board itself.

Complaints/allegations

Any author, reader, reviewer or editor may refer their complaints to the competent authorities.



Volume 14 - Number 2 - 2017
ISSN 1692-8407

Index

Articles

Editorial

El proyecto curricular de Tecnología en Electricidad de la Facultad Tecnológica de la Universidad Distrital Francisco José de Caldas, en alianza con el programa de Doctorado en Ingeniería, organizó la II Conferencia Internacional de Tecnología e Ingeniería Eléctrica (CITIE 2017). Dicho evento académico tuvo su casa en la ciudad de Bogotá (Colombia), en la emblemática Biblioteca Central Ramón Eduardo D'Luyz Nieto (Aduanilla de Paiba), durante los días 11 al 13 de octubre de 2017.

En este evento, que pretende convertirse en vitrina para la investigación local, nacional e internacional en ingeniería eléctrica, e icónico para el programa académico, se contó con conferencistas reconocidos en áreas de la electricidad con temas de punta en diferentes campos, como la robótica de servicios, las redes inalámbricas de comunicación, la localización de fallas, la operación de sistemas de potencia, los medidores inteligentes, los procesos de contratación, las habilidades blandas, las superficies selectivas en frecuencia, la corrosión en sistemas de generación, la prospectiva de los sistemas electromecánicos, y las políticas en ciencia, tecnología e investigación. Durante la conferencia se presentaron también un total de 22 ponencias, las cuales se publicaron en las memorias del evento, y en la revista universitaria Visión Electrónica.

En este nuevo número de la revista deseamos agradecer a los árbitros por su excelente y oportuno trabajo evaluando los manuscritos postulados para publicación. Además, agradecemos a la Editorial de la Universidad Distrital Francisco José de Caldas por el acompañamiento brindado.

Ph.D(c) Prof. Fredy H. Martínez S.
Docente Facultad Tecnológica
Universidad Distrital Francisco José de Caldas

Editorial

The Electricity Technology curricular project of the Facultad Tecnológica of the Universidad Distrital Francisco José de Caldas, in alliance with the Doctorate in Engineering program, organized the II International Conference on Electrical Technology and Engineering (CITIE 2017). This academic event took place in the city of Bogota (Colombia), in the emblematic Central Library Ramón Eduardo D'Luyz Nieto (Aduanilla de Paiba), from October 11 to 13, 2017.

In this event, which aims to become a showcase for local, national and international research in electrical engineering, and iconic for the academic program, there were renowned speakers in areas of electricity with cutting-edge topics in different fields, such as service robotics, wireless communication networks, fault location, power system operation, smart meters, contracting processes, soft skills, frequency selective surfaces, corrosion in generation systems, perspective of electromechanical systems, and policies in science, technology and research. During the conference, a total of 22 papers were also presented, which were published in the proceedings of the event and in the university journal Visión Electrónica.

In this new issue of the journal we would like to thank the referees for their excellent and timely work in evaluating manuscripts submitted for publication. In addition, we thank the Editorial of the Universidad Distrital Francisco José de Caldas for the accompaniment provided.

Ph.D(c) Prof. Fredy H. Martínez S.
Professor at the Facultad Tecnológica
Universidad Distrital Francisco José de Caldas

Tekhnê
July - December 2017, Vol. 14, No. 2, pp. 13 – 22

ISSN 1692-8407

Unfinished projects in Bogotá (Colombia)

Obras inconclusas en Bogotá (Colombia)

María C. Rios S.
Universidad Distrital Francisco José de Caldas
mcrioss@correo.udistrital.edu.co

Johan S. Lozano T.
Universidad Distrital Francisco José de Caldas
joslozanot@correo.udistrital.edu.co

The central theme of the article is the problem of unfinished works in the city of Bogota (Colombia). The most common causes and consequences are discussed, as well as the great negative impact this generates within the inhabitants, who are the most affected. Half-finished roads and abandoned buildings are the most common scenario for citizens, this occurs especially in projects where the government is the financier of the work. In these cases, improper handling of money is one of the most common causes.

Keywords: Bogotá, buildings, civil works, engineering, roads

El tema central del artículo es la problemática de obras inconclusas en la cuidad de Bogotá (Colombia). Se plantean las causas y consecuencias mas comunes, así como el gran impacto negativo que esto genera dentro de los habitantes, quienes son los mas afectados. Vías a medio terminar y edificaciones abandonadas son el panorama mas común para los ciudadanos, esto ocurre sobre todo en los proyectos donde el gobierno es el financiador de la obra. En estos casos, los malos manejos de dinero son una de las causas mas comunes.

Palabras clave: Bogotá, edificaciones, ingeniería, obras civiles, vías

Article typology: Research

Date manuscript received: November 27, 2017
Date manuscript acceptance: December 8, 2017

Research funded by: Universidad Distrital Francisco José de Caldas.

How to cite: Rios, M., Lozano, J. (2017). *Unfinished projects in Bogotá (Colombia)*. Tekhnê, 14(2), 13 -22.

Introduction

This article was elaborated with the purpose of informing and proposing possible solutions to the problems of the unfinished works of the city of Bogotá, taking into account the most common affectations in neighborhoods, mobility and citizen welfare in general. In its first part, we will deal with the statistics of the works in the city along with the social, environmental and economic impact. Later we will try to analyze some of the causes of the problem, and we will propose a possible solution (Sotomayor, 2015).

In Bogotá, there are about 25 unfinished works (Particular, 2014; Redacción, 2016). There is also a large number of futuristic works that have been stopped or have not fulfilled the expectations promised in the project. For this and other reasons, the people of Bogotá are skeptical of what has been suggested for the improvement of the city. Some of the most common reasons for the stoppage of these projects are the failure in contractual processes, the low investment and the loss of the capital stipulated to execute each work.

On the other hand, 94% of the resources invested in these works, warns the Comptroller General of the Republic (Redacción, 2016), correspond to the Bogotá aqueduct, the Secretary of Health, the Surveillance Fund, and the Universidad Distrital. As previously stated, the money has been lost, and a large percentage corresponds to the aforementioned entities. One of the most relevant works is the recovery of the Bogotá River (Fig. 1), corresponding to the aqueduct which, not only represents one work but five works, which committed about $767 thousand million Colombian pesos.

Figure 1. Decontamination of the Bogotá River (Redacción, 2016).

Investment in Bogotá's construction sites in jeopardy

It is surprising to know the amount of money invested and not applied to the works of the country. There are about 83 works throughout Colombia that have been abandoned, which corresponds to 1.3 billion Colombian pesos wasted and lost. In Bogotá, for example, one of the projects under the government's scrutiny is the police command, where more than 31 billion Colombian pesos have already been paid out of the 42 billion pesos earmarked for the work. At present, however, construction has been on hold for 14 months, although it was due to be delivered in 2012. In addition, there have been warnings about the presence of structural faults. Also in the health entities, there is money invested and lost.

As mentioned above, the aqueduct has about five unfinished works in the process of recovering the Bogotá river, which also represents a large amount of lost money. Table 1 shows some relevant data from these five works.

Table 1
Summary of unfinished works of the Bogotá aqueduct.

Work	Value in thousands of millions of Colombian pesos	Percentage of progress	Year of hire
Tunjuelo Canoas interceptor	$243,117	95%	2009
Fucha Izquierdo interceptor	$187,577	73%	2006
Fucha Tunjuelo interceptor	$160,706	99%	2006
Tunjuelo Bajo interceptor	$135,501	100%	2007
Tunjuelo Medio retention tank	$40,433	92%	2008

And finally, for the construction of building B of the La Macarena campus of the Universidad Distrital Francisco José de Caldas a contract was signed in 2010 for $12,441 million Colombian pesos, and to date, only 16% has been executed. This work had a completion period of 21 months and was suspended in November 2014.

Impact of unfinished works

The impact that we perceive because of so many works in a partial state is negative both socially and economically, so we believe that a proposal should be made to carry out a control of the purpose of these works.

The fundamental cause of the delays is constituted by the insufficient development of the executive projects, which propitiates anomalies such as the lack of detailed engineering, the vagueness of the technology to be used in the development of the work or the imprecision of the work site, among others (Fig. 2) (Economía, 2016). This situation is recurrent despite the mandate of the Law of Public Works and Services Related to the Same, which establishes as a requirement for the start of any infrastructure work, the existence of the executive project fully completed or with a degree of progress such that allows continuity in

ISSN 1692-8407

the execution of work. In this regard, it has been found that in many cases such work has begun with a limited basic engineering project.

Figure 2. Unfinished works in Colombia (Economía, 2016).

The initiative that seeks to create a national registry of unfinished civil works of state entities, passed to fourth debate in plenary Senate. Senator Claudia Wilches, the author of the project, explains that the project seeks to advance studies of unfinished civil works of state entities and to order that it incorporates the identification and assessment of those that have been built in whole or in part to determine whether they are completed or demolished. The principle of this project is to stop patrimonial detriment.

Social impact

The social impact of these poorly made investments is great, considering that a large part of the works designed were oriented to the health sector, education, and entities dedicated to providing services for the most vulnerable. The fiscal control agency noted that in many cases, the infrastructure of the works is more than 70 percent advanced, but little or nothing has served because its completion and provision requires a greater investment than that already made.

It is important that administrations become aware of their obligation to fulfill their citizens. In the first place, there must be a correct investment of resources, and in the second place, honesty and probity must be acted upon to avoid the corruption of some works, since many works are abandoned due to this problem, remaining as inconclusive at the mercy of anyone, without anybody having a sense of belonging to them (Fig. 3).

The effective execution and fulfillment of a state contract entails the development of the necessary activities for its termination adjusted to the negotiation clauses, within which the object, the consideration, the term of execution and the guarantee stand out due to their importance. In addition, the work, good or service must be delivered in working order and within the framework of the post-contractual guarantee. All this requires the planning of its realization, execution, and development to make successful the contract and to obtain


Figure 3. Unfinished works in Bogotá (Vernot, 2016).

the satisfaction of the need when putting in operation the contracted work.

The problem under study takes into consideration that the legal system and those involved in the state contracting of works have limited the concept of planning to a subject of previous studies that are developed in the pre-contractual stage, neglecting the other stages of the work process. These stages also require planning and are part of the execution, development, and fulfillment of the contractual terms. Thus, it is not known that planning is a system for the fulfillment of the purposes of the State and that a contract is a tool at its service.

The necessary factor for proper planning in any public contracting process is real and effective knowledge about the need to be fulfilled. What is required to contract, how many resources are available, what are the terms of both the budget execution and the requirements of the work required by the community, and what are the factors that influence the development of the processes that are carried out? Likewise, foreseeable risks must be defined, estimated and assigned. To do this, the main means is historical observation (Martínez, Martínez, & Montiel, 2016), because knowing what has happened, defining the causes and effects, recognizing phenomena associated with the fulfillment of contracts and the execution of works within a rational framework of methodological rigour, it is feasible to define actions, protocols, manuals and intervention plans on the situations that may arise in the development of the contract (Montiel, Martínez, & Jacinto, 2017). This must be reflected in the studies and documents prior to any state contract but is materialized throughout the administrative activity of contracting, which goes from the establishment of the need to when the terms of the guarantee are met.

One of the most outstanding elements of a planning model is its predictive capacity in scientific terms. That is to say, to anticipate future behaviors, of phenomena that previously have been studied and of which it has been possible in a hypothetical-deductive way, to establish regularities expressed in terms of cause and effect, of means and results

(Montiel, Jacinto, & Martínez, 2015). Therefore, planning conjugates not only the predictive element, attributed to science, but also the intervention factor of engineering and administration, because it produces results, it affects physical and social reality in order to shape and obtain clearly defined objectives within the framework of feasibility, established in a scientific and technical manner, based on available resources.

This means that planning is connatural to the administration and the exercise of power. Therefore, all public planning implies the field of politics (Torres & Santander, 2013), reason to understand the intrinsic relation between planning and Law, with respect to public contracting (Amaya, 2015), which in turn relates the economy, public finances, citizen participation, with the use of control mechanisms that citizens have to elect their representatives and become participants in decisions, of the government plans, through the so-called programmatic vote, and the constitutional mechanisms to demand through the action of compliance, the revocation of the mandate, group actions and other mechanisms provided by the Political Constitution of Colombia, that the development plans to which the governors have committed themselves at the local, regional and national levels be complied with (Rengifo, 2012).

In this order, the law has a performative factor on social interaction, and what the legal system seeks is to plan this interaction for the common good, taking social conduct to the fulfillment of State policies, reason, and vision embodied by legislators, governors, and judges. This has a value of control and, therefore, is part of the planning of society, in terms of the needs of coexistence and what is desired for the future in its development. For the same reason, the juridical ordering is not an absolute and static system, but it is a system in permanent transformation and adjustment to respond to the needs and challenges of the society that experiences a dynamic of continuous change, which must be done within a planned vision (Aponte, 2014).

Economic impact

The economic impact generated by these unfinished constructions is very high, almost doubling the value of the work. To cite an example, the case of a new command for the police in Bogota, the contract for $43,794 million Colombian pesos, was awarded on November 19, 2010, today is worth $82,000 million pesos to complete it. That is why it is important to carry out this proposal, which also seeks to mitigate the risk to the population that many of these works are abandoned.

The main causes are an inappropriate and delayed budget allocation and availability, late transfers between programs, budget reductions during the execution process, lack of capitalization of contractor companies and unpredictability about the consequences of the global problems of the capital goods market, which impact the cost and timeliness in the delivery of supplies.

The concern for planning obeys the collective and economic need to optimize resources, reduce costs, minimize human errors and achieve the development of works that are a social priority and not exclusively of a luxurious order, with respect to others of restricted use, which imply undemocratic or partial investment. It is part of the concept of modernization and efficiency of the state. The absence of planning creates an inadequate use of public resources due to ignorance of the needs and means available (Aponte, 2014).

A first approach to the subject from the legal sphere shows that in the Colombian legal system planning is not conceptually delimited, but through budgets or referents, guides are given that serve to give it fulfillment as a guiding principle of state contracting in general (art. 25 of Law 80 of 1993). Its implementation, diffusion, and development is presented as part of the procedure to make contracts in the State and in matters of public works, it still requires a practical development, from a technical and juridical component in the execution, to surpass the theoretical level, proper of the normative prescription, that limits it to the fulfillment of activities in the pre-contractual stage (Aponte, 2014).

From a legal perspective, a revision of the normative, doctrinal and jurisprudential order evidences that planning is not only a preliminary matter to the contracting of public works, it is also to limit, among the previous studies that propose the terms of reference of the contract in its objective dimension and the factual mode, corresponding to its fulfillment, parallel to the development and delivery to satisfaction of the contracted works. But, at the same time, in a post-liminal dimension of every contract and every finished public work, the planning proposes to consider the guarantee of the durability of the work in adequate operating conditions, economic sustainability and even to minimize the environmental and social impact (Aponte, 2014).

The planning of the works contract involves much more than legal procedures and compliance with the legal system in matters of public contracting (Aponte, 2014), because it has a higher material and social purpose, which exceeds the legally established forms, since the works contracted must be those that are required in response to current development plans that consider which are priority, that there are resources for their full execution and that no works are begun that cannot be completed. It is essential that they be paid for as fair as possible according to the market, and that the necessary prior studies be carried out in rational economic terms of time, use and commitment of public finances and, furthermore, that they be delivered to the service, with a guarantee for a time technically established in accordance with their functionality (Aponte, 2014). In the same way,

ISSN 1692-8407

that its sustainability and continuity is contemplated in time, so that they fulfill the objectives of social responsibility and good corporate governance so that the public treasury is used in an optimal way, serving what has been contracted for development with social justice.

Thus, the public entities that contract, apart from complying with the law, will do so within quality standards, strategic planning, international accounting, and financial reporting standards, good governance of public agencies, so that the problems of clientelism and corruption that have historically affected public contracting are minimized.

In this order, the planning of the public work also implies the full fulfillment of the contractual object, the correct development of the work, understanding that the same not only is exhausted with its delivery, but that it must be given to the service in optimal conditions for the work, reason why the planning necessarily links the pre-contractual, contractual and also the post-contractual stages. This affirmation starts from the material sense of the work contract, adhered to the principle of reality, in consideration of the legal good of development and social welfare, which has repeatedly pointed out the jurisprudence of the Council of State when it refers that the contracted works must be executed of quality, with diligence, delivered finished and with full functionality, in addition with a short, medium and long term projection that allows its financial sustainability, its preventive and corrective maintenance, its empathy with other existing or planned works and its sustainability, in terms of the environment. This is the only way to understand that the contract served to solve a need at the expense of the state.

To conceive planning in another way is to ignore that the foundation of state contracting is the attention to the ends and purposes of the state, established constitutionally, and would be limited only to the analysis for the validation of a legal procedure, in which stages or procedures must be complied with that, by themselves, do not satisfy any need, but are tools for the administrative operator to perform its function.

This poses a challenge for planning as a principle of state contracting, and that is that the concept goes from being a principle enunciated legally and briefly described in the ordinance, to become a more technical and therefore efficient instrument, which allows applying to law enforcement, a protocol or technical manual of what should be the planning in terms of public procurement. In said manual, the three stages already mentioned must be considered, but at the same time, it must be corroborated in the executed work that fully complies with the contractual object and with its social order justification, in terms of development and welfare for the community, to make works that imply the opening of democracy to participation in the social and economic dynamics, especially for the strata of society that traditionally have been excluded from development.

Environmental impact

The process of urban growth often leads to a deterioration of the surrounding environmental conditions, as a result of the execution of various civil works (Fig. 4). As a place of population growth, commercial and industrial activity, cities concentrate energy use and waste generation to the point where both artificial and natural systems are overloaded and the capacities to manage them are overwhelmed. This situation is worsened by rapid population growth in cities.

Figure 4. La Paz neighborhood health center (Vitola, 2017).

Among the relevant and known impacts of major civil works, the alteration of the natural environment stands out. The majority of major works are subject, in their project phase, to the evaluation of their environmental impact. The execution of large civil works has another important impact on nearby populations and crops, as well as on the natural environment, which derives from the emission of large quantities of dust and particles. Preventive measures should be included in the Environmental Management Plan of any project.

The promoters of civil works must avoid or minimize all negative impacts or effects on the environment. Works should not be placed in the territory as if it were a model. They must be fully and efficiently integrated into the environment, interacting with each other, which is altered at the moment when a work does not have its correct conclusion becoming even more harmful to the environment.

To plan is to foresee in order to lead the way towards the attainment of a goal. To administer, to go step by step, under circumstances in which there are certain elements as well as elements and factors that are random. To plan is to have a plan, a projection, a previously traced route, something that is available before starting a public work. To plan is related to the optimization of resources, to make them reach, to carry out an objective with the means available, to exert control on executors, actions and inputs, step by step during the different stages of the development of the public work.

To deploy an economic strategy to maximize the means available to meet needs that exceed resources (Fig. 5).

Figure 5. Unfinished works (Obras, 2017).

Planning should be understood as a dynamic system that integrates multiple pieces of knowledge and methodologies that can be applied in all fields of human intervention, in nature and in society.

The relationship between planning and law, with respect to public contracting, is related to the economy, public finances, citizen participation, the use of control mechanisms that citizens have to elect their representatives and participate in decisions, government plans, and constitutional mechanisms to demand compliance with the development plans to which governors have committed themselves at the local, regional and national levels. In this order, the law has a performative factor on social interaction and it should be the objective of the juridical order to plan the necessary interaction in the search for the common good, leading social conduct to the fulfillment of state policies, reason, and vision embodied by legislators, governors, and judges.

The planning of the works contract goes beyond compliance with the legal procedures for the execution of the contract (Aponte, 2014), since it is necessary to understand that public contracting has a higher material and social purpose, which exceeds the legally established contractual formulas, because it implies considering that the contracted works are those that are required in accordance with current development plans, considering their priority, that the resources exist for their full execution and that no works are begun that cannot be completed. That the fair amount is paid, according to the market, that the necessary preliminary studies are available, that they are carried out within rational economic terms of time, use and commitment of public finances and that, in addition, they are delivered to the service, guaranteeing their functionality for a time technically established, contemplating their sustainability and continuity, with a sense of social responsibility, duly taking advantage of the resources of the public treasury.

Corruption in public works in Colombia

The issue of corruption is one of the most debated in most of the fields and spheres that make up a society. It is a constant discussion about the good or bad that happens in the country and its surroundings. One of the most attacked corruption issues is public works, because it is one of the forms of corruption where the most money is lost, and no progress is evident.

In order to understand this social problem, it is necessary to take into account the causes for which it occurs, apart from negligence. One of the causes identified is inefficiency. This is probably the most important cause of corruption, as it creates the means for it to occur (Cepeda, 1994). Inefficiency reduces the quality of the service provided by the entities and therefore creates incentives for the client to offer money in exchange for obtaining the service. This allows the employee to be involved in these types of transactions. Inefficiency is associated with the lack or poor functioning of planning and control systems, which makes it difficult to differentiate the effects of corrupt actions, establish responsibilities and apply punishments. Inefficiency is one of the most important causes because it reduces the quality of service, and it is very evident because if there is no efficiency there is no good production. Inefficiency is associated with lack or poor performance, this is very marked in public works because commonly, employees damage good streets simply to demand large amounts of money and invest very little in works.

The biggest problem in the inefficiency of works is contracting without studies or designs. This practice has allowed multi-million price modifications and extensions of contracts (Montenegro, 2011). This is a key point to counteract corruption in the works. However, it is something that they use in favor, to continue incurring in this fault.

The second step is to eliminate the down payments (Montenegro, 2011). The government should not transfer any resources to the contractors (neither tolls nor other monetary contributions) before they finish and deliver the works. Only in this way, those who build a road will have no choice but to have enough capital and establish a debt structure backed by the risk rating agencies and fed with the resources of institutional investors. In this way, in one fell swoop, the adventurers who win contracts without capital or backing would be excluded. This is, in fact, a good strategy to prevent construction site theft. However, it is not something that is used by the government, so the contractors are under greater responsibility.

ISSN 1692-8407

How can we eliminate corruption in Colombia? According to Rose-Ackerman, the best way to fight corruption is to encourage honesty and punish the corrupt with a strong hand, but there are certain steps to achieve it (López, 2014).

Whether employees are adequately paid or poorly paid will undoubtedly influence motivation and incentives (Guerrero, 2017). If public sector salaries are too low, employees may be pressured to supplement their earnings in unofficial ways. It has been observed that in less developed countries, there is an inverse relationship between the level of public sector salaries and the presence of corruption.

Subsidies, tax exemptions, public procurement of goods and services, soft credits, extra-budgetary funds controlled by politicians all these are different ways in which governments manage public resources (Guerrero, 2017). Governments collect taxes, turn to capital markets for money, receive foreign aid, and develop mechanisms for allocating those resources to various needs. Some countries do this in a relatively transparent manner and strive to ensure that the public interest is the objective. The more open and transparent the process, the less likely there is to be illicit activity and abuse. In this sense, freedom of the press and educational levels also contribute to creating the context for reforms. An active civil society and a culture of participation in the country can be a key ingredient of strategies to reduce corruption.

New Zealand, which regularly ranks highest in Transparency International's Corruption Perceptions Index, has been a pioneer in creating transparent budget processes since it passed the Fiscal Accountability Act in 1994, which provides a legal framework for the transparent management of public resources (Campos & Pradhan, 2009).

The clear correlation between the presence of corruption and the degree of bureaucracy reflected, for example, in the Doing Business indicators, suggests that it is desirable to eliminate all unnecessary rules while protecting the essential regulatory functions of the state. Not only are the rules that prevail in many countries to create a new company, register a property, conduct an international commercial transaction and many other certificates and permits sometimes unbearable, but governments have often not stopped to think whether the purpose for which they were implemented has anything to do with today's needs.

Subsidies are another example of how an official policy can distort incentives and create opportunities for corruption. According to an FMI study (2013), subsidies on the consumption of energy products amount to about $1.9 trillion annually, equivalent to 2.5% of world PIB and 8% of government revenues. These subsidies are very regressive. In the case of gasoline, more than 60% of total profits go to the richest 20%. Their elimination could significantly reduce CO2 emissions and have other positive consequences. Subsidies often lead to smuggling, scarcity and the emergence of the black market.

Apart from opportunity costs (how many schools could be built with a year's worth of energy subsidies?) and the environmental repercussions of artificially low prices, subsidies can also put government at the heart of corruption. It is far better to replace these expensive, regressive subsidies with selective money transfers.

As corruption in a globalized economy has an increasingly transnational dimension (Guerrero, 2017), the international legal framework for the control of corruption is a key element in the options available to governments. This framework has undergone major improvements over the past decade. In addition to the OCDE Anti-Corruption Convention, the ONU Convention (CNUCC) entered into force in 2005. The latter, by the end of 2013, had already been ratified by the vast majority of its 140 signatories. The CNUCC is a promising instrument because it creates a global framework involving both developed and developing countries. It covers a wide range of issues, including domestic and foreign corruption, extortion, preventive measures, anti-money laundering provisions, conflict of interest laws and means to recover illicit money deposited by officials in offshore banks. Since the ONU has no powers to enforce agreements, its effectiveness as an anti-corruption tool will largely depend on the creation of adequate national oversight mechanisms to ensure government compliance.

Some argue that in the fight against corruption, a more feasible strategy would perhaps be to enforce anti-corruption laws in the 40 states that are signatories to the OCDE anti-corruption convention (Argandoña & Morel, 2009). Governments will need to take stronger action against OCDE companies that continue to bribe foreign officials. The executive, eager to protect the business interests of their domestic companies, have sometimes been tempted not to require them to comply with anti-corruption laws, in an unfortunate attempt not to weaken their position against competitors from other countries. It cannot be that the promotion of trade seems more important than the control of corruption. Governments continue to use double standards and criminalize bribes in their own country but turn a blind eye when such bribes affect foreign officials in non-OCDE states.

If the distortions created by governments offer many opportunities for corruption, frequent and direct contact between officials and citizens can also facilitate illicit transactions. One way to solve this problem is to use available technologies to promote a more distant relationship between the two sectors. In this sense, the Internet is an effective tool for combating corruption (Sour, 2017). In some countries, the use of Internet platforms for government relations with civil society and the business world has

flourished, especially in the areas of tax payments, public procurement, and bureaucratic procedures.

Perhaps one of the most fertile fields for corruption in the world is related to state purchases. Public purchases of goods and services can have an important dimension, between 5 and 10% of PIB in most countries. As contract awards may be subject to some degree of bureaucratic discretion, and as most countries have long histories of bribes, commissions and connivance in takeover bids, more and more states are choosing procedures that ensure appropriate levels of openness, competition, equality of opportunity for suppliers or clarity in bidding.

Chile has used the latest technologies to create one of the most transparent public purchasing systems in the world (Saavedra, 2017). In 2003, Chile Compra was created, an electronic public purchasing and contracting system through an Internet platform, which has earned a worldwide reputation for quality, transparency, and efficiency. It serves businesses, public institutions, and citizens, and is the country's largest business relations website, with 850 purchasing organizations involved. In 2012, users made 2.1 million purchases and issued invoices worth $9.1 billion dollars.

In many of the measures presented to combat corruption, the central philosophy is the need to eliminate the opportunity for corruption by changing incentives, closing legislative loopholes and eliminating ill-conceived rules that encourage corrupt behavior. But a strategy that focuses on changing rules and incentives, with a punishment severe enough for those who commit offenses, will be much more effective if it is accompanied by efforts to strengthen the ethical and moral foundations of human behavior.

We will now try to propose a series of opinion form steps for each of the above observations in order to reach a final conclusion.

It is necessary to use a two-pronged strategy to increase honesty and the costs of corruption. We could start from the most basic of a government, its employees, directly into workers, contractors, engineers. For this, the excellent remuneration of each entity is made obligatory, of each individual following this conductive thread, the total of these expenses will be reflected in transparency. This is a way that the government of a given country takes to manage public resources, collecting taxes to go to markets, receive foreign aid and develop mechanisms to allocate resources to different needs, discriminating against them by priority.

Some countries strive to ensure the public interest objective, because the more open and transparent the process, the less likely there is to be an illegal activity and abuse.

Eliminating bureaucracy is a key point because of the correlation between the presence of corruption and the degree of bureaucracy. This relationship is a very valuable indicator to determine whether it is essential to eliminate the excess of unnecessary rules.

Public works contracts should be assumed and awarded only to the best technical and economic offers understudies that truly reveal their feasibility to avoid the loss of time in the course of the work, and therefore the injections of money for the completion of the work. This must be done in the midst of transparent and competitive processes, without marked letters, and in a clear and open manner.

Conclusions

This article makes a critical presentation of the problem of unfinished civil works in the city of Bogotá (Colombia), presenting some of the openly identified reasons for the problem, as well as some proposed solutions.

We can conclude that the unfinished works are a large number of futuristic works that have been stopped, or have not fulfilled the expectations promised in the project. For this and other reasons, the people of Bogotá are skeptical of what has been suggested to them for the improvement of the city. One of the most common reasons for the stoppage of these projects is the failure in contractual processes and the investment and loss of the capital stipulated to execute each work.

The necessary factor for proper planning in any public contracting process is real and effective knowledge about the need to be met. What is required to contract, how many resources are available, what are the terms of both budget execution and the requirements of the work needed by the community, and what are the factors that affect the development of the processes that are carried out? Likewise, foreseeable risks must be defined, estimated and assigned. In order to do this, the main means is historical observation, because knowing what has happened, defining the causes and effects, recognizing phenomena associated with the fulfillment of contracts and the execution of works within a rational framework of methodological strictness, it is feasible to define actions, protocols, manuals and intervention plans on the situations that may arise in the development of the contract. This must be reflected in the studies and documents prior to any state contract but is materialized throughout the administrative activity of contracting, which goes from the establishment of the need to when the terms of the guarantee are met.

The biggest problem in the inefficiency of works is contracting without studies or designs. The first thing is not to contract again without studies and designs, this has been a historical practice that has facilitated the modifications and multi-million contract extensions. Until the designs are completed, the cost of not having adequate studies should be that the development of the work cannot begin. This is a key point to counteract corruption in the works, however,

ISSN 1692-8407

is something that is recurrently used to continue to incur in money thefts.

Another important point is to reduce the levels of corruption. The transparency of state processes, the reduction of opportunities for corruption by employees, and the stimulation of ethical and moral attitudes at all levels play an important role here. Key elements are the reduction of unnecessary rules, transparent and public processes, ideally with the least direct contact with employees, and adequate remuneration of state workers.

References

Amaya, C. (2015). El principio de planeación en la contratación estatal, un principio no tipificado. *Revista Via Iuris*, *20*(1), 105-119.

Aponte, I. (2014). Las fallas de planeación y su incidencia en el contrato estatal de obra. *Revista Digital de Derecho Administrativo*, *11*(1), 177-207.

Argandoña, A., & Morel, R. (2009). *La lucha contra la corrupción: una perspectiva empresarial.* on line. (Cuadernos de la cátedra La Caixa de Responsabilidad Social de la Empresa y Gobierno Corporativo)

Campos, J., & Pradhan, S. (2009). *Las múltiples caras de la corrupción. aspectos vulnerables por sectores*. Banco Mundial en coedición con Mayol Ediciones S.A.

Cepeda, F. (1994). *Las causas de la corrupción.* on line. Retrieved from https://www.semana.com/nacion/articulo/las-causas-de-la-corrupcion/23515-3

Economía, B. (2016). *Más de $ 1 billón de pesos están en riesgo por 83 obras inconclusas.* on line. Retrieved from https://www.eltiempo.com/archivo/documento/CMS-16534744

Guerrero, O. (2017). *5 tips para evitar la corrupción en instituciones públicas.* on line. Retrieved from https://www.megapractical.com/blog-de-arquitectura-soa-y-desarrollo-de-/software/5-tips-para-evitar-la-corrupci%C3%B3n-en-instituciones-p%C3%BAblicas

López, A. (2014). *Cómo combatir la corrupción en 6 pasos.* on line. Retrieved from https://www.esglobal.org/como-combatir-la-corrupcion-en-6-pasos/

Martínez, F., Martínez, F., & Montiel, H. (2016). Automatic design of heat sink using genetic algorithms, lindenmayer systems and digital image processing. In *Eighth international conference on digital image processing (icdip 2016)* (p. 1-6).

Montenegro, A. (2011). *Corrupción en obras.* on line. Retrieved from https://www.elespectador.com/opinion/corrupcion-en-obras-columna-257926

Montiel, H., Jacinto, E., & Martínez, F. (2015). Generación de ruta óptima para robots móviles a partir de segmentación de imágenes. *Información tecnológica*, *26*(2), 145-152.

Montiel, H., Martínez, F., & Jacinto, E. (2017). Visual patterns recognition in robotic platforms through the use of neural networks and image processing. *International Journal of Applied Engineering Research*, *12*(18), 7770-7774.

Obras, B. (2017). *Obras inconclusas.* on line. Retrieved from https://www.google.com.co/search?q=obras+inconclusas&source=lnms&tbm=isch&sa=X&ved=0ahUKEwio2tHy593XAhVxluAKHSR6Dp4Q_AUICigB&biw=1366&bih=662#imgrc=_

Particular, A. (2014). *Las 50 obras inconclusas del distrito.* on line. Retrieved from https://www.semana.com/nacion/articulo/las-50-obras-inconclusas-del-distrito/388832-3

Redacción, B. (2016). *En bogotá hay 25 obras inconclusas que comprometen más de $ 956 mil millones.* on line. Retrieved from www.elespectador.com/noticias/bogota/bogota-hay-25-obras-inconclusas-comprometen/-mas-de-956-articulo-632553

Rengifo, J. (2012). Evolución de la planificación regional en colombia tendencias y perspectivas del desarrollo. In *Xii coloquio internacional de geocrítica* (p. 1-18).

Saavedra, N. (2017). *Augusto lópez-claros, un enamorado del neoliberalismo a la chilena.* on line. Retrieved from https://m.elmostrador.cl/mercados/2018/01/15/1219071/

Sotomayor, L. (2015). Equitable planning through territories of exception: the contours of medellin's urban development projects. *International Development Planning Review*, *37*(4), 373-397.

Sour, L. (2017). Gobierno electrónico y corrupción en méxico (2005-2010). *Revista Innovar Journal*, *27*(66), 123-136.

Torres, J., & Santander, J. (2013). *Introducción a las políticas públicas: Conceptos y herramientas desde la relación entre estado y ciudadanía*. IEMP Ediciones.

Vernot, A. (2016). on line. Retrieved from http://www.wradio.com.co/noticias/bogota/ma769s-de-956-mil-millones-comprometidos-/en-25-obras-inconclusas-en-bogota769/20160516/nota/3134794.aspx

Vitola, O. (2017). *La fiscalía hace inspecciones judiciales en obras inconclusas en el distrito de santa marta.* on line. Retrieved from http://radiomagdalena1420am.com/la-fiscalia-hace-inspecciones-judiciales-/

en-obras-inconclusas-en-el-distrito-de-/
santa-marta-entre-ellas-centros-de-salud/

Tekhnê
July - December 2017, Vol. 14, No. 2, pp. 23 – 42

ISSN 1692-8407

More than garbage at the Doña Juana Landfill

Más que basura en el Relleno Sanitario Doña Juana

Fabián López
Universidad Distrital Francisco José de Caldas
Rick.lopez22@gmail.com

Karol Maca
Universidad Distrital Francisco José de Caldas
Karol.maca9906@gmail.com

Lisney Gordillo
Universidad Distrital Francisco José de Caldas
Karem.l.gordillo@gmail.com

This article details the mismanagement of organic waste and other residues of different kinds that arrive at the Doña Juana Landfill. Bad procedures and bad decisions have been identified in the problem due to the area where it is located and the design of the landfill. The recognition of all types of waste that arrive at the sanitary landfill should be done, and based on the conflicts that have been generated inside and outside the landfill, a better solution should be sought, so that the environmental impact is as small as possible, and the quality of life of the families that live in the periphery should be improved.

Keywords: Doña Juana Landfill, environmental impact, organic waste

Este artículo detalla el mal manejo de los residuos orgánicos y otros residuos de diferente índole que llegan al Relleno Sanitario Doña Juana. Se han identificado en el problemas, malos procedimientos y malas decisiones debido a la zona donde está ubicado y al diseño del mismo. Debe realizarse el reconocimiento de toda la clase de desechos que llegan al relleno sanitario, y con base en los conflictos que se han generado dentro y fuera del relleno, se debe buscar una mejor solución, para que el impacto ambiental sea lo menor posible, y mejorar la calidad de vida de las familias que habitan en la periferia.

Palabras clave: Impacto ambiental, Relleno Sanitario Doña Juana, residuos orgánicos

Article typology: Research

Date manuscript received: November 27, 2017
Date manuscript acceptance: December 8, 2017

Research funded by: Universidad Distrital Francisco José de Caldas.

How to cite: López, F., Maca, K., Gordillo, L. (2017). *More than garbage at the Doña Juana Landfill*. Tekhnê, 14(2), 23 -42.

Introduction

This article has been created with the intention of giving information to the reader about the events that occurred due to a bad management and distribution of the waste thrown in the Doña Juana Landfill. We will tell the story, how it was originated and all the problems that it has caused, for example, giving rise to the generation of diseases in the inhabitants of the areas and the flooding of pests like flies and rats. Even landslides that caused the stream that passed through this place was contaminated ceasing to be useful for agriculture that was carried out there, besides this also make known a possible solution for the use of these with alternative energy as it has been biogas which brings many advantages both environmental and economic in a community, besides being something aesthetic view of the inhabitants.

Of course, it is not only the fault of the people in charge of the landfill, since all these problems also derive from another hand that is the same inhabitants of the department of Cundinamarca due to the lack of culturalization and appropriation of the land, there are still many people who in spite of knowing the consequences of not recycling and following the campaigns that have been made on the classification of the garbage in industries as well as in homes, still make the mistake of not doing it, which makes things difficult when the waste arrives to the garbage trucks and from there to the dump, It is clear that we cannot leave aside the need to consume and produce food and even technology since this is what moves trade and the world, and this is where biogas comes in as the alternative energy we need since with this we can take advantage of organic waste to light homes, industries, heat and fuel for the different machines that have already been and will be created by the human being, of course you have to know how they work and how to obtain this, and what you get, and this is what we will show here, a mantle of concepts and knowledge of which you were probably unaware and could change your way of thinking about the waste coming out of your company or home.

What is a landfill?

A sanitary landfill is understood as a facility for the final disposal of solid waste that cannot be recycled or used, designed to minimize environmental impacts and reduce the health risks potentially generated by such waste (Arias & Buitrago, 2012).

The safe and reliable final disposal of non-recyclable and non-usable solid waste is a fundamental component in the integral management of solid waste, made up of four elements whose hierarchical order is reduction at source, use and valorization, treatment and transformation and finally controlled final disposal. For this purpose, it is important to develop the stages of planning, design, construction, operation, decommissioning, adaptation and final use that the adequate management that a sanitary landfill implies (Arias & Buitrago, 2012).

The selection of the method to be used for the operation of a landfill should be made based on the topographical, geotechnical and hydrogeological conditions of the site selected for the final disposal of the waste. The stratigraphic profile of the soil and the level of the groundwater aquifers must be established.

Stratigraphic profile and groundwater level

Stratigraphy is a branch of geology that studies rocks taking into account the temporal sequence and the materials that constitute them; therefore stratification is the way sedimentary rocks are deposited according to the agent and the sedimentary environment (Pasotti, 2017).

The stratigraphic profile (Fig. 1) is the one made from drilling data, geophysical prospecting data, or natural or artificial terrain cuts that show the rocks that make up the stratigraphic column, through which the subsoil stratigraphy can be reconstructed, according to the depth required by the project (Galvis, 2016; Sanjuan, 2012).

The phreatic level (Fig. 2) is a fundamental concept in hydrogeology, which is the branch of geology dedicated to the study of surface and underground water cycles. The phreatic level (water table) is the geometric location of the points where the water pressure is equal to the atmospheric pressure. The phreatic level is defined by the levels reached by the groundwater in observation wells. When water moves through pores and voids under the effect of gravity and meets an impermeable layer, it can be stored, leading to the formation of aquifers (*Nivel freático del suelo*, 2017).

An aquifer is a body of saturated rock through which water can easily move, according to the Idaho Museum of Natural History. Water moves through the pores of the rock. Aquifers can be considered confined or enclosed. The bottom of a free aquifer is a layer of porous rock, which restricts water flow, creating a barrier to the aquifer. The phreatic level is the upper layer of the unconfined aquifer (Quiroz, Martínez, & Massone, 2012; Varni, Zeme, Weinzettel, & Dietrich, 2014).

Suggested methods to be used

Trenching method. This method is used in flat regions and consists of periodically digging trenches two or three meters deep with a backhoe or a crawler tractor. The solid waste is deposited and accommodated within the trench and then compacted and covered with the excavated soil (Fig. 3).

Special care should be taken during rainy periods as water may flood the ditches. Therefore, perimeter channels must be built to capture and divert the water and even provide the ditches with internal drainage. Its slopes or walls must be cut according to the angle of rest of the excavated soil.

ISSN 1692-8407

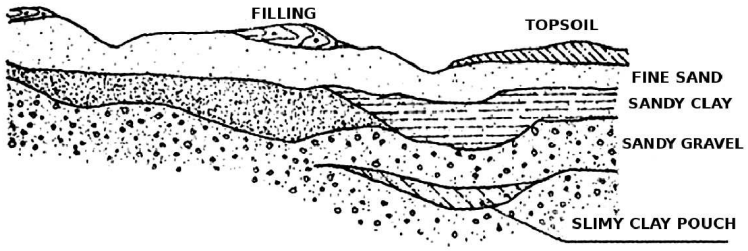


Figure 1. Stratigraphic soil profile.

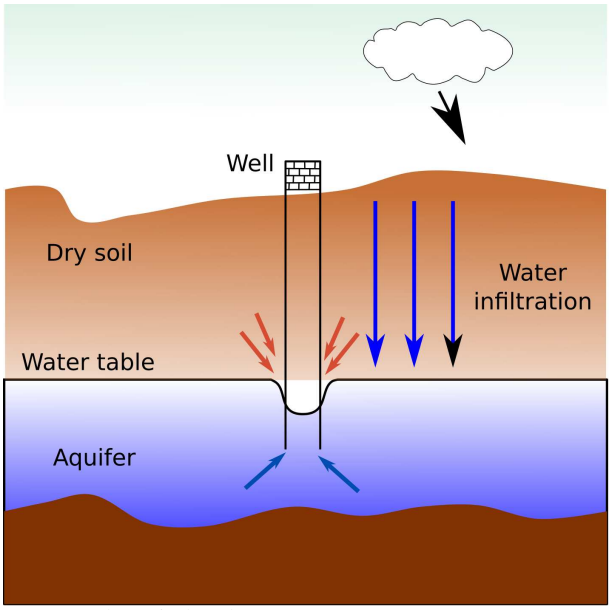


Figure 2. Phreatic level.

Trenching requires favourable conditions with regard to both the depth of the water table and the type of soil. Soils with a high water table or very close to the surface are not suitable because of the risk of contaminating the aquifer. Rocky soils are also unsuitable because of the difficulties of digging (Pagano, 1964).

Area method. In relatively flat areas, where it is not feasible to dig pits or trenches to bury the garbage, it can be deposited directly on the original soil, which must be raised a few meters, after waterproofing the ground (Fig. 4). In these cases, the covering material should be transported from other sites or, if possible, removed from the surface layer. The pits are built with a gentle slope on the slope to prevent slippage and to achieve greater stability as the fill is raised (Pagano, 1964).

It is also used to fill in natural depressions or abandoned quarries a few meters deep (Fig. 5). The covering material is excavated from the slopes of the land or, failing that, from a nearby place to avoid the costs of haulage. The operation of unloading and construction of the cells must be started from the bottom up.

The landfill is built by supporting the cells on the natural slope of the land, i.e. the waste is dumped at the base of the slope, spread out and pressed against it and covered with a layer of soil every day. The operation is continued by advancing on the land, maintaining a gentle slope of about 18.4 to 26.5 degrees on the slope, i.e. the vertical/horizontal ratio of 1:3 to 1:2, respectively, and 1 to 2 degrees on the surface, i.e. 2 to 3.5% (Pagano, 1964).

Combined method. Since these two methods of landfill construction have similar operating techniques, it is possible to combine both to take advantage of the land and cover material (Fig. 6).

For medium and low levels of complexity, the landfill must be reached by a public access road, which must be a main road of permanent use and must meet acceptable design conditions.

For high and medium-high levels of complexity, the layout of the internal routes must take into account the dimensions of the cells, sub-modules and modules, the operating methodology and the climatic conditions, such that the waste must be received under all conditions.

External roads must meet at least the following specifications: Access to the landfill must be on a public road, must be of permanent layout and must guarantee transit at any time of the year for all types of vehicles that come to the landfill.

With the creation of a sanitary landfill it is important to take into account the environmental quality criteria related to the disposal of solid waste since it is necessary to follow them up in detail. Among them are:

- The impact of gas emissions on the greenhouse effect.
- Uncontrolled generation of leachates, producing surface and ground water contamination.
- Risks and threats caused by instability of the filling.
- Uncontrolled escape of gases that can migrate away from the landfill site, producing bad odors and potentially dangerous conditions.
- Reproduction of sanitary vectors due to inadequate operation of the landfill, with risk to health (Arias & Buitrago, 2012).

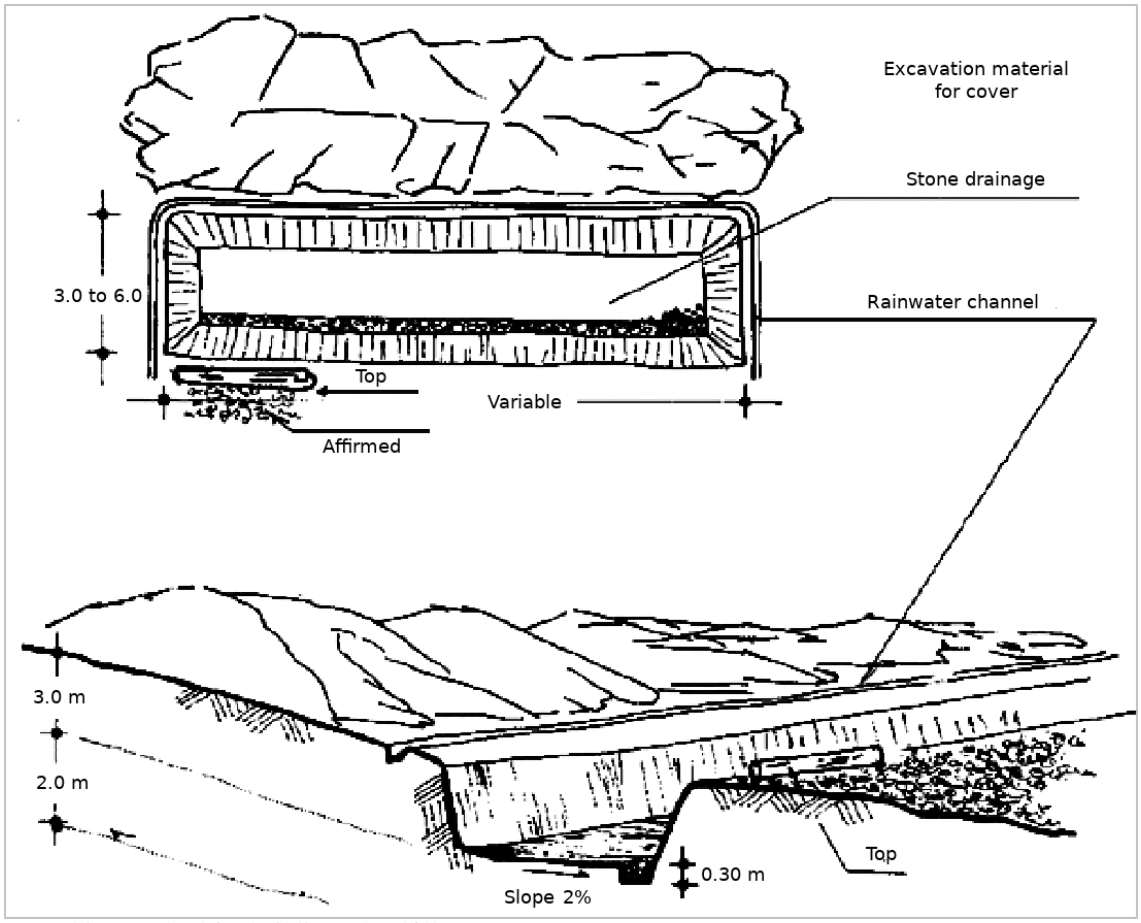


Figure 3. Trenching method for building a landfill.

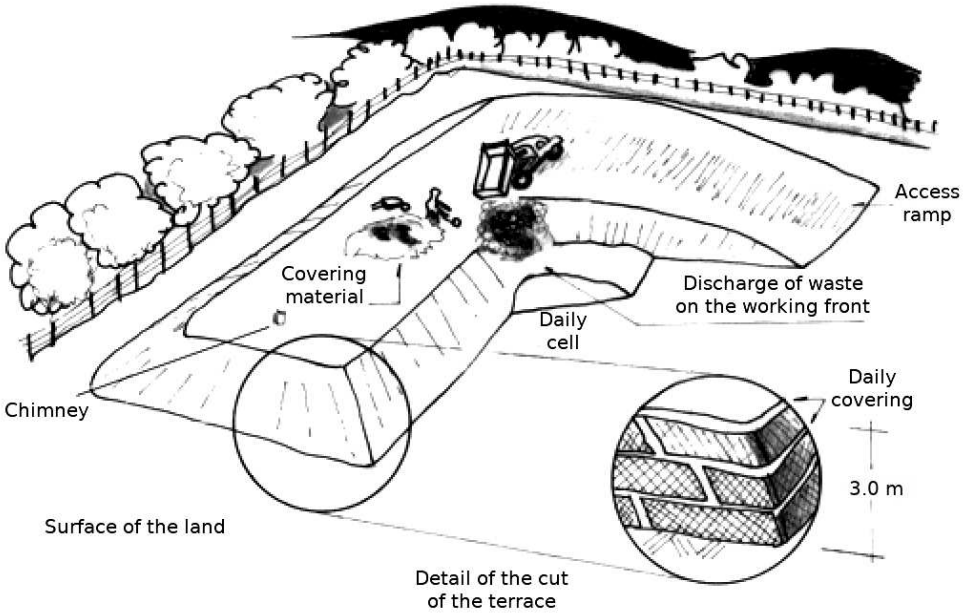


Figure 4. Area method for building a sanitary landfill.

ISSN 1692-8407

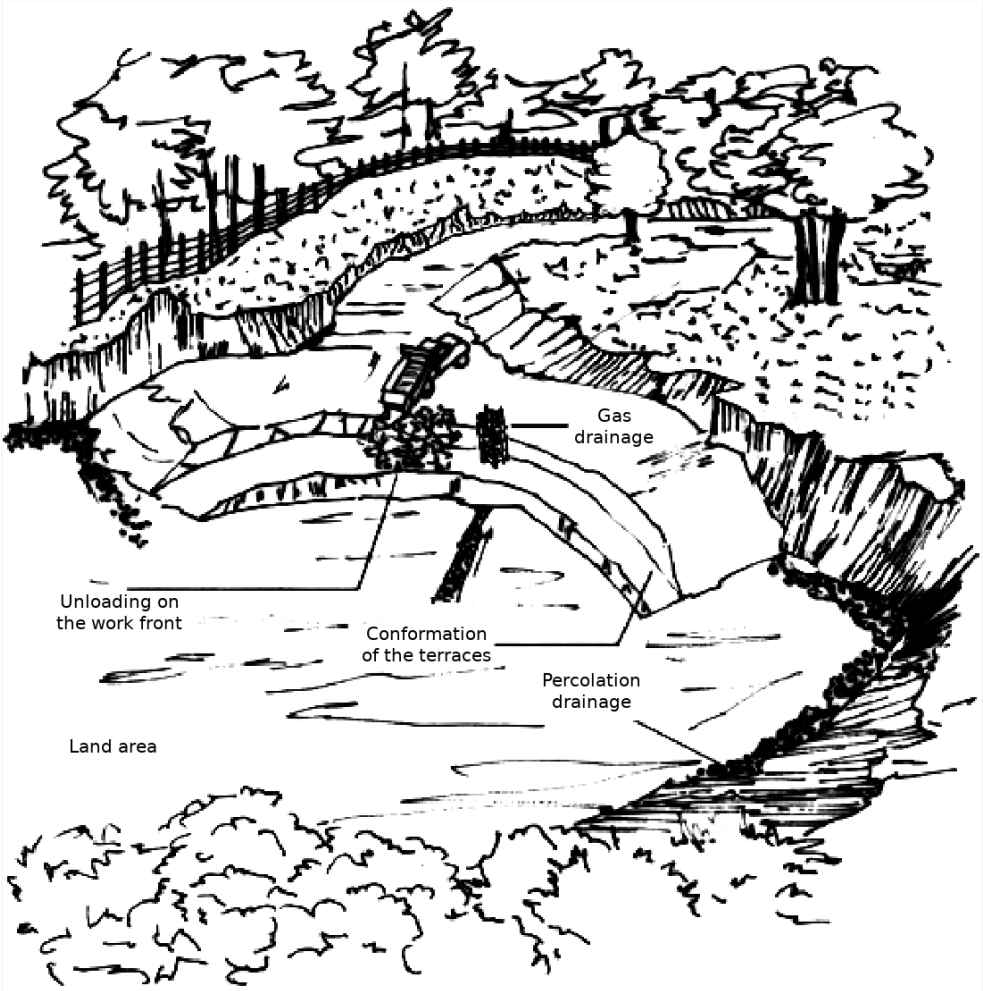


Figure 5. Area method for filling depressions.

Environmental control in the operation of landfills

An environmental monitoring program must be implemented in the operation of the landfills, covering them with ground and surface water, biogas and airborne particles. This must include measurement and control of the impacts generated at the final disposal site.

The frequency of monitoring should be related to the level of complexity of the landfill, depending on the population served by the system.

The parameters to be determined in the aquifer monitoring program are: pH, electrical conductivity, dissolved oxygen, heavy metals, COD, BOD5, organic matter, ammonia, nitrites and nitrates. For medium-high and high complexity levels, aquifers should be monitored with a half-yearly sampling frequency, and those of low and medium complexity with an annual sampling frequency.

1. **COD**. The Chemical Oxygen Demand (COD) determines the amount of oxygen required to oxidize organic matter in a water sample, under specific oxidizing agent, temperature and time conditions (Kolb, Bahadir, & Teichgraber, 2017).

2. **BOD5**. Biochemical oxygen demand - 5 days in water. It is a measure of the amount of oxygen used by microorganisms in the stabilization of biodegradable organic matter, under aerobic conditions, in a period of five days at 20^oC (Dasgupta & Yildiz, 2016).

The parameters that must be determined in the Biogas Monitoring Program are Biogas composition (CH_4, CO_2, O_2) that must be done bimonthly for the Medium-High and High complexity levels. The explosiveness must be daily for the High complexity level and monthly for the Medium-High complexity level.

The parameters to be determined in the Aero Transportable Particle Monitoring Program are Total Suspended Particles and Respirable Particles. The monitoring of these must be monthly for the Medium-High and High complexity levels and half-yearly for the Medium complexity level (Arias & Buitrago, 2012).

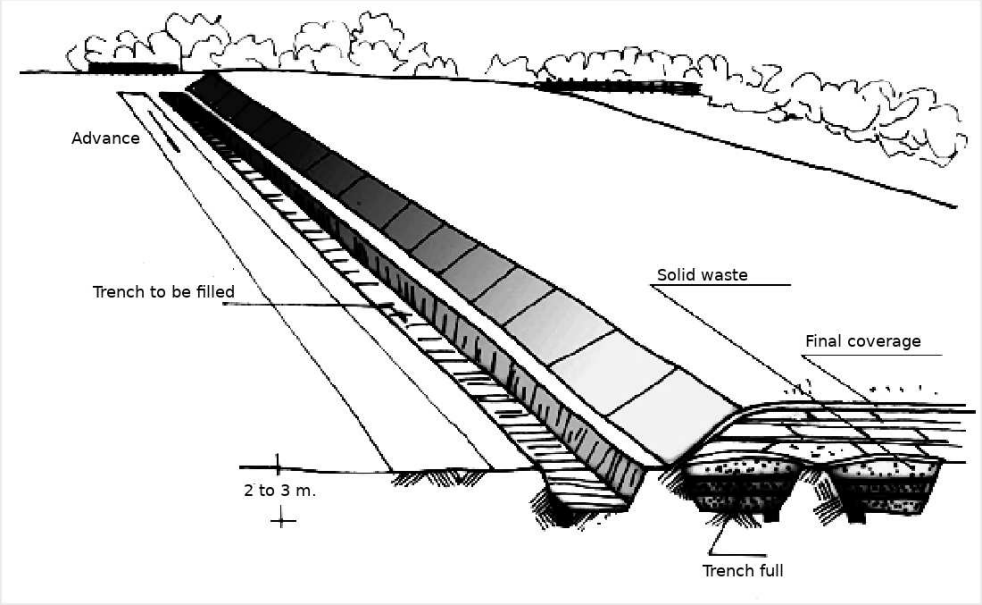


Figure 6. Combination of methods to build a landfill.

With these parameters, the aim is to have an adequate control of the operation of sanitary landfills, avoiding the emergence of environmental problems that trigger social and health problems.

Doña Juana landfill

The Doña Juana landfill is located in an urban and rural area of the Capital District of Bogotá, and in particular in the town of Ciudad Bolivar, south of the Sabana de Bogotá, in properties located on the left bank of the Tunjuelo River, along the highway to Villavicencio (Fig. 7) (Quintero, 2016).

Doña Juana has a total area of 456 hectares, of which only forty percent (40%) is used for solid waste disposal, divided into eight zones, where the conventional solid waste and hospital waste disposal stages have been implemented (L. Caicedo, 2016; Quintero, 2016).

The sanitary landfill currently has an average of 6,000 tons of waste per day (Murcia & Rodriguez, 2017) and an average of 180,000 tons per month; among these are household waste (65%), sweepings (6.4%), industrial waste (10.3%), rubble (10.8%), green waste (0.34%) and others (1.10%) (L. Caicedo, 2016).

The Mochuelo Alto was not always a designated area for what is now known as the Doña Juana dump, before, according to some inhabitants of this sector, it was a terrestrial part of the La Fiscala farm, where they grew onions, peas, barley and other crops to later go to trade in Bogotá, these crops were irrigated by several streams that passed through the area. Many of the inhabitants of here were no more than peasants, and Mochuelo only had approximately 30 houses that for the view of the district was like seeing an almost null population, this was an influential factor in the construction of the dump in the sector, besides having a quite open land and with abundance of clay which is a good cheap waterproofing.

The landfill was not originally planned to be built in that area, in fact, before that, three landfills were planned in Usaquén, Corabastos and Alicachín, which in the end were not carried out; and due to the high environmental pollution and accumulation of garbage in the city of Bogotá and surroundings (after the old dumps of Gibraltar and El Cortijo were closed), caused by the high production of waste from almost 3 million people, children and animals. And the need for a solution to this problem; the well-known Landfill (Botadero) Doña Juana was born on November 1, 1988 in the wide sector already mentioned Mochuelo in the town of Ciudad Bolivar, almost only 500 meters from Mochuelo Alto.

As a result, the landscape and life of the Mochuelo changed, and the area that was once one was divided into what we now know as the high and low Mochuelo, where the latter became increasingly populated due to the migration of recyclers and displaced persons, thus changing the landscape with the construction of tin and brick houses. By 1997 Doña Juana suffered a collapse of almost one million tonnes of waste, which was comparable to the amount of waste produced in half a year in the city, marking the beginning of a wave of events unfavourable to the population (Fig. 8). With the collapse of Zone II, which received waste from October 1995 to September 1997, the construction of the second phase of the Doña Juana landfill began, with Zone III and IV set up as an emergency zone for the collapsed waste (B. Caicedo, Giraldo, Yamin, & Soler, 2002).

ISSN 1692-8407

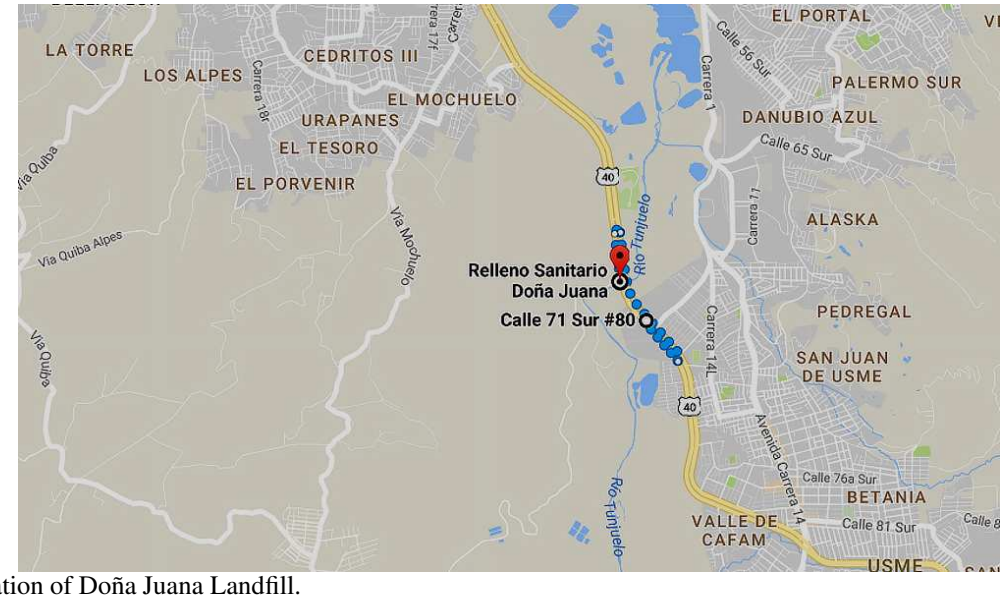


Figure 7. Location of Doña Juana Landfill.

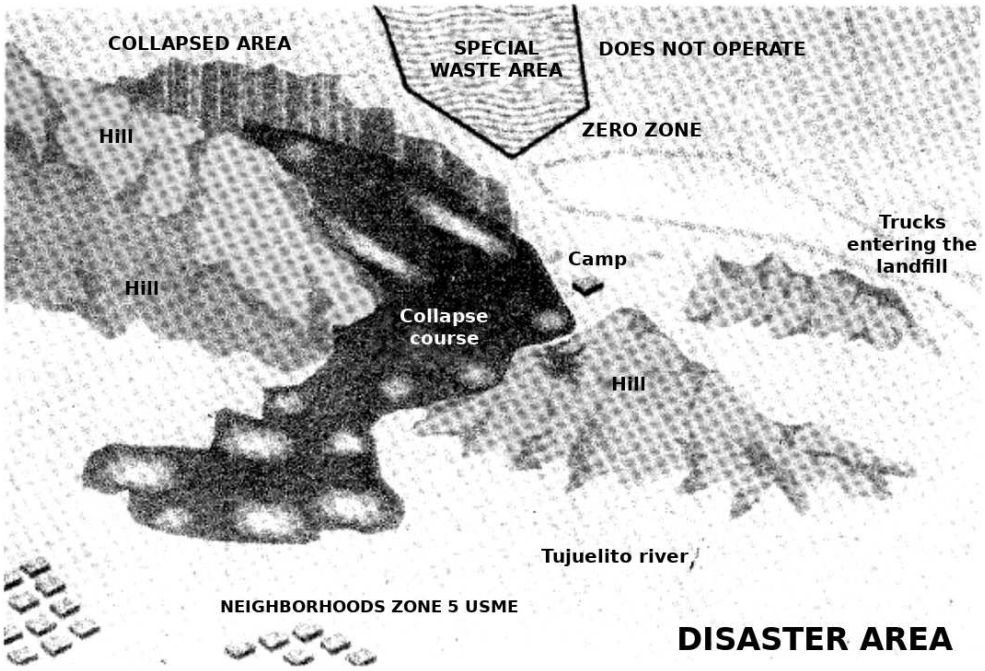


Figure 8. Doña Juana Landfill operation.

Conflicts generated by the Doña Juana landfill

The Doña Juana landfill has had several areas of operation since the beginning of its operations. Zone II received waste from October 1995 until 27 September 1997, when approximately one million tonnes of waste collapsed out of the three million tonnes that had been disposed of. This area had been estimated to have a useful life of approximately 4 to 5 years, but it was in operation for 1.5 years. Leachate management was carried out by recirculation within the waste mass, so the system depended on the proper functioning of the drainage system that maintained a balance between the amount of liquid entering and leaving. The system failed producing an increase in the pressure of liquids and gases in the pores of the waste mass, which caused changes in the characteristics of the material and, given the geometric configuration of design, the material became unstable and the cell collapsed, damming the Tunjuelito River (Fig. 9).

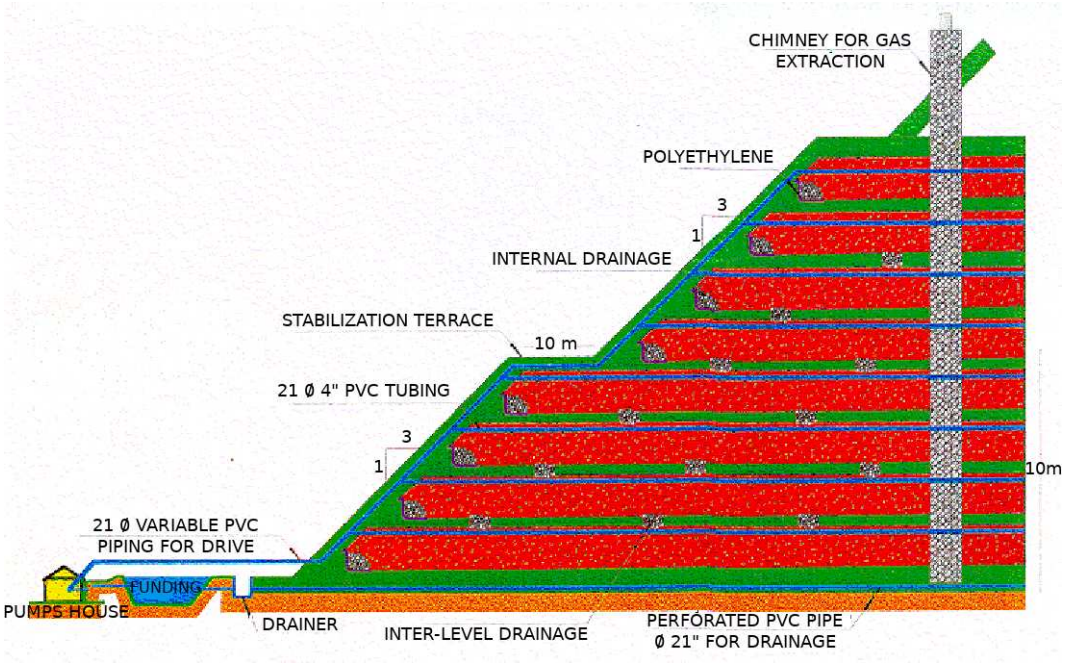


Figure 9. Landfill.

The emergency action plan consisted of: monitoring the stability of the refilled zone and the landslide zone; monitoring surface waters (leachates and the Tunjuelito River); monitoring gases that produce odors (H_2S and NH_3); monitoring methane gas; monitoring radioactive elements; attending to community consultations; and attending to public order. The firm SCS Engineers designed and put into operation a new zone, Zone IV. The design included leachate management through recirculation and gas management with PVC stacks at all levels of waste.

Currently the affected area was organized into three areas, as follows: Area 1, as of July 1998, restored, closed and re-vegetated. Area 2, arranged with part of the waste committed in the collapse, closed, re-vegetated and with a system of forced gas extraction. Area 3, disposed of with a percentage of waste committed in the collapse, closed and re-vegetated (B. Caicedo et al., 2002).

The materials that arrive at a sanitary landfill are of multiple natures and characteristics within which generally they are biodegradable materials, like all the organic compounds coming from animal or vegetal remainders, others coming from hospitals, factories, laboratories, electrical companies and chemical products, that must have a suitable handling by their dangerousness in the affectation of the environment and that attempts against the survival of many organisms and the human being by their high toxicity and contamination of the air and the water.

There are other materials coming from plastics that are not biodegradable and that remain without decomposition for a long time. In addition to these, there are many other materials and residues of other chemical substances used on crops such as herbicides, fungicides, fertilizers and in general that are used in agriculture.

This countless substances or materials interact with each other when mixed in large quantities to form a mixture of biodegradable crops and pollutants that are very harmful to ecosystems. It should be noted that all organic substances through time suffer a natural decomposition becoming especially substances such as hydrocyanic acid (HCN), hydrogen sulfide (H_2S), ammonia (NH_3), and gases such as methane (CH_4), ethane (C_2H_6) and propane (C_3H_8) which under normal conditions tend to be in a gaseous state that accumulates within the empty spaces of the decomposing substances, in which factors such as temperature, pressure, humidity and bacteria intervene, in addition to the presence of other substances.

Accumulated liquids of different types such as water, alcohol, oils, gasoline, paints are mixed in some way to form a large liquid mass that accumulates at the bottom of the deposited waste and accumulates over time increasing its volume if they do not have a good drainage process.

These factors accumulated in a place like Doña Juana's landfill generate great pressures on the bottom and the walls of the place where they are located and as the volume of the liquid and the quantity of the accumulated gas increases, the pressure increases in a considerably very high magnitude, these forces of great proportions unbalance the system and for some place that these pressures are not supported they become a time bomb, that at some moment for a telluric or vibratory movement they generate spaces that allow a great

ISSN 1692-8407

explosion throwing to great distances all the materials there accumulated.

Waste

Solid waste is all those materials or remains that have no economic value for the user, but do have a commercial value for recovery and incorporation into the life cycle of the material. Solid waste is a material or set of materials resulting from any process or operation that is intended to be disused, not to be used, recovered or recycled (Lee, Han, & Wang, 2017).

Chemical and physical characteristics

The characteristics of solid waste vary according to the dominant activity (industrial, commercial, tourism, etc.), the habits of the population such as rhythms, customs, food, habits, consumption patterns and climate mainly.

In order to determine the characteristics of solid waste in a given location, it is necessary to make periodic determinations (no more than 10 years on average) of the following aspects.

Physical characteristics.

1. **Gravimetric composition**. The percentage weight of each component in relation to the total weight of the waste handled, expressed as a percentage.
2. **Specific weight**. This is the ratio of the weight of the waste to the volume it occupies, expressed in kg/m^3. Its determination is fundamental for the dimensioning of equipment and installations (Arias & Buitrago, 2012).
3. **Compressibility**. Also known as degree of compaction, it indicates the reduction in volume that a certain mass of waste can undergo when it is subjected to a certain pressure, expressed as a percentage (Arias & Buitrago, 2012).
4. **Per Capita Production**. It relates the amount of waste generated daily by an inhabitant of a given region. It is expressed in kg/inhab-days (Arias & Buitrago, 2012).

Chemical characteristics.

1. **Calorific power**. Indicates the potential heat capacity that a material can give off when it is burned. This is an important parameter to determine the possible elimination method, basic parameter for an incineration treatment and to establish an energy balance in a pyrolysis process (Kcal/Kg) (Arias & Buitrago, 2012).
2. **Hydrogen potential (pH)**. Indicates the degree of acidity or alkalinity of the residues (Arias & Buitrago, 2012).
3. **Chemical composition**. It is important to know the percentages of ash, organic matter, carbon, nitrogen, humidity, potassium, carbon/nitrogen (C/N) ratio, calcium and phosphorus among others to define types of treatments applicable to the waste (Arias & Buitrago, 2012).

Waste classification

Separation at source is an activity that must be carried out by the generator of the waste in order to select it and store it in containers or recipients to facilitate its subsequent transport, use, treatment or disposal. This guarantees the quality of the waste that can be used and facilitates its classification (Figs. 10 and 11).

Figure 10. Classification of solid waste.

The waste is the result of domestic, commercial, industrial, institutional and service provision activities, among others (Fig. 12) (Amasuomo & Baird, 2016).

Hazardous waste. It is that which by its infectious, toxic, explosive, corrosive, flammable, volatile, combustible, radioactive or reactive characteristics can cause risk to human health or deteriorate the environmental quality to levels that cause risk to human health. Hazardous waste is also waste that, without being in its original form, is transformed by natural processes into hazardous waste. Likewise, containers, packages and packaging that have been in contact with them are considered hazardous waste (Kattel et al., 2016).

Solid waste or scrap. It is any object, material, substance or solid element resulting from the consumption or use of a good in domestic, industrial, commercial, institutional or service activities, which the generator abandons, rejects or delivers and which is susceptible to use or transformation into a new good, with economic value or final disposal. Solid waste is divided into usable and non-usable. Similarly, solid waste is considered to be waste from the sweeping of public areas (Kattel et al., 2016).

Usable solid waste. It is any material, object, substance or solid element that has no direct or indirect use value for whoever generates it, but that is susceptible to incorporation into a productive process (Kattel et al., 2016).

Unusable solid waste. It is any material or solid or semi-solid substance of organic or inorganic origin,

Figure 11. Waste classification.

Figure 12. Residues or solid wastes.

putrescible or not, coming from domestic, industrial, commercial, institutional or service activities, which does not offer any possibility of use, reuse or reincorporation in a productive process. These are solid wastes that have no commercial value, require treatment and final disposal and therefore generate disposal costs (Kattel et al., 2016).

Leachate

Leachate is the liquid waste generated in a landfill (Fig. 13). It comes from two sources:

- Percolation water: water of external origin, generally from rain, percolates through the landfill, resulting in the output of water loaded with organic and inorganic pollutants.
- Generation water: the fermentation processes that occur inside the waste produce the generation of water that percolates in a similar way to the previous case.

Percolation is a natural phenomenon that scientists and water managers can calculate and use to ensure that surface and groundwater is free of contaminants and also to ensure that water intended for human consumption is safe (Rasool et al., 2016).

Organic and inorganic compounds are solubilised in these waters, which form the leachate from the solid waste disposal site. It can be estimated that 25% of the average precipitation is converted into leachate. Leachates have a strong pollutant load as a characteristic (Li et al., 2017).

Under normal conditions the leachates are located at the bottom of the landfill, from there they move through the layers by means of lateral movements depending on the characteristics of the surrounding material. In this process, many of the chemical and biological components that were originally part of the waste are removed by the liquids emanating through the landfill. Some studies have been carried out on the composition of the water that percolates through a landfill, and these show that this water serves as a vehicle for pathogenic germs, in addition to contaminating the groundwater by incorporating heavy metals, among other pollutants (Pan, Lei, Liu, Wei, & Liu, 2017).

The leaching rate of leachate from the bottom of the landfill can be estimated using Darcy's law, which is expressed as follows:

$$Q = -KA\frac{dh}{dl} \tag{1}$$

Where:

- Q = Leachate discharge per unit of time, m^3/year.
- K = Permeability coefficient, m^3/m^2.year.
- A = Profile area through which the leachate flows, m^2.
- dh/dl = Hydraulic gradient, m/m.
- h = Pressure drop, m.
- l = Length of flow path, m.

The negative sign in Darcy's law comes from the fact that the charge loss, dh, is always negative. Leachate control is carried out by placing drainage lines at the bottom of the landfills, having previously waterproofed the lower surface of the soil with material suitable for this purpose. The contribution to the total volume of leachate from water entering the landfill through the surface can be calculated using Darcy's equation (**?**).

The waste, especially the organic ones, when compacted by heavy machinery, releases water and organic liquids, contained in its interior, which drains preferably towards the

ISSN 1692-8407

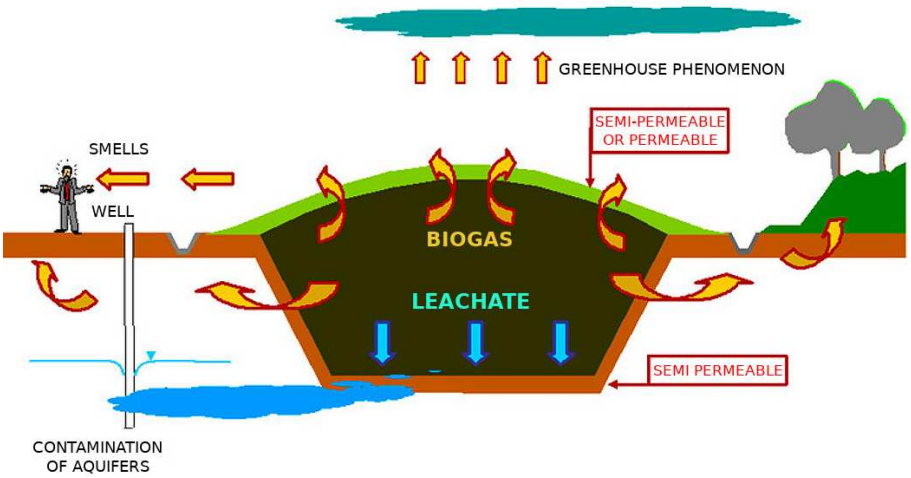


Figure 13. Leachate in a sanitary landfill.

base of the cell. The waste, which acts to some extent like a sponge, slowly recovers some of these liquids when the pressure of the machinery stops, but some of it remains at the base of the cell.

On the other hand, anaerobic decomposition quickly begins to act in a landfill, producing changes in organic matter, first from solids to liquid and then from liquid to gas, but it is the liquefaction phase that helps to increase the liquid content in the landfill, and at the same time its polluting potential.

At that point, the waste can be considered to be completely saturated and any water, either groundwater or surface water, that infiltrates the landfill will leach through the waste carrying with it suspended solids, and organic compounds in solution. This heterogeneous mixture, with a high potential for contamination, is what is called leachate or percolated liquid.

Leachate control is among the main requirements for the construction and operation of an organized landfill. Almost all contaminated sites and significant water contamination originate from uncontrolled leachate infiltration into the ground, and from there into the groundwater or a source (Alpaos & Moretto, 2016).

Although the composition of the leachates varies, in general, they are classified into three groups according to the age of the filler: fresh, intermediate and stabilized (Moody & Townsend, 2017).

The organic and inorganic contaminants in the leachate come from the solubilisation of the wide range of materials deposited in the landfill and from the products of the successive reactions of chemical, physical and biological processes that take place there. As a result these leachates have varying concentrations of toxic organic and inorganic and microbiological compounds (He et al., 2016).

But it is generally known that most contamination corresponds to organic matter, which is characterized by global parameters such as chemical oxygen demand (COD), which can vary from a few hundred to several tens of thousands of mg/L (Kaur, Mor, & Ravindra, 2016).

Fillers at an early stage of small methanogenesis emit more acid leachates containing high concentrations of fatty acids, the leachates produced in the older fillers have an active methanogenesis and therefore have a content of high molecular weight compounds (Moody & Townsend, 2017).

Methanogenesis

It's the production of methane by microorganisms. This is a very widespread and important type of microbial metabolism. There are several forms of methane production by microorganisms:

- The production of methane by reducing CO_2 is a type of anaerobic respiration. Methanogens do not use oxygen to breathe, as oxygen inhibits their growth. Therefore, generally this reaction is carried out from carbon dioxide (CO_2) and hydrogen (H_2), where CO_2 is an electron acceptor that is reduced thanks to the electrons supplied by H_2.
- The production of methane from organic molecules. Methanogenic bacteria can also produce methane from organic substrates such as acetic acid, methanol, methylamine, dimethyl sulfide and methane thiol. Using 14C, it has been shown that methane originates exclusively from methyl carbon in acetic acid.

$$CH_3COOH \longrightarrow CH_4 + CO_2 \quad (2)$$

In this phase the bacteria convert the acetic acid into methane and CO_2. As the acids and hydrogen gas produced by the acid formers are converted to CH_4 and CO_2, the pH inside the landfill will rise to more neutral values, in the range of 6.8 to 8. The pH of the leachate will rise, and

the concentrations of BOD5 and COD and the conductivity value of the leachate will be reduced. With higher pH values there are fewer inorganic constituents left in the solution and, as a result, the concentration of heavy metals present in the leachate will also be reduced.

Maturation and stabilization

This phase occurs after the inorganic biodegradable material CH_4 and CO_2 is converted. During this phase, the rate of generation of the landfill gas decreases significantly, because most of the nutrients have been separated with the leachate during the previous phases, and the substrates left in the landfill are slowly degraded. The main landfill gases during this phase are still CH_4 and CO_2. Depending on the sealing measures of the landfill, small amounts of nitrogen and oxygen may also be found in the landfill gas. During the maturation phase, the leachate will contain humic and fulvic acids, which are difficult to degrade biologically. Eventually, conditions may become aerobic again and this is when the landfill is stabilized (Arias & Buitrago, 2012).

Therefore, in the stabilized leachates, the fundamental components of the organic matter are the humic substances of high molecular weight; the rest of the components are compounds of low molecular weight, aromatic, aliphatic, phenolic, etc., considered toxic. The elimination of these organic compounds, which are generally very refractory to traditional treatment methods, is important because humic materials increase the presence of heavy metals such as cadmium, nickel and zinc in groundwater. Moreover, humic substances are the fundamental precursors of trihalomethanes which are proven carcinogenic compounds.

Trihalomethanes

Trihalomethanes are substances that are formed in the process of making water drinkable by reacting the organic matter contained in it with chlorine. The amount of trihalomethanes generated will depend on the dirt that persists in the water after the phase of elimination of the organic load that the water contains prior to purification.

Trihalomethanes are generated in the water purification process as a result of the chemical reaction that occurs when the natural organic matter present in the water comes into contact with the chlorine added as a disinfectant.

In this reaction three of the four hydrogen atoms of the methane molecules are replaced by halogen atoms, forming new compounds such as chloroform, dibromochloromethane, bromoform and bromodichloromethane, which are generically called trihalomethanes.

Chemical reactions

Two general types of chemical reactions take place within the mass of decomposing solid waste in a landfill.

- The first of these is the oxidation reactions due to the oxygen trapped in the disposed waste.
- The second type of acid-metal reaction, due to the presence of organic acids and CO_2.

These processes mobilize the metal ions and salts that are the potential contaminants. However, once the methane generation is established in the filler (Methanogenesis) less acid is generated and metals are generally retained.

Physical reactions

The effects of water when it comes into contact with the waste disposed of favour the dissolution of soluble materials, which become available for absorption and adsorption processes.

Usefulness

The term utilization refers to the process by which, through an integral management of solid waste, the recovered materials are reincorporated into the economic and productive cycle in an efficient manner, through reuse, recycling, incineration for energy generation purposes, composting or any other modality that entails health, environmental and/or economic benefits, according to Decree 1713 of 2002 of the Colombian Constitution.

A landfill is a biochemical reactor, with waste and water as the main inputs, and landfill gas and leachate as the main outputs. The material stored in the landfill includes: partially biodegraded organic material and other inorganic materials from the waste originally placed in the landfill.

Gas control systems are used to prevent undesirable movement into the atmosphere, or lateral or vertical movement through the surrounding soil. The gas recovered from the landfill can be used to produce energy, or it can be burned, under controlled conditions, to reduce the emission of harmful constituents into the atmosphere. The gases found in a landfill, according to various researchers in the field, are: carbon dioxide, carbon monoxide, hydrogen, hydrogen sulfide, methane, nitrogen and oxygen, as well as volatile fatty acids.

Biogas

Biogas is a gas composed of almost 60% methane (also known as natural gas) and 40% carbon dioxide, contains minimal amounts of other gases, including hydrogen sulfide (a compound whose formula is (H2S), is a colorless gas with a characteristic odor of rotten eggs.) that is part of this in a 1% and nitrogen that is perceived in about 2% (Urrego & Rodríguez, 2016).

ISSN 1692-8407

Table 1
Biogas composition.

Element	%
Methane (CH_4)	50-70
Carbon Dioxide (CO_2)	30-50
Nitrogen (N_2)	0.5-3
Sulfhydric Acid (H_2S)	0.1-1
Water Steam	Traces

Biogas is a little lighter than air, has an ignition temperature of 700^{o}C and its flame reaches a temperature of 870^{o}C, can be used like any other fuel, both for cooking food, replacing wood, kerosene, liquefied gas, etc., and for lighting, using lamps adapted to biogas. Biogas mixtures with air, in a 1:20 ratio, form a highly explosive detonating gas, which allows it to be used as a fuel in adapted internal combustion engines as well. It should now be clarified that this gas can only be used as a fuel when the methane present in it is greater than or equal to 50% concentration.

The longer the retention time, the higher the methane content, and with it the heating power. With short retention times the methane content can be reduced by up to 50%. With a methane content much lower than 50%, the biogas is no longer flammable. The first gas from a freshly loaded plant contains very little methane, so the gas produced in the first 3 to 5 days must be allowed to escape without use. The methane content depends on the fermentation temperature. At low fermentation temperatures a high percentage of methane gas is obtained, but the amounts of gas are lower.

This is naturally generated by rotting organic matter and is called natural gas or marsh gas. Artificially, biogas is produced by the decomposition of organic waste (animal manure, garden waste, food waste, among others).) through a process of anaerobic fermentation (absence of air), carried out by methane gene bacteria (living beings that produce methane), this process is carried out in a completely sealed plant called Biodigestor which is the tool that allows the production of biogas with the common principle of putting the organic matter, in anaerobic conditions, to start the process of gas production, which consists of three chambers in it, at first sight is a container of cylindrical or spherical shape, hermetically and impermeably sealed, which can be built with various materials such as brick, cement, metal or plastic.

This compound is quite advantageous as it reduces the amount of municipal solid waste, does not generate greenhouse gases and is renewable. It is something economical and very useful for schools, community kitchens, industrial and agricultural enterprises especially for areas where the natural gas network does not reach, it can be used for domestic use in cities, but it is necessary to have a constant amount of waste in order to generate gas.

From organic waste, electric energy can be generated, so it is an important resource that is often wasted. This leads to a great solution to supply electricity and gas services to small cities and remote villages; these are some solutions that biogas can generate in a community, it can be applied, but it is essential the collaboration of the community to make it work, because a family or small group of people is not enough to generate as much waste to feed the biodigester. Likewise, the biodigester does not have many disadvantages, but we can say that the burden of it requires a lot of time and patience since a selection and classification of the waste must be done previously; it can also present fluctuations in energy production due to the variable availability of natural resources, and finally, if it is due to its structuring, it can present problems of storage and distribution.

And how does it come about?

Biogas can usually be obtained from any organic material. Commonly used are excreta of any kind, cachet, distillery waste, organic components of municipal solid waste, organic waste from slaughterhouses, sludge from waste treatment plants, agricultural waste, organic waste from food production industries, etc. All organic materials that can be used as fermentation sludge are mostly composed of carbon (C) and nitrogen (N). The relationship between the two has a great influence on biogas production. With water, the flowability of the fermentation material increases, which is important for a more efficient fermentation process and therefore a higher biogas production. In a liquid fermentation sludge, methane bacteria reach the fresh fermentation material more easily, which speeds up the process. The fermentation process consists of two main phases: the acid phase and the methane phase. In the first one, amino acids, fatty acids and alcohols are formed from the proteins, fats and carbohydrates dissolved in the residual. In the second one, methane, carbon dioxide and ammonia, among others, are formed.

The facility for producing and capturing biogas is called a biogas plant. There are multiple designs and forms, depending on its size, raw material (waste) used, construction materials with which it is built, etc. Its variety is such that the existing models are adapted to practically all the needs and variants that are desired, in terms of volume, materials used and organic waste to be treated; Basically, it can be said that in all cases the process of biogas production is carried out in a container called a digester, as this is where the fermentation process takes place, similar to the digestion produced in our digestive system when we eat food, which is broken down by the action of enzymes, while the biogas is captured by means of a bell or vaulted or cylindrical surface (in most cases), from which the gas is extracted through a pipe or hose (Urrego, Rodríguez, & Sánchez, 2016).

Plants for the production of biogas can be classified into:

• **Discontinued or Bac**h. These are loaded once and completely emptied after a retention time. The continuous gas supply with these plants is achieved with gas tanks or with several digesters running at the same time.

• **Continuous**. These are loaded and unloaded periodically, usually daily, the fermentation material must be fluid and uniform. Continuous plants are suitable for rural households where the necessary maintenance is integrated into the daily routine and gas production is higher and more uniform. They have the advantage of being adapted to industrial use, e.g. in hatcheries where large amounts of manure must be treated and where both gas production and treatment of the pathogenesis of these wastes are not important. They are also suitable for automation.

The former are loaded and partially unloaded every day, periodically or permanently, while the latter are loaded at once and totally or partially unloaded after a certain time of using the introduced residual to ferment.

Among the simplest installations we can find those of fixed domes, Balloon type plant and floating bell (Fig. 14). Floating bell plants allow for constant gas pressure. The design and construction of the plant, as well as the materials to be used, must be carefully chosen according to the desired production, the characteristics of the soil, the type of load and the investment to be made. The climatic characteristics of the place must also be taken into account, as the digestion process itself is not exothermic, so heat must be provided to maintain its temperature. The temperature at which the digestion takes place varies the retention time of the sludge.

Sludge

It refers to mud that has a band consistency and is found in humid places and in the bed of lakes and rivers. Mud, on the other hand, is the combination of water and soil.

These biogas plants can be built for domestic or agricultural use, now, to ensure the successful operation of the digester (in a non-industrial size and for personal use) it is essential to perform a proper commissioning. To fill the plant, between 1 and 1.5 L of water per kilogram or liter of fresh excreta are mixed, always trying to keep the solids inside the digester in the range of 7 to 9%. Once this mixture is prepared, the digester starts to be filled, until it reaches the level of the floor of the compensation tank or pressure regulator.

It is very important that, during the filling process of the plant, from the referred level, the gas outlet valve is kept open, so that all the air contained in its interior escapes, as it fills up to its maximum water level, to avoid in this way the cracking of the dome by the action of shock loads (sudden filling). After this operation, the outlet valve is closed and we wait a few days, during which time biogas will be accumulated in the dome. If the filling took place with cattle excrements or inoculum (residual extracted from an anaerobic digestion process), for more than a week, the valve can be opened after 24 hours. Otherwise, it will be necessary to wait until the pressure inside the digester rises, which will be known by observing the exit of the liquid from the compensation tank until the bubbling begins in the area that communicates the digester with the compensation tank, which will indicate that the digester has reached its maximum working pressure and the start-up has been satisfactory.

In cases where there is easy access to sufficient quantities of water and the construction has not been done with the necessary rigour, it is advisable to carry out this start-up test with apparently clean water; and to do so, the same operation is carried out, but with the location of a pressure gauge, in the pipe at the gas outlet, to measure the pressure of the air accumulated in the dome, which will displace the water as the digester is filled, until the maximum pressure is reached. After reaching the maximum pressure, it is left full for 24 hours, and then the corresponding evaluations are made. If the loss of pressure during this time is negligible, then its start-up has been satisfactory, and it will be filled with excreta mixed with water or waste water, in the manner indicated above.

The gas accumulated in the dome above the water level at start-up should be disposed of by opening the valve placed, at the exit, in the inspection register, which will be used as a water trap, and immediately move about twenty meters away from the vicinity of the plant against the wind direction (smoking or lighting of any flame should be avoided), until the gas escapes completely (since methane is a highly toxic combustible gas and its inhalation can cause death). Afterwards, the plant will be turned over and when the pressure rises again it can start using the biogas in cooking.

In order to know the pressure that develops inside a biodigester, pressure gauges are used, which in a small biogas plant are less than 1.50 m from the water column (0.15 kg/cm^2) and can be made by the user himself with simple materials: a small diameter hose, preferably transparent, which supported on a vertical table allows the water inside to be observed (Fig. 15). The surface (meniscus) on one side is in contact with the biogas, and the pressure you want to know is exerted on it (on the meniscus of the outlet branch, the pressure is the atmospheric one). Initially, with the atmospheric pressure (Patm) on both branches, the two menisci occupy the position 0.0. As the pressure pA develops, it causes the meniscus to descend to the height h_1 and the height h_2 to rise. Thus, when measuring the difference between the two menisci, one has the manometric pressure:

$$pA = (h_1 + h_2) = Ht \tag{3}$$

At the first start-up, the pipe will be swept with the same gas. This initial gas should not be used because it is mixed

ISSN 1692-8407

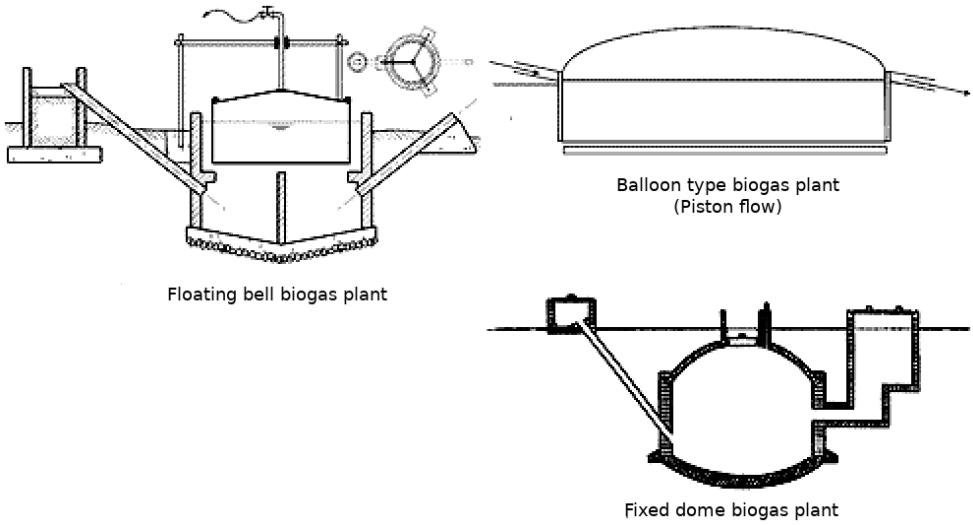


Figure 14. Biogas technology.

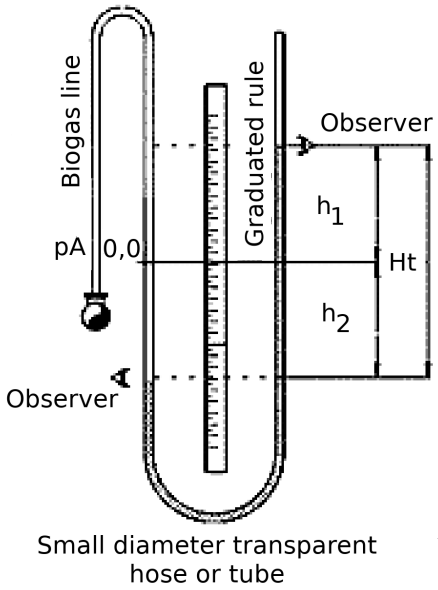


Figure 15. Manometric pressure measurement.

Figure 16. Biodigester structure.

with air and therefore can be explosive and dangerous (it may even be non-combustible due to the high CO_2 content), so it is recommended to let it escape into the atmosphere without being connected to the stove, in the same way as explained above. This biodigester can be as shown in Fig. 16.

Likewise, some precautions must be taken into account when setting up the biodigester, starting with the fact that the water used in the mixture must not be chlorinated. If it is supplied through an aqueduct, it is recommended that it is not directly from the network, since in the biogas there are colonies of microorganisms that can die or reduce their metabolic activity by the action of chlorine. In addition, this water cannot contain any disinfectant or toxic agent in concentrations that damage methano-genic microorganisms, such as acids, lubricating oil, detergents, antibiotics, etc.

Care must be taken that no soil or sand enters the digester, as they form sediments that are difficult to remove, as well as remains of fodder and straw, as they create surface crusts that reduce the level of effectiveness of the digester and make it difficult to operate and maintain.

The operation of a biogas plant

In one of these plants it is possible to see several processes of which we will speak in this section:

- Storage and conditioning of the substrates.
- Biogas production.
- Biogas conditioning.
- Energetic use.

Storage and conditioning of substrates

To begin with, we must know what substrates are. In biology, a substrate is the surface on which a plant or animal

lives. The substrate can include biotic or abiotic materials. For example, algae that live embedded in a rock can be the substrate for another animal that lives on top of the algae, there are many types of substrates that are divided according to their origin, which leads to storage being different for each. These are divided into:

Storage of substrates of vegetal origin. These storage systems serve to balance variations between demand and production of biomass. The shape and size depends on the type of biomass and flow of use, these silos that are used for this type of plant are generally made of concrete, but can also be made of different plastics when the volume to be stored is not excessive and a large territory is available.

These substrates are harvested with specialized machinery for subsequent storage in the silos, must be chopped to a size between 6 mm and 10 mm so that they retain their properties for the production of biogas.

Storage of liquid substrates (slurry). The slurry is transported with the tanker to the plant, and unloaded into the tank which can be concrete or steel, and go to ground level, these must be closed tanks to avoid odors, as not to lose their properties.

Storage of slaughterhouse substrates. When the substrates are of this type it is normal that they are properly sanitized, in order to eliminate bacteria, parasites, and viruses. This is done by heating the substrates to a temperature of 70^{o}C for one hour. These are contained in steel tanks after sanitization.

Biogas production

Feeding system. As recommended above, it should be continuous, and the mixing should be very accurate so that the substrates are well homogenized. Generally we have a smaller silo, with a mobile floor, from which the solid substrates (silage, solid waste) are introduced to the feeder and other conduits for feeding the liquid substrate (slurry, glycerine, serum, etc).

The most modern feeding systems weigh each substrate separately so that the mixture always contains the exact percentage of each one, there are other types of installations that allow a greater homogenization of the mixture such as internal agitators in the feeder, placing a pump with blades to prevent large particles from being introduced into the digester, sieves to remove stones and other materials that could damage the installations, and so on (Martinez, Martinez, & Hernández, 2017).

Digesters. Biogas plants can be made up of one or more digesters, which can be: vertical, horizontal, dry or wet mixing, and continuous mixing. Its final design will depend on the type of substrate to be used.

Digesters are classified by mode of operation, filling and emptying. The general classification defines them as stationary regime, semi-continuous regime, horizontal, and continuous regime digesters. Depending on the humidity of the process, they are available as wet mix (up to 15% DM content) or dry mix with a higher DM content (up to 25%). One of the fundamental variations in terms of plant design consists of carrying out the digestion in one or two stages, based on the fact that the different groups of bacteria that carry out the process require different pH conditions and retention times. This involves the construction of one or two tanks, in the first one part of the anaerobic digestion is carried out (hydrolysis and acidogenesis) and in the second one acetogenesis and methanogenesis is carried out.

Digester tanks are built above or below ground. The floor and walls of the agro-industrial digesters are made of concrete. The roof, generally, is made of EPDM membrane. The digesters are usually fed by a submersible pump. The discharge of the digested mixture or its recirculation to stabilize the humidity levels of the process is done by means of an overflow. A pipe is installed on top of the digester that will connect it to the digestate storage tank and/or the recirculation tank (Fig. 17).

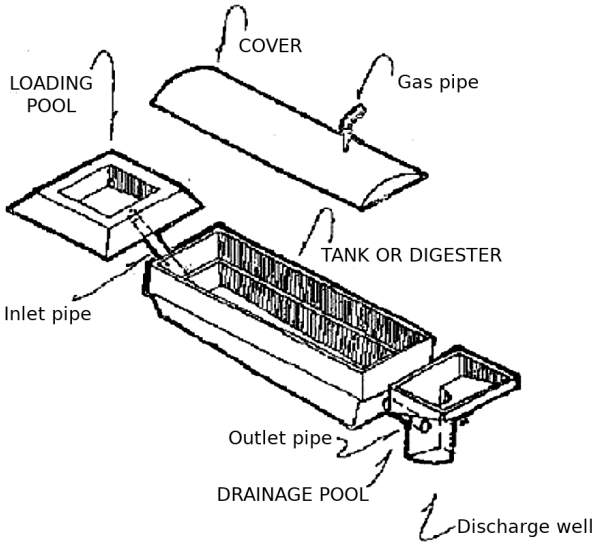


Figure 17. Biodigester: Components.

The cover of the digester as shown in Fig. 17 is where the biogas produced is stored, and can also be used as a gasometer.

Agitators. Thanks to these a better distribution of temperature, nutrients, also the elimination of biogas bubbles and a mixture of fresh substrate with all the bacteria that live in the digester: and all this due to the continuous agitation of the machine.

Heating system. The digesters will be equipped with a 4 cm thick polyurethane (or similar) insulation system to retain as much heat as possible. Likewise, a series of polyethylene pipes will be distributed inside the concrete wall to form the heating system.

ISSN 1692-8407

Biogas conditioning. Since the gas has a high moisture content and traces of other gases it must be treated and conditioned before handling. It must be conditioned in such a way that, the H_2SN (hydrogen sulphide) is reduced or eliminated, the percentage of humidity is lowered, there is a reduction of CO_2 (carbon dioxide), and finally the pressure of the biogas is corrected, calibrated and controlled.

When the biogas leaves the plants it is saturated with 100% humidity, and this problem increases when it is in summer due to the high temperatures, with this many particles that are not kept inert in the biogasification process travel through the water vapour, being harmful for the good use of the biogas. For this, a condensation unit is installed in the cogeneration unit, and in this way the biogas will be cooled to temperatures between 0^oC and 5^oC obtaining the condensation of the humidity in the biogas, after this, collection pipes will be made with a slope of 5% so that the condensate flows back to the digester.

The presence of Sulphuric Acid (H_2S) also known as sewer gas can be very harmful to health, since only about 30 ppm (parts per million) in the air to cause someone's death; it turns out to be a factor of difficulty when the biogas is to be used in engines, refrigerators, heaters and other metallic devices that can be affected by the corrosion produced by the acid in question. This can be removed or even controlled thanks to traps that use ferrous materials such as: steel, iron and castings, the gas is made to pass through a filter that contains iron hydroxide and thus the acid gas combines with the iron forming an iron sulfide (Fig. 18).

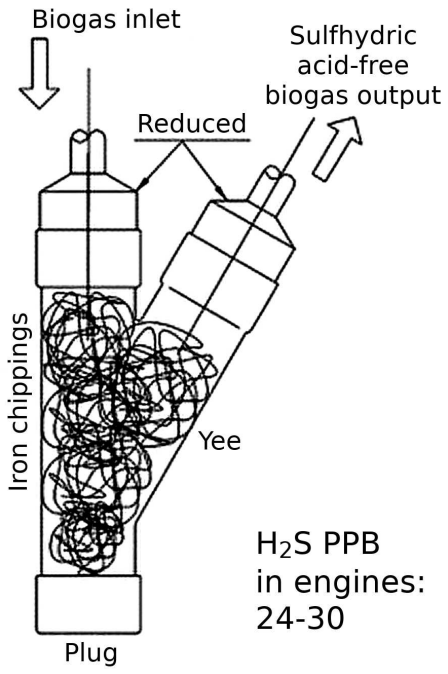


Figure 18. Biogas production and conditioning.

For the reduction of Carbon Dioxide (CO_2) can be made a purification with micro algae thus achieving an energy source of biomethane suitable for commercial use or domestic purposes, this is achieved by making a stream of biogas entering a hollow column and circulating in counterflow with micro algae in liquid medium that come from an open culture, the contact between these two produces the transfer of CO_2 from the gas to the liquid culture medium, this process takes place continuously 24 hours a day replicating natural light during half the process.

Energy use. Biogas has a high energy power of approximately 6 KW/m^3, this value depends on the content of methane gas in it; it can be used as a fuel for the generation of electrical energy and for the generation of heat.

The most common uses of biogas are:

- Combustion for heat production.
- Internal combustion engines with mechanical power utilization.
- Engines for electricity generation.
- Gas or steam turbines with use of electrical power.
- Motorized vehicles.
- Hook into the natural gas network.
- Production of chemicals.

Biogas as an energy source - Biogás Doña Juana S.A.S.. The biogas generated in the landfills is produced during the process of anaerobic degradation of the organic waste deposited there. This biogas, due to its methane component, is susceptible to being used as fuel for electric power generation engines and industrial processes involving high temperatures.

Since 2010, Biogás Doña Juana S.A.S. E.S.P. has been developing one of the most important environmental projects in Colombia and the world, as well as the only project in Colombia that currently uses biogas resulting from the decomposition of urban solid waste that reaches the Doña Juana Landfill for the generation of electricity and the reduction of greenhouse gas (GHG) emissions through the thermal destruction of methane (CH_4).

Approximately 6,700 tons of solid waste arrive at the Doña Juana Landfill every day and are disposed of in their entirety by the landfill operator (CGR) in a technical manner in waterproof cells with leachate drainage and biogas emission systems. Once the waste begins its anaerobic decomposition and biogas production begins, Biogás Doña Juana S.A.S. E.S.P. captures and conducts the biogas produced to the plant, where it burns methane and generates energy.

With the burning of methane, is reducing approximately 800,000 tons of carbon dioxide (CO_2) equivalent per year, this contribution to reducing emissions of greenhouse gases that makes Biogas Doña Juana annually, equivalent to:

- CO_2 capture from more than 160 million mature trees per year.

• To avoid the circulation during 1 year of approximately 400,000 compact vehicles in the city that travel 15 to 20 km per day.

Although it is true that with the treatment, thermal destruction and use of biogas, gas emissions are reduced, improving the air quality of the population located in the area of influence of the Doña Juana Landfill, in addition to reducing the presence of offensive odors; these aspects are the main effects of the construction of landfills in Colombia (Fig. 19).

At the Doña Juana landfill there is a project of electric power plants from biogas (Fig. 20). This project is structured in three plants, according to the availability of connection points granted by the Local Network Operator (CODENSA) and approved by UPME (Mining Energy Planning Unit):

• Central Doña Juana I:
• Phase I (1.7 MW) went into operation on 29 April 2016.
• Phase II (additional 3.3MW), will be operational January 2017-8.
• Central Doña Juana II:
• (9.8 MW) Will become operational in January 2018.
• Central Doña Juana III:
• (9.88 MW) Will be operational in the second half of 2018.

Conclusions

With the information exposed previously we can conclude that in the construction of a civil work as it is it a sanitary landfill it is of extreme importance that aspects like the planning, design, execution and operation are carried out correctly following certain guidelines to anticipate the emergence of problems in the future.

It is important the management given to the waste once they are deposited in the landfill, because if this management is not adequate can generate environmental problems, health, and even social, that is why seeking alternatives to find profits beyond those provided in its life is a vital issue. The generation of energy from biogas is a clear example of this, is an alternative that mitigates environmental damage and not only that, being a way to transform waste of which it is believed that its useful life just allows society to be aware of the importance of separating the waste that is generated, facilitating the management of these, thus giving opportunity to the emergence of sustainable projects that generate benefit to society and the environment. As it is a process that occurs through waste, it becomes a renewable resource since the source of generation is a constant since thousands of tons of waste are generated every day. This means that we do not depend solely on fossil fuels.

References

Alpaos, C., & Moretto, M. (2016). Landfills sizing in metropolitan areas. *Procedia - Social and Behavioral Sciences*, *233*(1), 95-100.

Amasuomo, E., & Baird, J. (2016). The concept of waste and waste management. *Journal of Management and Sustainability*, *6*(4), 88-93.

Arias, J., & Buitrago, J. (2012). Criterios sociales para la selección de la ubicación de un relleno sanitario (caso área metropolitana de Bucaramanga). *Dixi*, *14*(15), 82-102.

Caicedo, B., Giraldo, E., Yamin, L., & Soler, N. (2002). The landslide of dona juana landfill in bogota. a case study. In *Proceedings of the fourth international congress on environmental geotechnics (4th iceg)* (p. 1-5).

Caicedo, L. (2016). *Hablando de medio ambiente y nos mandaron el basurero encima: las resistencias en mochuelo alto frente al relleno sanitario doña juana*. Unpublished master's thesis, Universidad Distrital Francisco José de Caldas.

Dasgupta, M., & Yildiz, Y. (2016). Assessment of biochemical oxygen demand as indicator of organic loadin wastewaters of morris county, new jersey, usa. *Journal of Environmental & Analytical Toxicology*, *6*(3), 1-3.

Galvis, M. (2016). *Prospección geoeléctrica del recurso hídrico subterráneo en la vereda la ramada, sogamoso, boyacá*. Unpublished master's thesis, Universidad Pedagógica y Tecnológica de Colombia.

He, X., Xi, B., Zhang, R. G. H., Dang, Q., Li, D., & Huang, C. (2016). Insight into the composition and degradation potential of dissolved organic matter with different hydrophobicity in landfill leachates. *Chemosphere*, *144*(1), 75-80.

Kattel, E., Kivi, A., Klein, K., Tenno, T., Dulova, N., & Trapido, M. (2016). Hazardous waste landfill leachate treatment by combined chemical and biological techniques. *Desalination and Water Treatment*, *57*(28), 13236-13245.

Kaur, K., Mor, S., & Ravindra, K. (2016). Removal of chemical oxygen demand from landfill leachate using cow-dung ash as a low-cost adsorbent. *Journal of Colloid and Interface Science*, *469*(1), 338-343.

Kolb, M., Bahadir, M., & Teichgraber, B. (2017). Determination of chemical oxygen demand (COD) using an alternative wet chemical method free of mercury and dichromate. *Water Research*, *122*(1), 645-654.

Lee, U., Han, J., & Wang, M. (2017). Evaluation of landfill gas emissions from municipal solid waste landfills for the life-cycle analysis of waste-to-energy pathways. *Journal of Cleaner Production*, *166*(1), 335-342.

Li, Y., Wang, J., Yue, Z., Tao, W., Yang, H., Zhou, Y., et al. (2017). Simultaneous chemical oxygen demand removal, methane production and heavy metal precipitation in the biological treatment of landfill leachate using acid mine drainage as sulfate resource.

ISSN 1692-8407

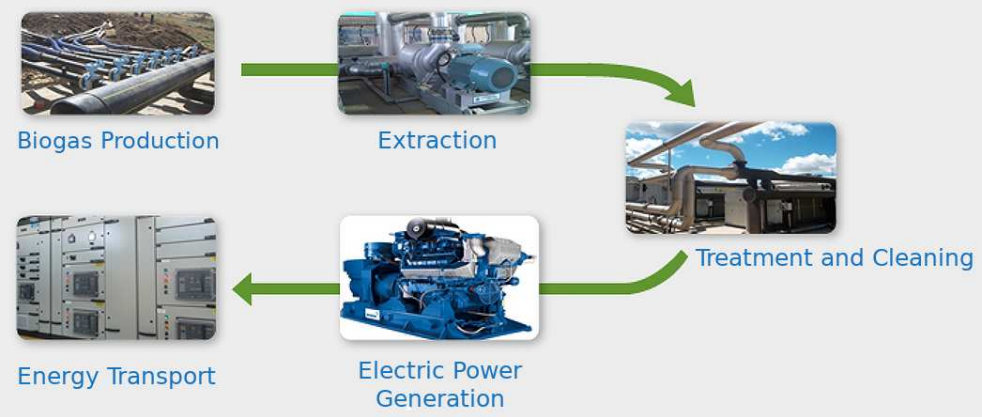


Figure 19. Cycle of energy production from landfill biogas.

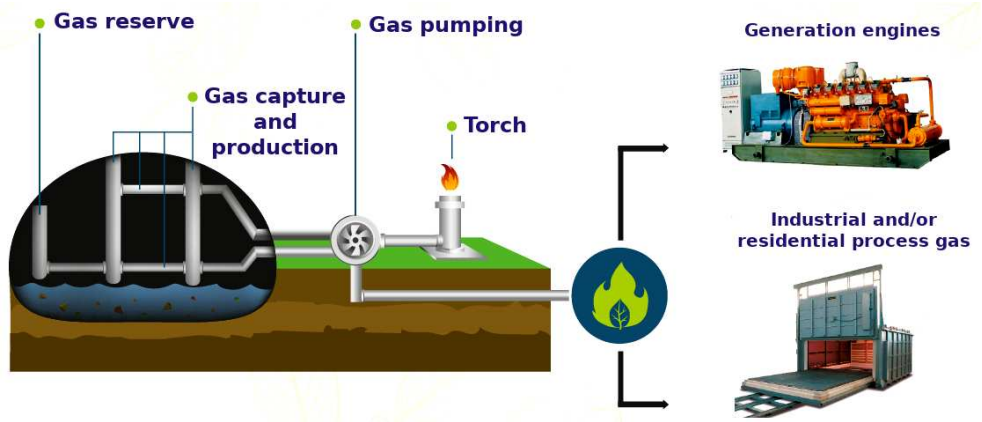


Figure 20. Transformación de energía eléctrica.

Journal of Bioscience and Bioengineering, *124*(1), 71-75.

Martinez, F., Martinez, F., & Hernández, C. (2017). Organic-shaped structures design using genetic algorithms and metaballs. *Contemporary Engineering Sciences*, *10*(21), 1001-1010.

Moody, C., & Townsend, T. (2017). A comparison of landfill leachates based on waste composition. *Waste Management*, *63*(1), 267-274.

Murcia, A., & Rodriguez, C. (2017). *Evaluación de tecnologías de disposición final de residuos sólidos urbanos mediante un análisis de ciclo de vida (acv). caso de estudio bogotá*. Unpublished master's thesis, Universidad Santo Tomas.

Nivel freático del suelo. (2017). On line. Retrieved from `https://ingeniero-de-caminos.com/nivel-freatico/`

Pagano, S. (1964). Sanitary landfill operations in new york state. *Public Health Reports*, *79*(6), 543-548.

Pan, H., Lei, H., Liu, X., Wei, H., & Liu, S. (2017). Assessment on the leakage hazard of landfill leachate using three-dimensional excitation-emission fluorescence and parallel factor analysis method. *Waste Management*, *67*(1), 214-221.

Pasotti, P. (2017). *Estratigrafía subsuelo de Rosario.* On line. Retrieved from `https://www.fceia.unr.edu.ar/geologiaygeotecnia/Subsuelo_print`

Quintero, D. (2016). El papel de la gestión territorial en la ubicación de rellenos sanitarios. caso de estudio: relleno sanitario doña juana, bogotá, colombia. *Perspectiva Geográfica*, *21*(2), 251-276.

Quiroz, O., Martínez, D., & Massone, H. (2012). Estimación de recarga de acuíferos en ambientes de llanura con base en variaciones de nivel freático. *Tecnología y ciencias del agua*, *3*(2), 1-6.

Rasool, A., Xiao, T., Farooqi, A., Shafeeque, M., Liu, Y., Aqeel, M., et al. (2016). Quality of tube well water intended for irrigation and human consumption with special emphasis on arsenic contamination at the area of punjab, pakistan. *Environmental Geochemistry and Health*, *39*(1), 1-17.

Sanjuan, A. (2012). *Apoyo técnico en el análisis de estabilidad geotécnica de laderas, taludes, terrazas y estructuras de contención en proyectos de desarrollo*

habitacional, en tijuana, baja california, méxico. Unpublished master's thesis, Universidad Francisco de Paula Santander Ocaña.

Urrego, E., & Rodríguez, J. (2016). Aplicación de las metodologías epa, mexicano e ipcc para la estimación de biogás, caso de estudio relleno sanitario doña juana, bogotá - colombia. *Universidad y Salud*, *18*(2), 338-344.

Urrego, E., Rodríguez, J., & Sánchez, J. (2016). Application of a proposed methodology for estimating natural gas in a landfill. case study landfill juana, bogota, colombia. *International Journal of Applied Environmental Sciences*, *11*(5), 1153-1172.

Varni, M., Zeme, S., Weinzettel, P., & Dietrich, S. (2014). Relación entre recarga al acuífero freático y otros términos del balance hídrico en azul, centro de la provincia de buenos aires. In *Ii congreso internacional de hidrología de llanuras (santa fe, 2014)* (p. 1-9).

Tekhnê
July - December 2017, Vol. 14, No. 2, pp. 43 – 48

ISSN 1692-8407

Impact of the civil work Gran Plaza El Ensueño Shopping Center

Impacto de la obra civil Centro Comercial Gran Plaza El Ensueño

Anderson C. Pardo G.
Universidad Distrital Francisco José de Caldas
camilopit.06@gmail.com

The interest of this article is to inform and conceptualize how large civil works intervene in the development of a community's activities and how these interventions will bring about dynamic and irreversible change. In order to situate ourselves in a specific case, we took the work of the Gran Plaza El Ensueño shopping center for this purpose, present in the town of Ciudad Bolivar due to its strategic complexity and current development. It gives an approach to the importance that have the civil works and how the mall Gran Plaza El Ensueño in particular is a drastic change in the community and in turn directly interferes in the local economy assuming not a benefit but a detriment to it by not meeting the needs of it.

Keywords: Ciudad Bolivar, civil work, Gran Plaza El Ensueño, shopping center

El interés de este artículo, es el de informar y conceptualizar como es que las obras civiles de gran magnitud interviene en el desarrollo de las actividades de una comunidad y de cómo estas intervenciones tendrán consigo un cambio dinámico e irreversible. Para situarnos en un caso específico se tomó a la obra del centro comercial Gran Plaza El Ensueño para ello, presente en la localidad de Ciudad Bolívar debido a su complejidad estrategita y desarrollo actual. Se da un acercamiento a la trascendencia que tienen las obras civiles y de como la del centro comercial Gran Plaza El Ensueño en particular supone un cambio drástico en la comunidad y como a su vez interfiere directamente en la economía local suponiendo no un benéfico sino una perjuicio para la misma al no suplir las necesidades de la misma.

Palabras clave: Centro comercial, Ciudad Bolivar, Gran Plaza El Ensueño, obra civil

Article typology: Research

Date manuscript received: November 27, 2017
Date manuscript acceptance: December 8, 2017

Research funded by: Universidad Distrital Francisco José de Caldas.

How to cite: Pardo, A. (2017). *Impact of the civil work Gran Plaza El Ensueño Shopping Center*. Tekhnê, 14(2), 43 -48.

Introduction

This article deals with topics such as: civil works and how they are proposed to meet the needs of a community in addition to optimizing space and thus give the community social and economic development, emphasizing the current construction of the shopping center Gran Plaza El Ensueño and the consequences that will have on the community a commercial focus of the magnitude of this, since the shopping centers in Latin America have become a proposal that consists of being able to develop multiple activities in a single space, it is possible that the impact that brings a focus of trade in the area of Ciudad Bolivar may be negative consequences as well as positive.

In order to analyze this phenomenon, it was necessary to consult journalistic and conceptual sources that analyzed the impact that the presence of shopping centers has brought to the community, in addition to consulting the position by which those responsible for planning and construction decided to make the Gran Plaza El Ensueño shopping center and how the presence of a shopping center changes the model of which Latin American society considers itself, making the city model similar to the North American model.

Shopping center as civil works

Civil works

The concept of civil works is used to designate those works that are the result of civil engineering and that are developed for the benefit of a nation's population because some of their objectives are the territorial organization and the maximum use of the territory (Ucha, 2017).

Figure 1. Civil works (Group, 2017).

Based on this definition, it is interpreted that civil works are for society and that is how they have an impact that transcends all its characteristics, such as its economy, culture and development, but how far can this go?

The construction of infrastructure triggers a series of direct and indirect or induced impacts, both positive and negative. A new infrastructure modifies the space where economic activities and ways of life are developed, consequently, it also affects the framework of life and habits of the society concerned. This initiates a more or less dynamic, but always irreversible, process of transformation (Moreno, 2017).

By the nature of change provided by the creation or modification of the infrastructure in which the activities of a community take place, civil works are distinguished from other engineering works and thus civil works have a visible social and economic value that characterizes only civil engineering.

Civil works approach

A civil work with its planning and subsequent construction, brings changes in the area where it is presented, this is undeniable and characteristic of civil works, are synonymous with change in the community. The notorious modifications that bring the civil works are of different types and can be social as well as economic.

Infrastructure indicates a series of induced impacts (changes in the hierarchy of the settlement network and in the factors of location of economic activities, empowerment of certain areas and marginalization of others, etc.), and a series of impacts on the economy (modification of the level of income, of the quantity and level of the active population, induction of economic activities, etc.) (Moreno, 2017) (Fig. 2).

Figure 2. Example of civil work with social impact (Business, 2017).

This is how civil works have a significance in the area and in the development of the daily activities of a population. Each work will have different impacts and that is how, depending on the emphasis that the work took, it will affect the community. Works can be focused on:

ISSN 1692-8407

Land routes of communication. Roads (both highways and federal roads), railways with their bridges and tunnels; airports with their runways, taxiways, commercial and general aviation platforms, hangars, fuel areas, passenger terminals, control towers and their electrical and electronic installations for the safety of aircraft operations; and finally, heliports.

Hydraulics. Storage dams, hydroelectric and derivative, in which water is captured to generate electricity, or to supply the population and is distributed in cultivation areas, especially to irrigation districts.

Health works. Drinking water conveyance and storage systems (surface tanks and elevated tanks), drinking water and wastewater treatment plants, sewage systems, industrial and storm drains, and landfills (garbage control).

Marine projects. Sea and rainwater ports, with their protection works breakwaters, jetties, and breakwaters, piers, terminals of various kinds: industrial, fishing, agricultural, tourist for the care of yachts, passenger and trade.

Buildings. Housing complexes, condominium buildings, offices, multiple uses for businesses, plazas, commercial and recreational centers, cinemas, theaters, cultural centers, auditoriums, sports stadiums, supply centers, industrial parks and other buildings with various types of services (Linares, 2017).

This approach or classification serves to understand the trajectory that a civil engineering project will take and that is how you can focus on the needs present in a community.

Shopping center

The structure called shopping center is a civil work that is designed and structured to have within it a great diversity of shops, besides being a space which the population has taken as an environment of leisure and recreation (Fig. 3).

The main function that a shopping center can fulfill is to be able to place a great amount of population in a same space so that they can be potential buyers and to supply the demands that they can demand, this can be fulfilled due to the diversity of commerce that the structure contains. This interpretation is reflected with the following one.

"A shopping mall is a construction consisting of one or more buildings, usually large, which house services, premises and commercial offices grouped together in a given space, concentrating a greater number of potential customers within the site" (Sarlo, 2017).

Figure 3. Example of a shopping center in operation in the city of Bogotá (Colombia) (Data, 2017).

Operation of a shopping center

A shopping centre is a commercial space in which premises are available for the trade of different types of products but these spaces are distributed among different owners for the development of a competitive and varied market within it (Martínez, Hernández, & Rendón, 2017). Most shopping centres are governed by the motto *Coordination of Business Activities*.

"Shopping centres are full of independent businesses in the same workplace and the shopping centre must regulate all of these in order for the centre to function properly. Therefore, it is necessary to clarify why the Coordination of Business Activities is of great help in a shopping centre, whether you are a manager of the centre or have a business within it" (Prevencionar, 2017).

By means of this regulation by which the activities of a shopping centre are developed, the owners of the premises and the owner of the commercial space (shopping centre) develop their activities. The responsibilities and duties contracted by the owners of premises and the owner of the commercial space (shopping centre) in the operation of the *Coordination of Business Activities* are as follows:

- To inform the other competing entrepreneurs of the specific dangers of their activity that may affect other companies.
- Take into consideration the information received by the owner and by the other competing entrepreneurs and also include it in their evaluation of hazards and planning of the preventive activity.
- Comply with the instructions received by the incumbent employer.
- Communicate to their workers the information and also instructions received by the owner and other competing employers.

• Communicate to the other competing companies the accidents and emergency situations that are generated, if they affect or may affect workers from other companies.

• To hold business activity coordination meetings with the representatives of all the competing companies, in which the above points are discussed (Prevencionar, 2017).

And on the part of the owner of the commercial space those of:

• To inform and give instructions to the concurrent employers about the dangers inherent in the workplace, prevention measures and emergency measures to be adopted.

• Fulfill your obligations as a competing company, if you have workers carrying out activities in the workplace.

• Establish the necessary means of coordination and communicate them to the rest of the competing companies (Prevencionar, 2017).

It is through this system that shopping centres are regulated internally.

Gran Plaza El Ensueño

The Gran Plaza El Ensueño shopping centre has just been taken over by the construction company PACTIA, which is responsible for building the shopping centre named Gran Plaza Bosa in the locality of Bosa, Gran Plaza Soacha in the locality of Soacha and the Gran Plaza brand of shopping centres that can be found in the cities with the greatest growth potential in the country. It is developed on Avenida Villavicencio with Avenida Jorge Gaitán Cortés, which makes it a shopping center of great commercial interest due to its location near the community of Ciudad Bolívar and also the concurrence of the university community on behalf of the Universidad Distrital Francisco José de Caldas (Fig. 4).

Figure 4. Artistic recreation of the front of the Gran Plaza El Ensueño shopping center (Rojas, 2017).

In addition to the strategic position of the Gran Plaza El Ensueño shopping centre, it has been designed to contain within it the number of 250 premises and 1300 parking spaces (Pactia, 2017).

The approach of the Gran Plaza El Ensueño shopping center is ideal for a commercial axis, but this represents a change in the community due to the commercial increase that the area will have spontaneously. But will this increase in commerce be concentrated in one spot, in turn segregating the surrounding businesses? Being a commercial center of such dimensions with a varied offer of products, it is not unreasonable to suggest that the preference of a buyer is to have in the same place several commercial offers to have to choose between the limited offer of its local commerce. The preference that a commercial center of the magnitude of Gran Plaza El Ensueño will have will mean that the local businesses will lose the competition they enjoy, consequently, it discourages their sales affecting the economy of said commerce, as well as it could mean an increase in the interest of that area causing the fluctuation of population to increase, increasing at the same time the density of possible buyers in the area and improving the economic activity of the surroundings (Ortegón & Royo, 2017).

Let's suppose that the effect of the Gran Plaza El Ensueño shopping center is one of a growing weakening of the urban center and local commerce that benefits the North American model of the expanded city. This is a model which needs the complement of private cars, and which causes the abandonment of public property, impoverishing it in turn and leaving it responsible for shaping the lifestyle of society to market forces (Gammage, 2016).

The following interview was conducted by El Avance, a journalistic entity which developed an interview to represent what the mall has meant to the community so far (Avance, 2017).

El Avance consulted the opinion of an inhabitant of the locality in this case, Mrs. Sol Teresa Valbuena, president of the Community Action Board of the neighborhood La Casona del Libertador, located in the area of influence of the new Shopping Center.

EA: Sol Teresa good evening, tell us about this shopping center and this work that is being developed very close to your neighborhood.

STV: Good evening for me the construction site has not had much impact because there are many people without jobs and they have gone and are not receiving them, so for us it has not been like a good benefit with this construction because we should be more benefited because we are the closest ones and we are the ones who are going to benefit from this shopping center.

EA: Does this mean that initially a series of job offers have been promised for the inhabitants of the town and especially those in the area, and this was not carried out successfully?

STV: No, at the moment it hasn't been taken up because there is no one working there, there are a lot of unemployed people.

EA: What do you think could be the positive impact that this work could bring to the local residents?

ISSN 1692-8407

STV: Well, I think that our sector will be valued more because of the shopping center, but I hope that if employment is promoted more, because this sector needs many people to work there.

EA: Well Sol, let's hope that the construction of the Shopping Center, will bring benefits to the inhabitants of the neighborhoods of the town and this will allow us to improve the name of the town to bring investment and more prospects for security.

STV: Thank you Mr. David, God bless you.

In this brief interview we show how a community leader such as Mrs. Sol Teresa Valbuena describes what the construction of the Gran Plaza El Ensueño shopping center has brought to the neighboring community so far, and that it has not met the needs of the town as it is to employ this community in the contraction of it.

This is what has been able to explore the Gran Plaza El Ensueño shopping center, and how it is that so far it has not contributed to meeting any of the needs of the community in which it is presented, but it is expected that the positive effects of the work will be presented at the culmination of the project.

Reality

In the construction of the mall Gran Plaza El Ensueño has brought a bad experience to the community because it did not meet one of the needs of the community, but the expectation remains that the completion of the work, will bring the expected positive benefits but these can only be studied at the completion of it, so we can not immediately classify the work as a work that influences negatively.

In order to classify the impact that the civil work of the Gran Plaza El Ensueño shopping center has had, it would be correct to do so in the historical sense that the work has had from the moment of its planning, construction and liquidation, instead of classifying it as a negative impact. For this reason, it is expected that the completion of the work will bring about the expected results of social and economic development for an area that needs it, such as Ciudad Bolivar.

Conclusions

The evidence shown above demonstrated that civil works are manifestations of design and planning by civil engineering and how they are willing to improve the community by using the land and space, In addition to placing us in the system that hierarchises a shopping centre as a relationship of responsibilities and duties between the owners of premises and the owner of the commercial space, in order to show how the people in the community will have access to it and how, in particular, the specific case of the Gran Plaza El Ensueño shopping centre will mean a commercial alternative of which the citizens of the neighbouring community will form part in the future, since at this time it has been demonstrated that the work has not met the needs of the community. To develop a complete survey of the significance of the specific case of the Gran Plaza El Ensueño shopping center is pertinent to wait for its completion and subsequent development with the community.

References

Avance, E. (2017). *Ciudad bolivar tendrá uno de los centros comerciales más grandes de bogotá.* Retrieved from https://www.elavance.co/noticias/bogota/localidades/ciudad-bolivar/ciudad-bolivar-tendra-uno-de-los-centros-.comerciales-mas-grandes-de-bogota/

Business, O. (2017). *Obsbusiness.* Retrieved from https://www.obs-edu.com/sites/default/files/styles/blog_post/public/post/istock_000004406173_small.jpg?itok=BLVp1qkj

Data, B. (2017). *Big data.* Retrieved from https://elbigdata.mx/wp-content/uploads/2016/04/centro-comercial-santa-fe.jpg

Gammage, G. (2016). *The future of the suburban city. lessons from sustaining phoenix*. Island Press.

Group, A. (2017). *Supervisión técnica obra civil.* Retrieved from http://www.anteagroup.com.co/sites/default/files/styles/width1520/public/supervision-tecnica-o-de-obra-civil_0.jpg?itok=l7vyK9BC

Linares, M. (2017). *Las obras de infraestructura y su clasificación - construcción civil.* Retrieved from http://www.ingenierocivilinfo.com/2011/02/de-las-obras-de-infraestructura-y-su.html

Martínez, F., Hernández, C., & Rendón, A. (2017). A study on machine learning models for convergence time predictions in reactive navigation strategies. *Contemporary Engineering Sciences*, *10*(25), 1223-1232.

Moreno, K. (2017). *Impactos sociales y territoriales de la ingeniería civil.* Retrieved from https://kmoreno17.blogspot.com/2013/05/impactos-sociales-y-territoriales-de-la.html

Ortegón, L., & Royo, M. (2017). Attraction factors of shopping centers: Effects of design and eco-natural environment on intention to visit. *European Journal of Management and Business Economics*, *26*(2), 199-219.

Pactia, C. (2017). *Activo gral plaza el ensueño.* Retrieved from http://www.pactia.com/

activo-gran-plaza-el-ensueno-18

Prevencionar, A. (2017). *Cómo funciona una adecuada coordinación de actividades empresariales en los centros comerciales.* Retrieved from http://prevencionar.com/2016/11/25/funciona-una-adecuada-coordinacion-activi.dades-empresariales-los-centros-comerciales/

Rojas, J. (2017). *Pactia invierte $ 325 mil millones en centro comercial gran plaza.* Retrieved from https://www.elcolombiano.com/negocios/pactia-invierte-325-mil-millones-en-centro.-comercial-FI4831272

Sarlo, B. (2017). *Centro comercial.* Retrieved from https://es.wikipedia.org/wiki/Centro_comercial

Ucha, F. (2017). *Definición de obra civil.* On line. Retrieved from https://www.definicionabc.com/general/obra-civil.php

Tekhnê
July - December 2017, Vol. 14, No. 2, pp. 49 – 58

ISSN 1692-8407

How can concrete be improved through processes that are bio-friendly to the environment and that enhance its construction qualities?

¿Cómo mejorar el concreto mediante procesos bioamigables al medio ambiente y que repotencien sus cualidades en construcción?

Juan A. Guzmán
Universidad Distrital Francisco José de Caldas
Juanguzmanh@colegiocundinamarca.edu.co

Juan D. Ramírez
Universidad Distrital Francisco José de Caldas
Juan2000rmz@gmail.com

Since the beginning of civilizations, man's need to improve his living conditions has led to constant development. A basic problem is the need to protect our life from the problems that it can offer us, not only the changes of nature but also the need to protect ourselves from others. From this arises the idea of generating structures capable of overcoming this need. Consequently, the first cements appeared, which were capable of resisting and joining these first structures. The cement must go according to the development of the humanity, one of the new innovations is the cement based on microorganisms, that not only is friendly to the environment, but its efficiency is such that it has the capacity to seal fissures. Bio-concrete is capable of regenerating the cracks that sooner or later appear in the concrete due to solar action, humidity, temperature differences, etc.

Keywords: Bio-concrete, concrete, micro-organisms, seaweed

Desde comienzos de las civilizaciones, la necesidad del hombre por mejorar su condición de vida nos ha llevado a un constante desarrollo. Un problema básico es la necesidad de proteger nuestra vida frente los problemas que nos pueda ofrecer, no solo los cambios de la naturaleza si no también la necesidad de protegernos de otros. De ahí surge la idea de generar estructuras capaces de sobrepasar esta necesidad. En consecuencia aparecen los primeros cementos, que eran capaces de resistir y unir estas primeras estructuras. El cemento debe ir acorde al desarrollo de la humanidad, una de las nuevas innovaciones es el cemento a base de microorganismos, que no solo es amigable al medio ambiente, sino que su eficiencia es tal que tiene la capacidad de sellar fisuras. El Bio-concreto es capaz de regenerar las grietas que, tarde o temprano aparecen en el concreto por la acción solar, humedad, diferencias de temperatura, etc.

Palabras clave: Algas marinas, bio-concreto, hormigón, microrganismos

Article typology: Research

Date manuscript received: November 27, 2017
Date manuscript acceptance: December 8, 2017

Research funded by: Universidad Distrital Francisco José de Caldas.

How to cite: Guzmán, J, Ramírez, J. (2017). *How can concrete be improved through processes that are bio-friendly to the environment and that enhance its construction qualities?*. Tekhnê, 14(2), 49 -58.

Introduction

Since the beginning of civilizations and through time, the importance of cement in great housing and infrastructure works has been evident. These have belonged to the most relevant moments in the history of man that are built with this material, which more than a discovery has become a true engine of development for humanity. According to some investigations, the oldest known findings about the use of cementitious mixtures "*date back to 7000 and 6000 B.C. when in the regions of Israel and the former Yugoslavia respectively, traces of the first concrete floors were found from calcined limestone. Later, around the year 2500 B.C., mixtures of calcined limestone and gypsum were used to glue together the large stone blocks that were used to build the pyramids of Giza in Egypt...*" (Jahren & Sui, 2017; Osorio, 2017). From there we see the first intentions of human beings to improve their creations, and they idealized a plan that consisted of a material based on porous volcanic rocks for the elaboration of concrete and thus improve its qualities when putting it into practice. It is known that these ideas of concrete have been important since ancient times.

But the advances did not stop there, but rather throughout history a way has been sought to improve this material, which is so vital when it comes to construction, and it is sought to respond better and better to the new problems of the last century. As for the compressive strength of concrete, it is known to range from 2500 psi (17 mpa) for residential concrete, to 4000 psi (28 mpa) for commercial structures (Mirza & Lacroix, 2002; Mostafazadeh & Abolmaali, 2016). At the moment of making a mix, these resistance test studies are made to know if the mix is complying with the minimum requirements of the specific resistance in some already established parameters.

Today, concrete is one of the most resistant mixtures, and it is formed by the union of sand, water and cement. Cement is a conglomerant formed from a mixture of calcined limestone and clay, and later ground, which has the property of hardening on contact with water (Wikipedia, 2017). The resulting product of the grinding of these rocks is called clinker and becomes cement when a small amount of gypsum is added so that it acquires the property of setting when water is added and hardens later. Although there are different types of cement that are implemented in the construction industry and among these are the portland cement, masonry or mortar, mixed cement or the cement implemented for the elaboration of oil wells, and they can vary in their use or their qualities it is known that they still seek to improve their qualities at the time of their use.

Although its final quality depends in a very important way both on a deep knowledge of the material and on the professional quality of the engineer, concrete in general is unknown in many of its seven major aspects: nature, materials, properties, selection, and maintenance of the structural elements (Mehta & Monteiro, 2014). The possibilities for the use of concrete in production are increasing, and it can now be used for a wide variety of purposes. The only limitation to its multiple applications may be the engineer's lack of knowledge of all the aspects already indicated; as well as the relative importance of them according to the use that is intended to be given to the material.

Building application

Literally *live* concrete

Since 2009, a material has been implemented that improves thermal comfort in buildings and reduces CO_2 (carbon dioxide) emissions into the atmosphere. According to the virtual journal www.upc.edu a biological concrete is being developed to build with lichens, mosses and other microorganisms.

One of the qualities of this innovative idea according to Mundo magazine is that this revolutionary concrete has the property of repairing itself, no doubt an incredible quality for a material that is exposed to different factors that can alter its structure and can cause the failure of such an object.

In the last decade a biological material for construction has been developed based on lichens, mosses and other microorganisms that allow reducing the CO_2 emissions to the atmosphere and that has the quality to seal fissures in the concrete, and to increase the durability of the cement along the time.

This type of microorganism helps to seal, in an environmentally friendly way, the micro fissures present in the structure that are not detected by the naked eye. At the Dolft Technical University in the Netherlands, a type of inconcrete was developed that is literally a living material that can regenerate and wear away from buildings.

Another study carried out by the National University of Colombia encouraged workers to test walls by insulating them for a time in a saline solution. As a result, they found two layers that generate calcium carbonate, something never before recorded, and in turn a bacteria that helps improve the durability and strength of the cement.

The objective of this discussion is to publicize new, more effective, and more environmentally friendly ways of building using a chemically modified cement to improve in all its aspects. One of the advances is the implementation of algae and microorganisms to the concrete, which has been called biological concrete. This is a new material that promotes biological growth on its surface, specifically certain families of micro algae, fungi, lichens and mosses.

This concrete is made from two cement-based materials. The first is conventional carbonated concrete, based on Portland cement, and the second is a magnesium phosphate cement, a fast-setting hydraulic binder (Fig. 1).

ISSN 1692-8407

Figure 1. Multilayer concrete developed by the Universitat Politècnica de Catalunya (Staff, 2017).

To obtain this new material it has been necessary not only to modify the pH of the mixture, but also to modify other parameters relating to porosity and surface roughness to favour the bio-receptivity of the material.

The new green concrete achieves the direct growth of organisms by being a multilayer element formed by the following layers (Manso & Aguado, 2016):

1. The structural layer, in charge of resisting actions on the structure.

2. A waterproofing layer located above the previous one, which serves as protection against the passage of water towards the structural layer to prevent it from deteriorating.

3. A biological layer, which will allow colonization and has the capacity to capture and store rainwater, this layer facilitates the development of biological organisms.

4. A layer of coating, discontinuous that will make the function of reverse waterproofing, allowing the entry of rainwater and preventing its loss leading to the output of water where you want to obtain biological growth.

The challenge of living inside the concrete

The new material has many environmental advantages. Thanks to the biological coating it will absorb and consequently reduce CO_2 from the atmosphere, purify the air around it and contribute to the maintenance of biodiversity. It has the capacity to capture solar radiation and will be able to regulate the thermal conductivity inside buildings. And the most obvious advantage will be an ornamental alternative that will allow to decorate the façade of the buildings or the surface of the constructions with different finishes and chromatic shades.

To reduce the CO_2 emissions generated by cement manufacture, research has been carried out recently. One of these investigations is being carried out in the city of Bogotá (Colombia) by the company Argos (Argos, 2017). These investigations are based on the fact that micro algae are perhaps 100 or 200 times more efficient than trees in capturing CO_2.

One of the ways in which the design is intended is that the algae on the bio-reactive facade grow faster under direct sunlight, thus providing more internal shade in summer. In this way, the bio-reactors not only produce biomass that can later be harvested, but also capture solar thermal energy, two sources of energy that can be used to power the building.

But as mentioned above this material has too many qualities and one of these is to be sealed, but how do they do this? With the isolation of microorganisms that form calcite (calcium carbonate crystals) the production of a material that provides greater durability to the cement is studied.

These types of microorganisms help to seal the micro-fissures present in the internal structure of the bio-cement in an environmentally friendly way, since small spaces may remain in the mixture.

To do this, Sandra Milena Montaño Salazar, a biology student at the National University of Colombia in Bogotá, collected samples from walls and platforms of different buildings at the university campus, and in the Microbiology Laboratory she immersed them in saline solution, and subjected them to a process of agitation at 10 degrees centigrade for 15 days (Montaño, Lizarazo, & Brandão, 2018). With this experiment he managed to isolate the material for the respective release of the microorganisms. Later, he sowed them in culture platelets, thus generating calcite precipitation and allowing, in turn, to know which are the microorganisms that produce it. As a result, two strains were found to generate calcium carbonate, something that had not been recorded in the scientific literature. In addition, a bacterium was found that helps improve the durability and strength of cement.

Algae and its applications with constructive purposes

Algae as insulating material for construction

Since the beginning of humanity, microorganisms and algae already existed. The most important and diverse number of living beings in the biosphere is represented by microorganisms, which include some metazoan animals, protozoans, numerous algae, fungi, bacteria and viruses (Fig. 2).

These microorganisms possess unique characteristics that distinguish them from others. Thanks to these characteristics, their study is facilitated. These microorganisms are also distinguished by their relatively short life cycle and their large populations. One quality is their adaptability and reproductive capacity. They tend to form dense populations according to the environmental conditions in which they are found.

Electricity, gas and petroleum are more expensive than ever and therefore intelligent energy management has never

Figure 2. Algae treatment plant (Argos, 2017).

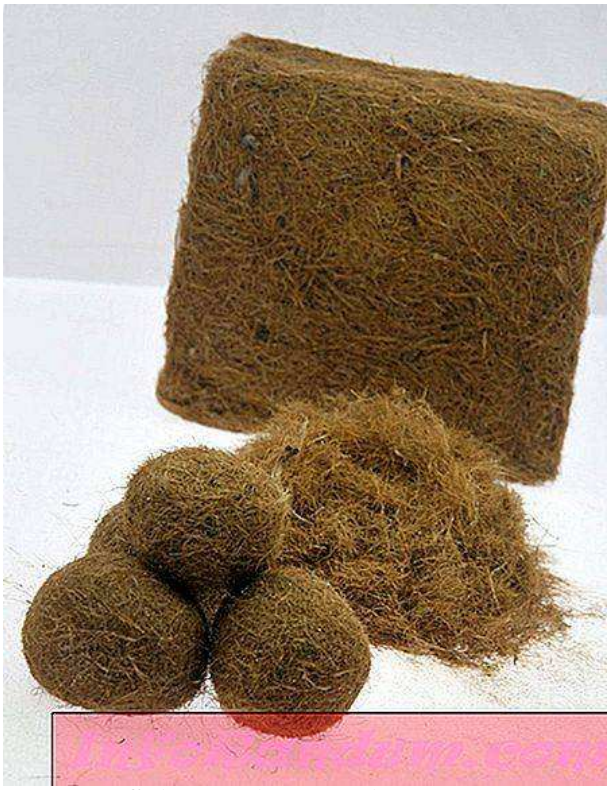


Figure 3. Stuffed seaweed (Coxworth, 2017).

been more important than it is today. Given this situation, it is worth asking what the practical implications of energy efficiency are, what the environmental and economic benefits are, and whether drastic limitations leading to a reduction in consumption can be accepted.

Buildings use 40% of the energy consumed in Europe, and generate a third of the greenhouse gas emissions. Smart buildings will be needed to reduce the carbon footprint of society and increase its energy efficiency. Many new building proposals include energy-efficient cooling technologies such as solar heating systems, combined heat and power generation, heat pumps and thermal energy storage. All these innovations already exist on the market. But there is another option available and cost-effective: insulation using environmentally friendly means.

For many coastal residents, stranded seaweed is nothing more than an inconvenience. But what do these plants have to do with buildings and their heating? German researchers have discovered that this natural material can act as building insulation and together with a team of industrial partners have succeeded in turning it into a viable insulation material (Fig. 3).

The beaches of the Mediterranean are filled during autumn, winter and spring with small balls of algae from the plant Posidonia oceanica. Although this abundant and renewable natural material is considered a waste product and usually ends up in landfill, it could be too valuable to simply discard. Algae have a number of interesting characteristics for construction, such as being practically fireproof and resistant to mould. They can be used as insulation material without the addition of exogenous chemicals in the spaces between the roof beams and the inside of the walls and they buffer the environmental conditions by absorbing and expelling water vapour without losing their insulating properties. In addition, their low percentage of salt, between 0.5 and 2 points, allows them to be used without causing decomposition problems.

However, the process of converting these algae into a building material is not easy because the sand that impregnates them must first be removed, they tend to adhere to almost any object, even each other, and they tend to clump together during processing and when they are spread into the spaces to be insulated. The Fraunhofer Institute for Chemical Technology (ICT), in collaboration with other industrial partners, has found new methods to convert Posidonia residues into a viable insulating material (Fig. 4). The project partners set out to create an insulating material that could be attached or sprayed on to its target space without too many complications.

Shaking the Posidonia balls is the ideal way to achieve the longest possible fibers without sand, explained Dr. Gudrun Grübe of the Fraunhofer ICT (Industrial, 2017). The meticulous separation of the algae masses achieved by Dr. Grübe and her team guarantees an ideal way of obtaining

ISSN 1692-8407

Figure 4. Fraunhofer Institute for Building Physics (Scheithauser, 2017).

fibres. After cleaning them from sand, they reach the crusher via a conveyor belt, which deposits fibres of between 1.5 and 2 centimetres in bags.

The Fraunhofer Institute for Building Physics (IBP) in Holzkirchen (Germany) found that the insulation material obtained is capable of storing a considerable amount of energy (2,502 joules per kilogram kelvin (J/kgK)), 20% more than wood or wood products. This characteristic allows it to keep buildings cool during hot periods by protecting them from heat during the daylight hours. The results of an analysis confirmed the high insulating capacity of Posidonia fibres. It can be used in construction at a density high enough so that it does not sink under its own weight. The required density was determined at the MPA NRW Materials Testing Institute in Dórtmund, Dr. Grübe explained. The suitability of this material from a health point of view was also investigated. The results provided by the Eco-Institute in Cologne revealed that it does not contain any toxic or residual materials and is therefore particularly suitable for allergy sufferers.

Environment

In 2008, Argos, a leader in the cement and concrete production sector, began to develop research projects in biotechnology to minimize the environmental effects of its operations. The following year it opens the Research and Development Center within the university campus. In 2010, EAFIT begins with Argos Adaptatio, a pioneering research project aimed at generating at the University the scientific capacity to grow micro algae, which was the foundation of the SP1 project (Restrepo, 2017).

This biotechnological research in its initial stage seeks to characterize, by 2014, the conditions in which CO_2 capture is maximized, within the range provided by the cement industry. Specifically, it seeks to evaluate the response of micro-algae to gas mixtures from sulphur and nitrogen oxidation, found in the stacks of the cement production process.

Argos believes that innovation is the fundamental pillar for achieving sustainable and environmentally friendly growth. With this research, the company intends to consolidate the bases for the development of a technology that will allow the mitigation of the emission of polluting gases and replicate this good practice to any type of industrial activity that generates CO_2, says Camilo Restrepo Restrepo, Vice President of Innovation at Argos.

Importance of micro algae

About 75 percent of the oxygen that is breathed is produced by micro-algae, of which there are about 40,000 species. These are characterized by their speed of growth and their capacity to capture CO_2, 10 times faster than a normal plant.

These microorganisms are a source of nutrients of great importance for the rest of living beings, they are the food base of the pyramid, they provide oils that can be used as chemical precursors, biofuels or as food (omega 3 oil, etc.). Some species produce colourings and even hydrocarbons and alcohols.

This project, framed in sustainability, is aligned with Argos and EAFIT policies, where science is shared, visible and responsible (Fig. 5).

Figure 5. SP1 Research of EAFIT University and Argos Company (Restrepo, 2017).

Tests of concrete with microorganisms

The idea sounds as appealing as science fiction: buildings that close their own cracks as if they were living beings healing their wounds. For the Dutch scientist Henk Jonkers, this project that sounds fantastic is, let's say, a fairly concrete reality.

At the Technical University of Delft in the Netherlands, they have developed bio-concrete, a material that is literally alive and can regenerate the wear and tear of buildings. Our concrete is going to revolutionize the way we build,

because we are inspired by nature, Jonkers said when he was nominated for the European Inventor Award in 2015 (Fig. 6).

Figure 6. Earthquakes in Latin America. Another cause for bio-concrete research (Mundo, 2017).

But more than inspired by nature, bio-concrete is composed of it. The extraordinary properties of this material are due to tiny beings: bacteria.

Hard to kill

To prepare bio-concrete, traditional concrete is mixed with strains of Bacillus Pseudofirmus bacteria that in their natural state can live even in such hostile environments as active volcano craters. The amazing thing about these bacteria is that they form spores and can survive for more than 200 years in the building, Jonkers explains. Calcium lactate is added to that mixture, which is what the bacteria eat, and the bio-concrete is ready (Fig. 7).

Figure 7. Pseudomonas Aeruginosa (Mine, 2017).

This is how one of the smallest beings on the planet can be a fundamental part of the most imposing constructions that man can design. In only three weeks, when cracks are formed in buildings made of this material, the bacteria that inhabit it are exposed to the elements, mainly water.

The humidity that penetrates the cracks awakens the microorganisms that begin to feed on calcium lactate and as a final product of their digestion they secrete limestone. This material seals the cracks in the bio-concrete in as little as three weeks.

Bio-concrete in Latin America

Bio-concrete is a new material that helps to filter water. In the Design Week of America, the prototype of a house called Rainhouse was presented, causing a great impact. In this house, rainwater is channeled through a series of stainless steel pipes, where barrier filters remove the largest impurities, to a bio-concrete tank, installed on top of the house. This tank acts as a natural limestone cave, which automatically adjusts the pH of the water to an optimal level. The tank has a special silver-based coating, which ensures that it stays clean, and a series of filters that complete the work of purifying the water to make it drinkable, without the use of chemicals (Fig. 8).

Figure 8. Examples of bio-concrete use (Verde, 2017).

As part of the evaluations of bio-concrete, Henk Jonkers reported that this material has been used to build irrigation canals in Ecuador, a highly seismic country. Although it can be more expensive than traditional concrete, the economic benefit is soon evident because it saves on maintenance costs, the scientist told the English daily The Guardian. But even old buildings crisscrossed by cracks, the kind that abound in Latin America and which risk collapsing even with the slightest tremor, could have hope.

The Technical University of Delft has a spray on the market, made on the basis of the same principle, which can be applied directly to small cracks. Although the idea of a building being repaired is only fascinating, bio-concrete still has to pass the toughest test: the market.

This project is going to revolutionize the way we build, because it is inspired by nature. Known by the name of bio-concrete or organic concrete, this material can regenerate and heal itself, by the wear and tear of the buildings, caused by any telluric movement or some blow to the structure.

The Technological University of Delf is working on this experimental cement that is mixed with a bacterium, which

ISSN 1692-8407

helps to repair the cracks in the cement. The experts conducting this experiment are: Eric Schlangen, and micro biologist Henk Jonkers, who indicate that bioconcrete does not directly cause the loss of strength of structures.

The extraordinary properties of this material are due to tiny beings or bacteria, which in their natural state can live even in such hostile environments as active volcano craters. Calcium lactate, which is what the bacteria eat, is added to the mixture between the concrete and the batteries in order to have the organic concrete ready. The amazing thing about these bacteria is that they can survive for over 200 years in the building (Fig. 9).

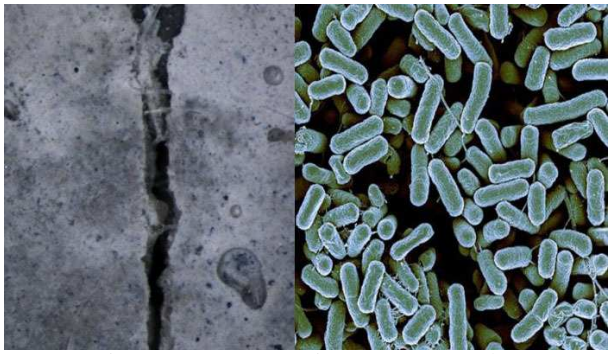


Figure 9. Bioconcrete or organic concrete (Verde, 2017).

Although concrete is the most widely used building material in the world, it has one flaw: it can easily break when under stress. If these cracks become too large, they will lead to corrosion of the steel reinforcement, which not only results in an unattractive appearance, but also jeopardizes the mechanical qualities of the structure. That is why engineers often use more than the necessary amount of steel reinforcement inside a concrete structure to prevent cracks from becoming too large. This extra steel has no structural use and is an expensive solution as steel prices are high. Another way to deal with cracks is to repair them, but this can be extremely difficult in underground or liquid retaining structures. The solution would be self-healing concrete, which is exactly what TU Delft researchers are working on.

By embedding calcite precipitating bacteria into the concrete mix, it is possible to create concrete that has self-healing capabilities. As the pH value of concrete is very high, only so-called alkali bacteria are able to survive. They have mixed several of these bacteria in a cement paste and after one month they found the spores of three particular bacteria.

In theory, the use of bacterial concrete can lead to substantial savings, especially in steel-reinforced concrete. It will also mean that durability problems can be addressed more economically when designing concrete structures. Bacterial concrete is ideal for the construction of underground hazardous waste retainers, as no human being would have to go near it to repair any cracks that occur. However, for residential buildings it seems that traditional crack repair will remain the most economically attractive solution for now.

Research is currently focused on creating the right conditions for bacteria to produce as much calcite as possible and on optimizing the distribution of food for bacteria. They are also studying the self-healing capacity of bacterial concrete and how this is affected by the various deterioration mechanisms involved, such as sulphate attacks or temperature fluctuations. All research is carried out in TU Delft's Microlab, where equipment is available for fracture testing as well as numerical tools for information on structures and fracture models.

The Self Healing Concrete project is part of the TU Delfts research program on Self-Correcting Materials at the Delft Materials Center (DCMat). They also work in collaboration with the Biotechnology section of the School of Applied Sciences and the South Dakota School of Mines in the United States.

Bacterial bio-concrete, as it has become known to the media, incorporates bacillus bacteria into the basic concrete mix developed by the Dutch university, producing spores that can survive for up to five decades without food or oxygen, Jonkers told The New Scientist in 2010, when the research had succeeded in its first experiments a year earlier.

How does it work? To carry out the repair, the bacillus bacteria are stored inside the concrete in capsules made of biodegradable plastic, which open when they come into contact with water, once the mixture has solidified. The bacteria are stored in calcium lactate and produce limestone, the material that repairs concrete.

The team of researchers is currently working on testing the different capacities of bacteria to respond to sulphate attacks or wide thermal oscillations. They also seek to reduce their production costs to become an accessible alternative to the current offer, since their potential for commercial exploitation is wide: from residential buildings to the construction of underground containers for hazardous waste, since people would not have to go near them to repair the cracks produced, according to the TU Delft's MicroLab.

Applications

In the application of microorganisms in the construction industry, different biotechnological products and biotechnologies for civil engineering have been created, based on a new science that we could call construction biotechnology, as we have already observed throughout the article. The application of microorganisms, algae and other biological material is one of the alternatives, if not the best in the application to improve and enhance the main material in civil works as it provides us with an environmental balance and a better adaptation to environmental conditions (Figs. 10, 11 and 12).

Figure 10. Concrete slab with freshly formed cracks (Alvarez, 2017).

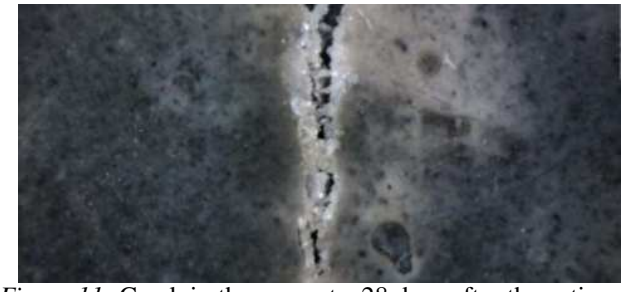


Figure 11. Crack in the concrete, 28 days after the action of the bacteria (Alvarez, 2017).

Figure 12. Crack in the concrete, 56 days after the action of the bacteria (Alvarez, 2017).

One of the solutions proposed during the course of the project is the effectiveness that concrete has with these additives that add a quality, as important as having the ability to seal the cracks, this is shown in the BBC magazine article the idea sounds as attractive as science fiction: buildings that close their own cracks as if they were a living being healing their wounds. For the Dutch scientist Henk Jonkers, this project that sounds fantastic is, let's say, a fairly concrete reality. At the Technical University of Delft in the Netherlands, they have developed bio-concrete, a material that is literally alive and can regenerate the wear and tear of buildings.

But the most extraordinary thing is that these bacteria form spores and can survive for over 200 years in the building. Just thinking about this quality we are amazed at the great benefit micro algae provide but how this method works. When cracks are formed in buildings built with this material, the bacteria that inhabit it are exposed to the elements, mainly water. The humidity that penetrates the cracks awakens the microorganisms that begin to feed on calcium lactate and as a final product of their digestion they secrete limestone. Bio-concrete can save billions of pesos in the maintenance of structures as varied as buildings, bridges or dams. Not to mention that the maximum sealing capacity is 8 millimeters wide regardless of length. This is just one of the many benefits that the implementation of this material for concrete brings (Fig. 13).

Figure 13. Cracked wall already repaired (Alvarez, 2017).

Undoubtedly, this quality will be very useful when building on irregular surfaces or unstable soils with a high degree of humidity or soils containing a high proportion of water, since these soils are more prone to cracking due to the sinking of the earth; but thanks to this material this will no longer be a problem in the future.

Another of the qualities of this material, if not the most important, is its ability to reduce CO_2 emissions (carbon dioxide). This quality of the material is so important not only for the material but for the ecosystem itself, since the area of the constructions produces 5% of the world's pollution. In Colombia, the Argos cement company has been carrying out studies on this problem.

Together with researchers from the EAFIT University, Argos has been carrying out one of the most promising research projects in the country since 2010, with the aim of consolidating the bases for a sustainable technology that allows a rational mitigation of the emission of gases that cause the greenhouse effect. Currently, research is advancing in the search for the most effective species in CO_2 capture, so that in the near future these findings can be projected to any type of industrial activity generating emissions, thus contributing to the development of more sustainable industries through science and innovation. The goal for 2018 is to implement the technology in one of

ISSN 1692-8407

Argos' nine cement plants in Colombia and achieve a 20% reduction in CO_2 emissions (equivalent to 140,000 t of CO_2) generated in the production process of 700,000 t of cement (November 2013). Recently, several researches have been released regarding the implementation of microorganisms in the construction industry due to their high effectiveness in absorbing CO_2 through algae, since they help to reduce CO_2 emissions. It is known that some of them have the quality of being 100 or 200 times more effective than trees in terms of their main function of transforming CO_2. Without doubt it will be a great help to the environment (Fig. 14).

Figure 14. Microalgae plant (Argos, 2017).

The new material has many environmental advantages, thanks to the biological coating it will absorb, and consequently reduce CO_2 from the atmosphere, purifying the air around it, as well as contributing to the maintenance of biodiversity. It has the capacity to capture solar radiation and will be able to regulate the thermal conductivity inside the buildings; and the most obvious one will be an ornamental alternative that will allow to decorate the facade of the buildings or the surface of the constructions with different finishes and chromatic shades.

Undoubtedly this material shows us a new way not only for the constructions and other applications but a new form of sustainable development, in other investigations they have given the name of biological ormigon the material is thought to be used as vertical garden in buildings not only of new construction but to rehabilitate the already existing ones, or used in other constructions in Mediterranean climates. Last year it won the Beyond Building Barcelona-Construmat prize for an innovative project in its sixteenth edition (29 June 2016). This material not only helps the environment but also opens up new designs for buildings, creating self-sustainable models.

This material not only brings us new and better working conditions but also goes hand in hand with the environment, without a doubt this could be a solution to the new trends with each and every one of the qualities already mentioned. We could say that the microorganisms, algae and others are one of the exits to face future problems not only in the construction but in the fight against the deterioration of the earth in our time.

Conclusions

There are currently hundreds of methods in the world literature for determining the composition of conventional concrete mixtures. The choice of one or another depends on several factors, basically the type of concrete required and the experience or customs of the place. However, the evolution of the market towards the production of concrete in an industrialized way has caused that the prefabrication plants have developed their own methodology, mainly to be more competitive and to obtain the maximum saving in the cement consumption.

The objective of the dosage is to find the best combination of ingredients that responds, in each case, to the three main phases of the life of a concrete, that is, the laying, the contractual age and, from this, the useful life. This translates into requirements for workability, strength and durability, respectively.

In this sense, the analysis of the structure of bio-concrete, the influence that its component phases (aggregates, transition zone and hardened cement paste) have on the most significant properties in practice, can only increase its importance. Of particular interest is the influence of the porous structure of the cement paste on the permeability (durability) and strength of the concrete.

It is important to keep in mind that optimization of total costs (economic, environmental) is one of the essential purposes in any process. In this sense, it has been shown that cement represents around three quarters of the cost of the materials used to manufacture one cubic metre of normal concrete without chemical additives, so reducing this cost, without compromising workability, strength and durability, means major economic benefits and a reduction in the consumption of oil in cement manufacture.

It is interesting to note that, as the water/cement ratio decreases, the paste content must be increased to obtain the same workability. The type of aggregate used also influences the amount of slurry, so that the more rounded particles require a smaller volume of slurry as the workability of the mix increases.

On the other hand, several authors (Abrams, for example) point out that it is only the quality of the hardened cement paste that controls the strength of comparable concretes.

There is no doubt that the water/cement ratio is the most influential factor in the strength of a fully compacted concrete; however, the use of microorganisms, cement and aggregates, as well as the maximum size of these, play a significant role in the strength of concrete.

The conglomerant used in dams is made up of Portland clinker and natural fly ash or pozzolan, this reduction in cement content being beneficial from a thermal and economic point of view. Depending on the percentage of additions, they can be classified as type II or type IV cements (pozzolanic cement).

To carry out the repair, the bacillus bacteria are stored inside the concrete in capsules made of biodegradable plastic, which open when they come into contact with water, once the mixture has solidified.

Concrete is extremely alkaline and healing bacteria must wait inactive for years before being activated by water.

Jonkers chose calcium lactate, placed the bacteria and calcium lactate in capsules made of biodegradable plastic, and added the capsules to the wet concrete mix.

References

Alvarez, J. (2017). *Bioconcreto - nota: 17.* Retrieved from https://www.studocu.com/es/document/universidad-andina-del-cusco/concreto-armado/informe/bioconcreto-nota-17/5875588/view

Argos, C. (2017). *Microalgas para reducir las emisiones de co2.* Retrieved from http://grandesrealidades.argos.co/593/

Coxworth, B. (2017). *Déchets d'algues utilisées comme isolants - environnement - 2020.* On line. Retrieved from https://fr.inforandum.com/waste-seaweed-finds-use-93612

Industrial, T. (2017). *La posidonia del mediterráneo podría ser usada como aislante.* Retrieved from http://tecnicaindustrial.es/TIFrontal/a-5163-la-posidonia-mediterraneo-podria-usada.-aislante.aspx

Jahren, P., & Sui, T. (2017). *History of concrete: A very old and modern material*. Chemical Industry Press.

Manso, S., & Aguado, A. (2016). The use of bio-receptive concrete as a new typology of living wall systems. *Matériaux & Techniques*, *104*(5), 485-495.

Mehta, P., & Monteiro, P. (2014). *Concrete: Microstructure, properties, and materials* (4th ed.). McGraw Hill.

Mine, C. (2017). *Normen, wetgeving en een beetje chemie.* Retrieved from http://www.properwater.org/index.php/nl/2/0/15

Mirza, S., & Lacroix, E. (2002). Comparative study of strength-computation methods for rectangular reinforced concrete columns. *Structural Journal*, *99*(4), 399-410.

Montaño, S., Lizarazo, J., & Brandão, P. (2018). Isolation and potential biocementation of calcite precipitation inducing bacteria from colombian buildings. *Current Microbiology*, *75*(3), 256-265.

Mostafazadeh, M., & Abolmaali, A. (2016). Shear behavior of synthetic fiber reinforced concrete. *Advances in Civil Engineering Materials*, *5*(1), 371-386.

Mundo, B. (2017). *El revolucionario bio-concreto, el material que se repara a sí mismo.* Retrieved from https://www.bbc.com/mundo/noticias-37199563

Osorio, J. (2017). *Historia del concreto y del cemento.* Retrieved from https://www.360enconcreto.com/blog/detalle/historia-del-concreto-y-del-cemento

Restrepo, C. (2017). *Microalgas para reducir emisiones de co.* On line. Retrieved from http://www.eafit.edu.co/investigacion/revistacientifica/edicion-162/Paginas/microalgas-para-reducir-emisiones-de-co2.aspx

Scheithauser, K. (2017). *Fraunhofer isc, zentrum für hochtemperatur-leichtbau htl, bayreuth.* On line. Retrieved from https://www.as-fassaden.de/project/fraunhofer-institut-bayreuth/

Staff, I. (2017). *Spanish researchers develop biological concrete that easily builds living walls.* On line. Retrieved from https://inhabitat.com/spanish-researchers-develop-a-biological-.concrete-that-easily-builds-living-walls/

Verde, P. (2017). *Bioconcreto, el material de construcción del futuro.* Retrieved from https://pensemosverde.com/2016/10/18/bioconcreto-el-material-de-construccion-.del-futuro/

Wikipedia, E. (2017). *Cemento.* Retrieved from https://es.wikipedia.org/wiki/Cemento

Tekhnê
July - December 2017, Vol. 14, No. 2, pp. 59 – 64

ISSN 1692-8407

Importance of empirical knowledge in civil works

Importancia del conocimiento empírico en obras civiles

Juan D. Merchán P.
Universidad Distrital Francisco José de Caldas
jdmerchanp@correo.udistrital.edu.co

Se presenta este artículo sobre la importancia del conocimiento empírico con el fin de dar a conocer la necesidad, incidencia y aplicación de dicho conocimiento en obras civiles. Además, se realiza con el fin de documentar sobre el tema que involucra a maestros de obra, ingenieros, obreros y demás participantes de obra, pero que no cuanta con difusión. El artículo se realizó mayormente en la Universidad Distrital Francisco José de Caldas, Facultad Tecnológica con el apoyo de obreros de la zona, maestros de obra, ingenieros civiles y demás participantes de obras en la universidad y en zonas aledañas. Se establecieron necesidades del pensamiento empírico y se dejó claro que no es lo único necesario para un buen desempeño en obra civiles, llegando a la conclusión de que el conocimiento empírico y el conocimiento académico son necesarios para desempeñarse de la mejor manera en obras civiles pues ambos conocimientos son importantes para ciertos momentos de la vida laboral.

Keywords: Academic knowledge, civil works, empirical knowledge, field of action

This article is presented on the importance of empirical knowledge in order to make known the need, incidence and application of such knowledge in civil works. In addition, it is made with the purpose of documenting the subject that involves masters of work, engineers, workers and other participants of work, but that does not count with diffusion. The article was mostly written at the Universidad Distrital Francisco José de Caldas, Facultad Tecnológica, with the support of workers from the area, master builders, civil engineers and other participants in the work at the university and in the surrounding areas. It established the need for empirical thinking and made it clear that it is not the only thing necessary for good performance in civil works, reaching the conclusion that empirical knowledge and academic knowledge are necessary to perform in the best way in civil works because both knowledge are important for certain moments of working life.

Palabras clave: Campo de acción, conocimiento académico, conocimiento empírico, obra civil

Article typology: Research

Date manuscript received: November 27, 2017
Date manuscript acceptance: December 8, 2017

Research funded by: Universidad Distrital Francisco José de Caldas.

How to cite: Merchán, J. (2017). *Importance of empirical knowledge in civil works*. Tekhnê, 14(2), 59 -64.

Empiricism. Historical reference

Empirical knowledge

Empirical knowledge or empiricism is that knowledge acquired through experience of practice and direct contact with reality (McNeill & Nicholas, 2019). This knowledge is acquired through continually repeated actions, whether or not we have scientific knowledge (Fig. 1) (Li, Jiang, Song, & Liu, 2017).

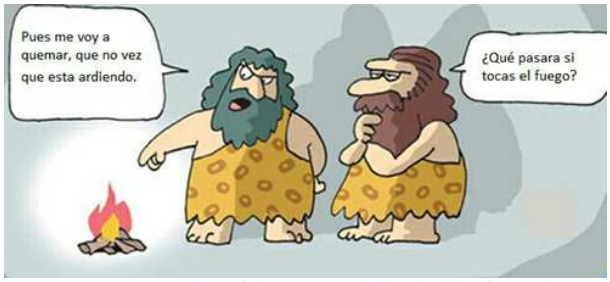


Figure 1. Example of how empirical thinking develops (Cobaem, 2017).

Empiricism is a philosophical current that arose in England in the 17th century and spread during the 18th century, whose maximum representatives are J. Locke (1632-1704), J. Berkeley (1685-1753) and D. Hume (1711-1776) (Prieto, 2011; Rawbone & Jan, 2019).

They considered that the senses generated impressions or ideas in the mind, what we would know as visual images that is to say that something is seen in a certain colour and with a certain shape and they maintained that these sensory data were mental states or objects that are presented to the mind and are within them (Anstey & Vanzo, 2016; Pihlström, Stadler, & Weidtmann, 2017; Westphal, 2017). The human mind behaves like a blank piece of paper that acquires content through experience.

For empiricism, experience is the basis of all knowledge, not only in terms of its origin but also in terms of its content. One starts from the sensitive world to form the concepts and these find in the sensitive their justification and limitation.

Empirical knowledge in different fields of work

Empiricism, when understood as all knowledge obtained through practice, supposes that this can be obtained in the practice of diverse processes, such as labor processes, whether they be in construction, manufacturing, or transportation, among others (Cooper & Stowe, 2018). Due to this, in different labor environments this phenomenon is presented, with which people without official training carry out a great deal of work, and how is it that people with official training are not totally capable of carrying out their work due to the lack of this knowledge (Fig. 2).

In the work environment it is essential to have great skill in the tasks to be performed, but for this it is logical that one must have time for practice and experience in what one is going to do and that is why the knowledge obtained through practice (empiricism) will take precedence, since this will provide those who have it with a familiarity and comfort with their tasks and results. The comfort and familiarity that empirical knowledge gives the person, will mean that their results will be better and more efficient. At this point it will be shown that this trait is present in all types of environments but that this trait is given in each work environment in different ways as it can be that in companies receive personnel not trained to perform a task in which they have no knowledge and through the performance of this task learn to do and do it well, this is how more than one person acquires the understanding of a trade and is linked to the industry. There are cases that demonstrate that professions such as bricklaying are the product of empirical knowledge, which are generally learned and perfected through years of practice.

Figure 2. Variety of work fields citepMaile2017.

Empirical knowledge is an indispensable part in the formation of people from the most basic learned in the growth of each, as in the development of a profession or work (Goldenfein, 2019; Martínez, Hernández, & Acero, 2016). Indispensable in the formation of any person, but this phenomenon is present in every field and its presence in the work environment diagnoses the quality of the processes that these will perform and this is how empiricism in every work environment has an impact. The impact is not easy to measure, but it is easy to observe and that is how in each labour field it has an importance and impact.

Appearance and presence of empirical knowledge in civil works

The empirical knowledge appears in works at the moment in which a civil engineer sees himself in the task of carrying out the tasks that have been indicated to him (Fig. 3).

It is necessary to go through a vulgar knowledge, a knowledge that consists of using a language and techniques present in a certain specific society (Ayala, 2017). This conclusion is reached because of the need to understand the

ISSN 1692-8407

Figure 3. Example of civil work (Eiffage, 2017).

techniques used in the work by the team that does the work in the most beneficial way for the project.

Interviews conducted on September 20, 2017 with civil engineers at the Universidad Distrital Francisco José de Caldas reveal the opinion they have about recent graduates in civil works.

They think they know everything. They have a lot to learn. A classroom is not the same as a building site. They have the tools, but they don't know how to use them. These are some of the most striking opinions with which many other engineers agreed. These opinions make clear the idea that, although university study is very important and leaves several tools, according to these engineers, it is necessary to get a job and gain experience through it to perform successfully in civil works.

Empirical knowledge in a civil work

Is it important?

Before speaking about empirical knowledge in a civil work, it is necessary to emphasize that through it the *common* man knows the facts and their apparent order, creates explanations concerning the actions performed by him, performed without method. It is thanks to personal research that a person without great knowledge can understand how to achieve certain things, can learn to do a job thanks to empirical knowledge (Fig. 4).

When we see how a team works in a civil work, it becomes visible that *practice made the master* (without making any reference to the master builder). It must be clear that a person needs practice in any type of action in order to do it better, do it more efficiently, and well, this is when empirical knowledge comes into play.

Making an analogy we can imagine a musician, this imaginary musician has never played an instrument in his life, but he has been studying music theory for several years. After several years this musician considers that he is able to create songs, he knows which notes and chords to combine to create a melody. The problem would arrive when the musician tries to play an instrument to create that melody, in reality the musician can know all theoretical knowledge about music (Fig. 5), but if he has never practiced with an instrument he will not know how to materialize his knowledge, here it is necessary to have a previous practice, a personal investigation with some instrument to be able to materialize this knowledge.

In civil works it's the same. Today you can see many people who in their lives have studied a lot, but the reality is that if you have never participated in a work very likely when you first try it you will be lost because, although you have a lot of knowledge it will take some practice to participate actively and efficiently.

Relationship between empirical knowledge and academic knowledge

In order to be able to relate academic knowledge to empirical knowledge, we can return for a moment to analyse the analogy of the musician (Fig. 6).

Looking at the analogy from another point of view we can *turn it around* and think that this musician has played an instrument since he was very young, but has never studied a bit about theory. Although the musician will have the ability and some experience with the instrument he will have trouble (as in the previous example) creating melodies, because, although he has all the necessary skill to materialize the melody he does not have the knowledge to create it.

And that is the point, it is not about two types of exclusive knowledge that cannot coexist, let alone two types of knowledge that are in conflict with each other. They are two types of knowledge that are valid and necessary for the life of any human being.

Returning to the field of civil works is the same, a person can perform very well in a job with the empirical knowledge he has acquired, and likewise someone can perform very well with the academic knowledge he has. Both of them will have problems in some areas because they don't have the kind of knowledge they need and that's why these two types of knowledge are related.

We can see academic knowledge as a set of tools that one has, and empirical knowledge as the knowledge of what should be achieved.

On the one hand, with academic knowledge you can have many tools, but finally you do not know how or where to use them, with empirical knowledge you know what you should arrive at, but you do not know if you arrived correctly.

These two thoughts are useful and necessary to each other as far as civil works are concerned, the ideal will always be to have all the knowledge available, because, although with only one of the two you can progress in works, having both knowledge will help to solve problems more easily, reaching an end in the right way and finally helping to create the work with an excellent job.

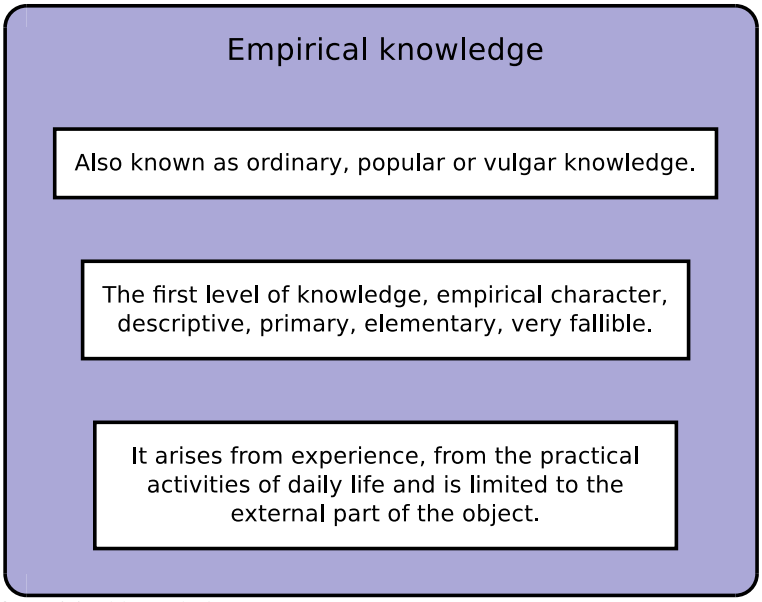


Figure 4. Characteristics of empirical knowledge.

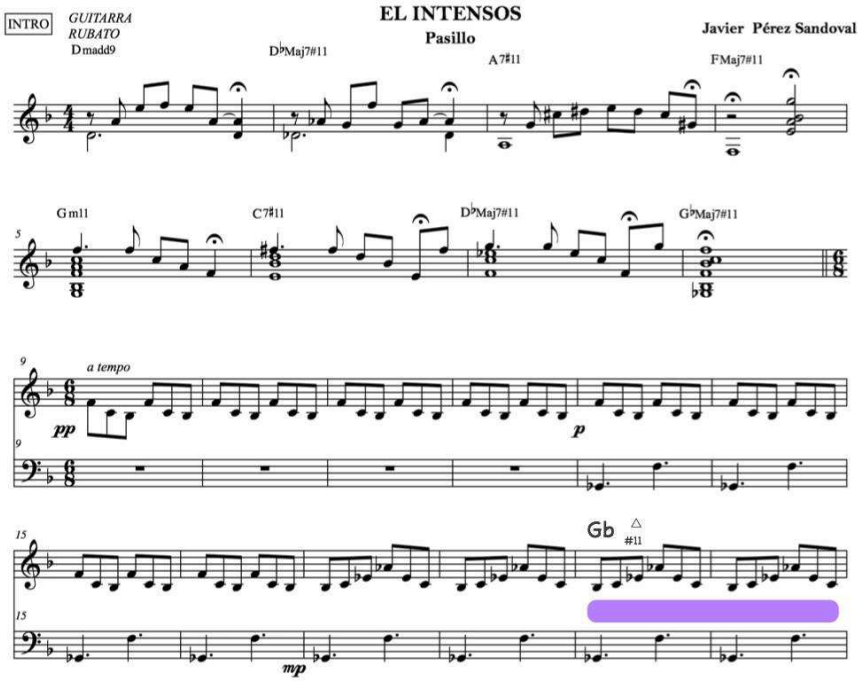


Figure 5. Music score *El intensos* (Quinta, 2017).

The need for empirical knowledge in a civil work

According to everything explained above we can reach a conclusion about the importance of empirical knowledge in civil works.

With what was discussed in previous sections we can see that empirical knowledge is necessary for a good performance in a civil work. But the conclusion cannot stay there, because it would be wrong to say that empirical knowledge is the only thing necessary to perform well in a civil work.

For this reason, the conclusion is that empirical knowledge is necessary for the good performance of a worker in civil works, a person can perform well without this knowledge, but at some moments of the working life will see the need for empirical knowledge. In addition, it is to be highlighted that with only the empirical knowledge it will

ISSN 1692-8407

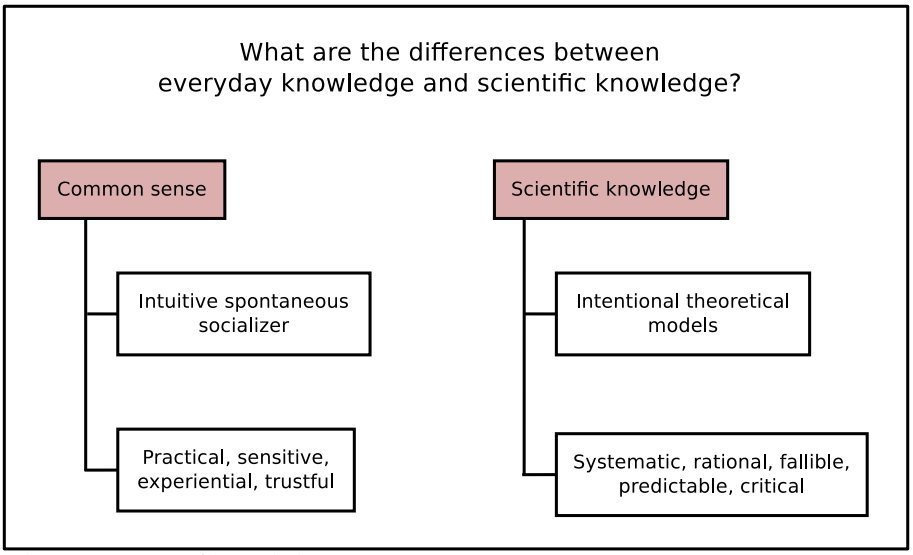


Figure 6. Differences between types of knowledge.

not be enough, because you will also find some cases of your working life in which you will need academic knowledge.

The problem has existed in the social dynamics where the workers involved in civil works become engrossed in thinking that empirical or academic thinking is better than the other.

For this type of case, it is necessary to create awareness of the importance and advantages that possessing both knowledge (empirical and academic) gives a worker. Advantages that will make the workers on site able to perform better and thus allow the civil work to advance in the right way and more efficiently.

Conclusions

Empirical knowledge is necessary for a good performance in a civil work. The competence in such a work, shall then depend on how much you have so far made use of your knowledge and wisdom and gained experience in the study of this art. When we have empirical knowledge, our knowledge becomes an extension of our rational judgment. In the presence of evidence, we can revise our rational judgment without being restricted to a rationality that is limited to empirical knowledge. When our knowledge cannot be changed without the help of evidence, the space of knowledge becomes so limited that a decision or action on the basis of rational judgment becomes impossible. What is empirical knowledge? In science, it is the practical, inductive facts that you know are true (or invalid) by observation and experimentation.

References

Anstey, P., & Vanzo, A. (2016). A companion to experimental philosophy. In J. Sytsma & W. Buckwalter (Eds.), (p. 87-102). Wiley-Blackwell.

Ayala. (2017). *Tipos de conocimiento aplicados a la ingeniería civil.* Retrieved from `https://karencitafilosofica.blogspot.com/`

Cobaem, C. (2017). *Conocimientos de las ciencias sociales.* Retrieved from `https://cienciassocialesyconocimientos.blogspot.com/2015/10/conocimientos-de-las-ciencias-sociales.html`

Cooper, M., & Stowe, R. (2018). Chemistry education research—from personal empiricism to evidence, theory, and informed practice. *Chemical Reviews*, *118*(12), 6053-6087.

Eiffage, E. (2017). *Obra civil y construcción.* Retrieved from `https://www.energia.eiffage.es/lineas-actividad/obra-civil-construccion/`

Goldenfein, J. (2019). The profiling potential of computer vision and the challenge of computational empiricism. In *Proceedings of the conference on fairness (fat'19)* (p. 110-119).

Li, X., Jiang, Z., Song, B., & Liu, L. (2017). Long-term knowledge evolution modeling for empirical engineering knowledge. *Advanced Engineering Informatics*, *34*(1), 17-35.

Martínez, H., Hernández, C., & Acero, D. (2016). Color image segmentation based on bacterial quorum sensing. *Tecnura*, *20*(EE), 55-63.

McNeill, T., & Nicholas, D. (2019). Creating and applying knowledge for critical social work practice: Reflections on epistemology, research, and evidence-based practice. *Journal of Ethnic & Cultural Diversity in Social Work*, *28*(4), 351-369.

Pihlström, S., Stadler, F., & Weidtmann, N. (2017). *Logical empiricism and pragmatism*. Springer.

Prieto, S. (2011). Jovellanos: la educación como necesitad, la ilustración como deber. *Dendra Médica*, *10*(2), 177-198.

Quinta, C. (2017). *Guía de audición el intensos pasillo colombiano carrera quinta.* Retrieved from `https://www.youtube.com/watch?v=Gt15VE81DAY`

Rawbone, T., & Jan, S. (2019). The butterfly schema in the classical instrumental style: A product of the tendency for congruence. *Music Analysis*, *39*(1), 85-127.

Westphal, K. (2017). Pragmatism in transition. In (p. 169-198). Springer.

Tekhnê
July - December 2017, Vol. 14, No. 2, pp. 65 – 75

ISSN 1692-8407

The hecatomb of the La Linea tunnel

La hecatombe del túnel de La Línea

Erick Jiménez
Universidad Distrital Francisco José de Caldas
eajimenezm@correo.udistrital.edu.co

Brayan Alfonso
Universidad Distrital Francisco José de Caldas
bhalfonsoa@correo.udistrital.edu.co

Lina Suárez
Universidad Distrital Francisco José de Caldas
lnsuarezp@correo.udistrital.edu.co

The La Línea tunnel is one of the largest civil works projects ever undertaken in the country. We could say that it is the most efficient in terms of other works, but of course, we live in Colombia, a country full of corruption. This makes most of the civil works splash in over costs and delays as it is the tunnel of La Linea. In this article, we summarize what the work has been, and we focus more on the delays and failures of this work, and what has produced them. We relate the catastrophe to this work as it is a synonym of the former because it is a great catastrophe. This work, which makes the country and all Colombians look bad, gives us to understand how the country is, and that if we don't put an end to this filth called corruption, everything will be a hecatomb.

Keywords: Budget, contractors, corruption, delays, failures, infrastructure, roads

El túnel de La Línea es una de las obras civiles más grandes que se han hecho en el país. Podríamos decir que es la más eficiente en cuanto a otras obras, pero claro vivimos en Colombia, un país lleno de corrupción. Esto hace que la mayoría de las obras civiles resulte salpicada en sobre costos y retrasos como lo es el túnel de La Línea. En este artículo resumimos lo que ha sido la obra, y nos enfocamos más que todo en los retrasos y fallas de esta obra, y que los han producido. Relacionamos la hecatombe con esta obra ya que es un sinónimo de aquella, porque es una gran catástrofe. Esta obra, que hace quedar mal al país y a todos los colombianos, nos da a entender cómo está el país, y que si no damos fin a esa mugre llamada corrupción, todo será una hecatombe.

Palabras clave: Contratistas, corrupción, fallas, infraestructura, presupuesto, retrasos, vías

Article typology: Research

Date manuscript received: November 27, 2017
Date manuscript acceptance: December 8, 2017

Research funded by: Universidad Distrital Francisco José de Caldas.

How to cite: Jiménez, E., Alfonso, B., Suárez, L. (2017). *The hecatomb of the La Linea tunnel*. Tekhnê, 14(2), 65 -75.

Introduction

One of the great internal problems of most countries that cost millions of dollars a year, involve crimes such as corruption, bribery and other types of influence within governments and entities responsible for contracting works and public good projects (Cirilovic, Vajdic, Mladenovic, & Queiroz, 2014; Limam, 2012; Rose, 2008; Walcher, Stempkowski, & Apfalter, 2012). These problems are seen even more in societies with little respect for the common good, with instruments of vigilance in the hands of people not suited to the positions and great concentrations of money in few hands (Andreescu, 2016; Clem, 2011; Herath, 2015; Loomis, 2010; Meduri & Annamalai, 2013).

The La Línea tunnel is a civil construction project located in the departments of Tolima and Quindío. This work consists of the main tunnel of 29.5 km, 21 bridges, 24 viaducts, 2 depressed and an initial budget in 2004 (the year when it began to be realized) of 629,000 million pesos, but that up to the moment has ascended to $1.27 billion Colombian pesos. The bidding process and subsequent award for the execution were granted to the consortium Segundo Centenario by the National Government in 2008, and it was intended to be completed in July 2014. In principle, no delays were expected in the work, but now it is expected that this work was delivered in November this year and that by 2018 it will be fully operational.

The director of INVIAS (National Institute of Roads), Carlos García Montes, informed that it is expected that the crossing of the central mountain range (La Línea tunnel) will be delivered on November 30th, 2017 and that it will be fully operational in the first period of 2018 when the five contracts that make up one of the most ambitious mega-projects currently underway in the country should be completed.

In recent public statements, the Intertunel consortium has said: "We as engineers think that they will have to honor this commitment and deliver the work to the country in 12 months".

Description of the project

The La Línea tunnel is one of the most important road projects being executed in Colombia, since it is the road that aims to facilitate traffic on National Route 40 (a route that crosses the country from East to West from Buena Aventura to Puerto Carreño), hence its importance. This will make the country's capitals more connected to the sea ports located in Buena Aventura, which will generate more profits for the country (Fig. 1).

This project is divided into four modules and six sections.

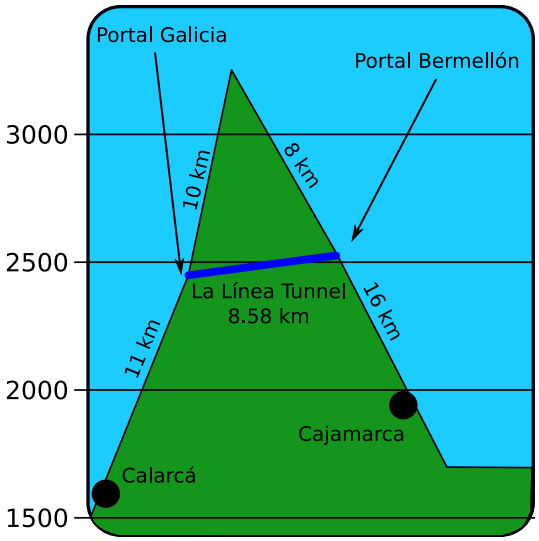


Figure 1. La Línea Tunnel profile.

Modules

The following is a list of the progress made by each according to information from INVIAS. The first module is the main tunnel of 8.6 km that has several fronts in which the progress is different. Here the different fronts and their level of progress will be presented.

- Fault treatment 66%.
- The concrete lining of the tunnel walls 60%.
- Paving of the track 27%.

The second module, which has 8.89 km of construction for the second roadway, has 13 bridges, and the percentage of progress is as follows.

- Bridge raising has a progress level of 88%.
- Annexed works at 96%.

The third module includes 11 bridges and five tunnels, which have a progress level of 80%. The fourth module includes annexed works and the completion of other alternative routes, which is only 58% complete. These include the Pilotó Tunnel and a tunnel parallel to the main one.

We can say that in the total of the work it is necessary to complete 46% of annexed works, 32% of the lifting of bridges and tunnels, 40% of concrete resentment in the tunnels, 34% of the treatment of faults and 73% of paving in the track of the first module. What makes us think that this work has not been executed normally because of the failures and promises that have put the country in bad reviews.

Sections

- Section 1: Buenaventura - Buga (Invias, 2013).
- Section 2: Buga - La Paila (in concession).
- Section 3: La Paila - Armenia - Calarcá (in concession).

ISSN 1692-8407

- Section 4: Calarcá - Cajamarca (of which La Línea Tunnel is part).
- Section 5: Cajamarca - Girardot (in concession).
- Section 6: Girardot - Bogotá (in concession).

Carlos Collins, the first contractor of the La Línea tunnel at the age of 77, and a well-known infrastructure builder in Colombia, with the Segundo Centenario temporary union, is fighting a battle against the state for the breach of contract. To complete 12% of the project, contractors Conconcretó and Carlos Solarte won the tender. It must be said that Carlos Collins had budgeted for the remaining 12% $255 billion and not $363 billion proposed by the new contractors (Fig. 2).

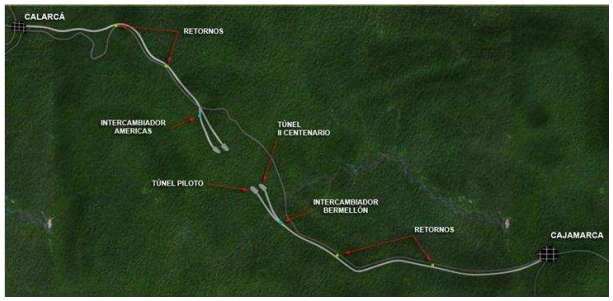


Figure 2. La Línea tunnel (Invias, 2013).

The construction of the site in the advance that it was would not be reversed. On July 13, 2007, the Infrastructure Guild sent a letter to Andrés Uriel Gallego, dismayed at the error this would imply, and proposing to analyze a second option, to bet on two one-way twin tunnels. The reason was reduced to issues of competitiveness, the fact of having two tunnels would not only guarantee greater vehicle capacity but would also be compatible with the double roadway scheme planned for the Bogotá-Buenaventura corridor.

There was no response to this letter. The country's engineers insisted on studying the possibility of inviting tenders for the construction of two tunnels in a single contract. They also proposed to Gallego to have public-private participation given the interest of local and foreign investors. The union asked to verify the budget of the work rigorously, including the sections of the double roadway between Cajamarca and Calarcá, contemplated in the project by the decision of the Government. The union concluded that the project in its entirety (the two tunnels plus the sections of the second roadway) bordered the 1.2 billion pesos with a value of 2007, that value was less than what the bidding proposed.

As the years went by, something gave the play a new lease of life. It happened during the government of Andrés Pastrana when the president created the Conpes 3084 in 2000, which authorized the Nation to contract external credits up to 218 million dollars to finance the tunnel and build it at 2,520 meters above sea level. However, this proposal drowned and was not carried out. It was not because of money issues, but because of the lack of performance guarantee policies to support the idea. This scenario revealed what a hecatomb this tunnel was. Then the government of Alvaro Uribe Velez came to take control of the work. The Minister of Transport at that time, Andrés Uriel Gallego, announced, in agreement with the Japanese years ago, the decision to build the tunnel in the highest part of the mountain range, which would be "*less tedious*" (Fig. 3).

Figure 3. La Linea construction (Ejatlas, 2016).

The pilot tunnel

The pilot tunnel, with a final length of 8.5 km and a diameter of 4.4 m, parallel to the main tunnel, is a rescue work, which is part of the Segundo Centenario Tunnels. It was built to establish the geological risk of the area and determine the process of execution of the tunnel.

Benefits of the pilot tunnel

- Quantification of geological risk, such as failures, characterization, yields, etc.
- Lower costs of the main tunnels at the design level.
- Knowledge of hydrogeology, stabilization of equipotential flow lines, stable infiltration flows.
- Higher performance due to better knowledge and drained conditions.
- Different excavation fronts of the first Main Tunnel.
- Pre-treatment of identified fault zones.
- Better planning and programming of material and machinery supply.
- Benefit of the Pilot Tunnel, as a rescue tunnel.
- Discarding of volcanic incidence.

Main factors affecting the civil works

This work has presented delays in the Quindío due to the liquidation of the insurance company Cóndor that issued the policies of the fulfillment of the work. The problem began when the Calarcá aqueduct system presented contamination

in its waters, geological faults that were thought not to be so great.

In November 2015 a geological fault in the pilot tunnel reached greater delays than those mentioned above since, also, it must be taken into account that the work is close to the Machin volcano in Tolima, which causes this instability.

According to Carlos Collins, a former contractor of the work, there was another factor due to the trucker's strike that stopped the project from being carried out for 60 days. The last one was generated in December 2015, when the Quindío Regional Autonomous Corporation (CRQ) found that the permits approved to INVIAS, for the execution of the external works, were not in order (Fig. 4).

Figure 4. Works in the La Linea tunnel (El Espectador, 2017).

Factors affecting road works in Colombia

The president of the Colombian Society of Engineers, Daniel Florez Perez, and of the Colombian Chamber of Infrastructure, Juan Martin Caicedo, take as the most important factors affecting road works in the country the following:

1. Insufficient studies and project designs. To be able to advance the contracting of civil works, before the bidding process, the public entity must have basic engineering information.

2. Lack of infrastructure planning. Problems due to poor planning or clarity of land use or infrastructure.

3. Deficiency in the elaboration of budgets for public works. The more information and detail in the study and designs prior to the work, the less uncertainty there is in the final cost.

4. Delays in meeting the obligations of social and environmental management in the projects. Environmental and social management inconveniences which affect communities and create social or environmental impacts from the project under construction, such as untimely debris management.

5. Delays in the acquisition of land for the projects. The delay in the purchase and delivery of project land is one of the main factors affecting the delay in road works.

6. Lack of inter-institutional coordination. The delay in the processing of licenses and permits of contracting entities such as environmental authorities suffer delays, taking much more than the required time and in many cases the extra cost for the elaboration of the work.

7. Deficiencies in social management with communities. Social management in construction projects is very deficient. This generates the discontent of social groups that can turn into protests that end up affecting the execution of the project.

8. Distortion of the work of the auditing office. Contracting and public entities rely on audits to generate more paperwork, value to the project, and strengthen coordination between the contractor and the contracting party.

Colombia in road infrastructure

Colombia currently lags in terms of road infrastructure by more than 30 years. Speaking of roads, it is 30% below the level it should be. Globally, Colombia ranks 126th in terms of national road infrastructure in 2016, being one of the worst qualified countries, not only in Latin America but worldwide. This year it climbed 16 places from 126th to 110th.

Similarly, in 2017, Colombia has built 2,350 kilometers of dual carriageways, while in 2014 it was 1,796 kilometers, 2,052 kilometers in 2015, and 2,293 kilometers in 2016 (table 1).

Table 1
Road Infrastructure quality ranking (Sectorial, 2014).

Country	***Rank***	***Rating***
France	*1*	*6.50*
Chile	*23*	*5.60*
Panama	*49*	*4.50*
Mexico	*50*	*4.50*
Ecuador	*53*	*4.40*
Peru	*100*	*3.11*
Bolivia	*101*	*3.10*
Argentina	*106*	*3.00*
Brazil	*123*	*2.70*
Colombia	*126*	*2.60*

Occupational safety for workers in civil works in Colombia

Workers who work in civil works are exposed to risks such as exposure to cold, heat, and extreme temperatures,

ISSN 1692-8407

this is because most of the time they are working outdoors. Also, they must perform work at high altitudes that puts them at great risk, and they may suffer a fall. They work with equipment, some of which are dangerous if you do not have prior knowledge of how to operate the equipment. Sometimes they suffer from fatigue as they have shifts of up to 12 hours. They work near heavy machinery, which can cause them to be slightly deafened by the loud noise of the machines. Finally, in Colombia, the occupational safety of the workers needs to be put into context, both by the construction companies and by the workers themselves who are exposed (Fig. 5).

Figure 5. Protests by workers in the La Línea tunnel (El Tiempo, 2014).

The problems that the mega work had due to budget and environmental policies have made this work to have many delays. To make a comparison, the main environmental problems that occurred in the construction of Colombian tunnels and the environmental delays of the La Línea tunnel are discussed.

Frequent environmental problems in road tunnel construction

The main environmental conditions, common to any construction process, generated or induced by a road tunnel project, are the effects on fauna, flora, landscape, soil, water, air, as well as the social and health effects due to pollution (environmental contamination by industrial waste) and other harmful materials.

Affects to the fauna. The most common effects on the fauna in a civil work are basic problems in the face of the need to build there the original habitat of the fauna.

Affections to the flora. This type of affectations is the removal of the flora (plants, trees, excavations, and deformations of mountain systems, etc.), which is done according to the environmental policies in force for the execution of the work.

Effect on water sources. The most common effects on water sources are in the pollution, elimination, and consumption of lakes, wetlands, rivers, etc. surrounding the work in progress. This is done by resolving and obtaining environmental permits for the execution of this work.

Airborne affectations. The effects on the air surrounding the work in progress are pollution, the production of high-impact odors, and the production of harmful gase

Affections to the community surrounding the work. Breathing problems in children and the elderly due to pollution, possible deterioration of the structures of the houses surrounding the tracks, mobility problems in terms of partial or total closure of the tracks, among others.

Environmental problems in the La Línea tunnel

The works in La Línea, besides the budget problem, have also suspended work due to environmental damage.

Contamination of water sources. It was given by the bad process of elimination of industrial residues, and its contamination to the hydric sources. Concrete cases include San Rafael Creek, La Gata Creek, and the El Salado tributary, which caused INVIAS to suspend discharges in several areas of Calcará.

La Gata stream. In March 2007, the Corporación Autónoma Regional del Quindío granted a five-year discharge permit over La Gata stream to the partner Conlínea, and although it was granted to INVÍAS in 2009, it expired in 2012 and has not been renewed.

El Salado stream. More than 80 thousand inhabitants of Calarcá (Quindío) lost the El Salado stream, the main water source that supplied their aqueduct.

High investments in water recovery. $8,622,155,911 Colombian pesos were used, which corresponds to approximately 1% of the budget of the value of the contract used for water recovery and management. This budget was used for domestic wastewater treatment, soil erosion, environmental training for communities, etc.

Budget problems in the La Línea tunnel

In addition to the environmental problems, there are budget delays. Complaints by dozens of workers who claim to have fallen ill as a result of the construction work, investigations, legal proceedings, fines, and sanctions that have not managed to stop the damage caused in Quindío.

There are legal problems regarding the omission of the cessation of permits for discharges into water sources and their pollution which expired in 2012. The remaining works are 3 km of the lining of the main tunnel, nine bridges with average progress of 70%, and four short tunnels.

The Superior Council of Fiscal Policy approved $133 billion of the 2018 INVIAS term to open the contract to finish the remaining 12% of the Line's tunnel, which would be awarded on June 13, 2017.

Lawsuits were filed for the violation of the collective rights and the environment of the inhabitants of Calarcá. The Defender of the People in Quindío, Piedad Correal Rubiano, filed a popular action that the Administrative Court of Quindío admitted and ruled in 2012, against INVIAS and the contractor of the tunnel works, UTSC, for the pollution generated in the creeks.

On April 15, 2014, the Unión Temporal Segundo Centenario, represented by Carlos Collins, filed an arbitration claim with the Arbitration and Conciliation Center of the Bogotá Chamber of Commerce against the Instituto Nacional de Vías INVIAS (National Institute of Railways), to obtain recognition of the price difference it had to assume as a result of a change in the material used for lining the tunnel of La Línea.

The completion of the remaining works is based on five contracts and a technical, legal and financial analysis, in which INVIAS did not accept the request for extension made by the Unión Temporal Segundo Centenario (UTSC), whose contract expired on 30 November 2016, the date agreed for the completion of the works.

Machinery was sold to guarantee payment to 87 former workers of the Carlos Collins S.A. consortium of the Segundo Centenario temporary union, due to the insolvency after the judicial liquidation of the construction company. Also, in July 2017 there is a cost overrun of 363 billion Colombian pesos more than 57% of the initial cost.

Works attached to the tunnel

These are the advances in terms of the annexed works for access to the main tunnel, which cost 45,468 million Colombian pesos (Fig. 6).

- Estrella tunnel: 326.5m (100%) finished.
- Robles tunnel: 841.40m (95.08%).
- Los Chorros Tunnel: 209.20m (33.96%).
- Estrella bridge 1: progress is made on the bridge plate.
- Estrella bridge 3: provisional embankments were formed.
- Robles bridge 2: progress was made in the assembly of beams for the construction of the slab.
- Alaska bridge: progress has been made in the assembly of beams for the construction of the slab.

At present, the Abbreviated Selection process was opened for the contracting of the Studies and Designs, Social, Property and Environmental Management, Construction and Operation of the Project "Crossing the Central Mountain Range: II Centenary Tunnels - Line Tunnel and Second Calarcá Roadway - Cajamarca", worth $703,000 million.

Figure 6. Works attached to the tunnel (Icconstructores, 2017).

Contractors

The formation of the Unión Temporal Segundo Centenario consortium is as follows: Condux S.A. de CV, Constructora Herreña Fronpeca, Constructora Carlos Collins S.A., Álvarez y Collins S.A., Promotora Montecarlos Vías S.A., Túneles de Colombia S.A., Construirte Ltda., Gayco S.A., Tecnicíviles S.A., HyH Arquitectura S.A., and Miguel Camilo Castillo Huertas. The Minister of Transport, Andrés Uriel Gallego Henao and the Director General of the National Roads Institute, Daniel Andrés García, awarded the contract to the consortium Unión Temporal Segundo Centenario.

The consortium is made up of two Spanish companies, one Mexican and eight Colombian, and obtained a score of 1,000 points in the order of eligibility, by offering to execute the four modules into which the work is divided, for a value of $629,052'989,746 in the period established by the entity of 70 months.

INVIAS, due to the non-compliance of contracts of the works contemplated in contract 3460 of 2008, by the contractors of the temporary union Segundo Centenario, finished on November 30, 2016, and not extended, is looking for new contractors and the generation of a new contract. The Superior Council of Fiscal Policy (Confis), for the year 2018 approves a future term that grants 133,000 million pesos, to contract the execution of 12% of the remaining works for the tunnel. For this it has $249,000 million, said the General Director of the National Roads Institute, Carlos Garcia Montes.

ISSN 1692-8407

The Minister of Transport, Jorge Eduardo Rojas, and through INVIAS, requested, on behalf of the National Government to Confis, the approval of $144,000 million for 2018 to complete these works, therefore the remaining $11,000 million to complete the required budget of $249,000 million, will come from national resources of the present period (Figs. 7 and 8).

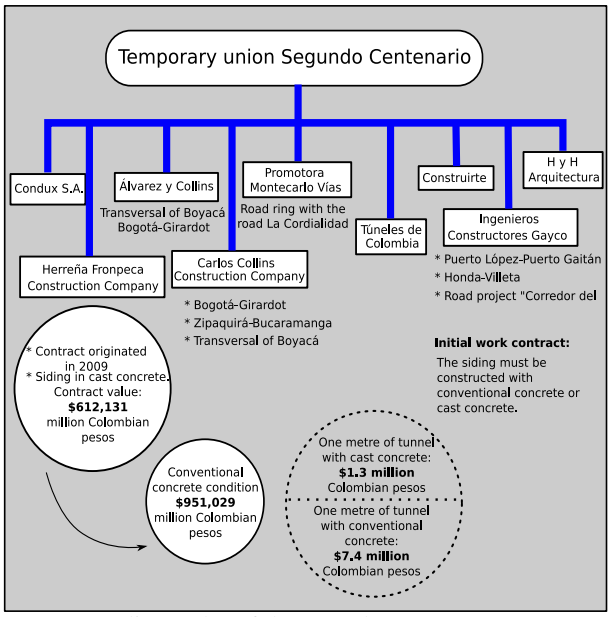


Figure 7. Radiography of the tunnel.

The Intertunel Consortium was the winner within the framework of the process CMA-DO-GTL-090-2016, whose purpose is the audit for the completion of the project Crossing the Central Mountain Range - Line Tunnel and Second Calarcá-Cajamarca Roadway. This was announced by the Ministry of Transport through INVIAS.

The Intertunel consortium is made up of the firms R&Q ingeniería Colombia S.A, with 40% (Chile), Saitec branch Colombia with 30% (Spain), and Joyco S.A.S with 30% (Colombia). The company competed with 11 other companies, and with it, the national government completed the awarding process for the completion of 12% of the remaining works for this project.

INVIAS awarded the Consortium the execution of the works for which it submitted a bid for $224,407 million, and not the $249,000 million agreed by Carlos Collins. Thus, the contractor Intertunel with this contract will be in charge of almost $250,000 million, which will be distributed as follows: $62,000 for geological faults, $21,000 for short tunnels, $50,000 for remaining viaducts, $56,000 for the tunnel lining, $24,000 for paving, and $36,000 for open-air works.

The General Director of INVIAS, Carlos García, asked for speed in the works to finish them as soon as possible and

Figure 8. Projects at risk due to expiration (La Republica, 2017).

underlined that the commitment of the Entity is to finish the projects that it is in charge of.

Value of the work

The cost of the project, initially agreed in approximately 629 billion pesos, as of July 2017 has already exceeded that value, being in the order of 1.27 trillion pesos. Also, there are different additional to add as the settlements and demands. The Control Office is going to take action on the case by going to the Public Prosecutor's Office, as these values are lacking in fines, environmental damage, and observations made by the auditor of the work. The control office says the deadline, which expired on November 30 last year, was extended by 39 months, a 50 percent extension. These changes affect the execution of the work and the budgeting of equipment for it.

The control office says that it will continue this project until it is finished, which is why it summarized that the La Linea tunnel project is going to cost more and take longer than expected.

Problems with workers in the La Línea tunnel

In this work, several problems have arisen in which the main protagonists are the workers. The problems range from delays in salary payments to deaths. Within 45 days, the

workers were not paid, causing more than a hundred workers to go on strike and block the Pan-American Highway. To solve this problem, the mayor of Calarcá at that time, Juan Carlos Giraldo, intervened so that the workers would retract and reach an agreement, in order to make the contract valid.

In August 2011 a worker was killed and two others injured in the Alpes 1 sector, when they were drilling a part of the central mountain range, and doing other work. At that time a landslide came over them, burying several workers. Miraculously, some of them escaped unharmed, and the two injured were taken to the Santa Lucia de Cajamarca hospital. These problems are due to the poor organization in terms of occupational risks, and the lack of training to be able to avoid this case of emergency.

The lack of compliance with contracts, geological faults, and environmental problems, are the causes of this work that have a delay of four years.

Contract

Contract No. 3460 of 2008 by the contractors Unión Temporal Segundo Centenario, led by Carlos Collins Espoleta, had as its objective the study and design of social management of property and environment, construction and operation of the project "crossing the central mountain range: tunnels of the II centenary - tunnel of the line and second roadway Calarcá - Cajamarca". The term to comply with this contract was 70 months (eight months of papers, 46 months of the construction stage, and 16 months for maintenance, from the date of commencement of the contract on April 14, 2009. The contract was signed for a value of 629,052,989,746 Colombian pesos.

Contractual non-compliance

INVIAS declared the partial breach by the contractors of the Temporary Union Segundo Centenario. According to INVIAS, during the execution of the contract for the La Línea tunnel, in September 2014, the controller recommended the initiation of administrative proceedings to sanction the alleged serious breach of obligations and to declare the expiration of Contract No. 3460 of 2008. In addition to the above, INVIAS, guaranteeing the contractor's right to due process and defense in the respective auditor's report, reached agreements, and it was even necessary to reschedule the work schedule. Therefore, the UTSC must pay at least 16,133 million pesos, because according to the INVIAS institute, the contract was not fulfilled due to environmental failures and the non-delivery of the work in the mentioned period (70 months).

The environmental licence

In the 2008 contract, the environmental license is ordinary, i.e. it does not include the permits, concessions, and authorizations for the use of natural resources required for the project, such as the execution of activities such as the exploitation of sources of materials, disposal of excess material from excavations, exploitation of water sources, whether surface or underground, temporary or permanent occupation of watercourses, dumping, etc. These permits must be managed and obtained from the environmental authorities in the area of jurisdiction by the contractors.

In March 2007, the Corporación Autónoma Regional del Quindío granted a five-year discharge permit for the La Gata stream to the partner, and although it was granted to INVIAS in 2009, it expired in 2012 and was not renewed, but the discharge continued during 2013. The Council of State confirmed the ruling of the Quindío Administrative Court declaring INVIAS, the National Environmental Licensing Agency (Anla), the Quindío Regional Autonomous Corporation (CRQ), the intervening consortium and the company in charge of the construction of the La Línea tunnel responsible for the environmental damage caused by the lack of compliance and the contamination of the La Gata stream and the El Salado affluent.

This demand was for the maintenance of the water and its good use, so it was decided to use more than 1% of the value of the contract for the purification of these water sources of Quindio. The analysis of the evidence reveals that the contamination comes from the construction of viaducts, poor management of sludge, stagnation of wastewater, and earthworks on the double roadway Calarcá - Cajamarca. The main sector affected is the El Salado viaduct, because there has been concrete leakage during the construction of the infrastructure, which is dumped in the San Rafael stream.

The most affected by this lawsuit are the contractors, UTSC and INVIAS, since one is in charge of carrying out the environmental licenses and the other is responsible for evaluation, control, prevention, and monitoring. The Corporación Autónoma Regional del Quindío (CRQ) found that the permits approved to INVIAS, to carry out the external works, were not in order.

Payment of salaries

To guarantee the payment of salaries, social benefits, and compensations of the personnel that the Contractor is to use for the execution of the Contract, a value equivalent to five percent (5%) of the Contract Value, with a validity of 9 years, was held. This was not complied with, and the payment to 87 former workers of the consortium Carlos Collins S.A. of the temporary union of Segundo Centenario had to be supported with the sale of machinery, generating extra costs to the work.

ISSN 1692-8407

INVIAS and contractor

Carlos Collins claims that only 76% was delivered to carry out the 88% that today make up the work, but INVIAS contradicts him, saying that in the contracts it appears that more than that 88% was delivered. Also, the contractor assures that there were cost overruns and delays due to the value of materials and stoppages presented in Quindio.

Extensions for Carlos Collins

According to INVAS, as it has been stated in the follow-up process agreed between the Government and the businessman Carlos Collins, the legal representative of the contractor firm, Unión Temporal Segundo Centenario, the execution of the works was being carried out. Therefore, Carlos Collins requested extensions for the completion of the work, since the problem was budgetary, and it was expected that the work would be completed by the date stipulated by a conciliation agreement of March 2016 between the Ministry of Transport and the contractor. This agreement resulted in the project receiving 327 billion pesos from different sources. Of these resources, the contractor contributed 30 billion pesos, and a beneficiary was established, which would manage the resources. This would allow the construction of the missing bridges and tunnels, and conclude the works before November 30th, 2016. But after four extensions issued, INVIAS decided not to grant a fifth, since it was not sure the completion of this in the four months requested by the contractor because the monthly progress was less than 1%. INVIAS, stated that the reasons for this decision were the impossibility of finishing the construction of the work in the foreseen time of construction, the lack of economic resources, and materials to finish the work, as well as noncompliance with environmental and technical specifications.

The builder requested a first extension of four months in March 2012, then three months in October 2012, 12 months in September 2013 and 20 months in April 2015. Previously the work had taken 46 months, which in principle was set for 85 months.

Geological faults

The La Línea tunnel is made up of eight geological faults, noticed by the Veeduría Técnica Especializada. Among them are La Gata, La Soledad, and El Viento. The most difficult to control are in Quindío. These faults imply support and concrete injection to guarantee safety in the tunnel. The contractor, by not attending to all the faults, helped delay the work (Fig. 9).

The report also pointed out that after the lining of the II Centenary Tunnel, some stretches of the tunnel are covered by infiltrated water. This also has to do with the poor environmental management of this work. Therefore, Orjuela,

Figure 9. Water pollution from the construction site (Cronica del Quindio, 2017).

president of the Society of Engineers of Quindio, warned the contractor UTSC to correct this situation and to verify the waterproofing procedure because this cannot happen in the tunnel after the conclusion of the works.

The mountain where the La Línea tunnel will be built, which will connect central Colombia to the Pacific more quickly, as it is in an area affected by geological faults and close to the Machín volcano in the central mountain range, is a work that is being transformed every day and requires permanent monitoring. In addition to these faults, the central mountain range has weaknesses and fractures, where the material is very loose since it is composed of metamorphic rocks reworked and at some point, could affect the structure of the tunnel, such as the arches and the stabilization itself.

Collapses in the tunnel

In the maintenance of the La Línea tunnel, the National Institute of Roads (INVIAS) is working hard with machinery and personnel from the depletable amount contract to restore the passage on the Cajamarca-Calarcá (Alto de La Línea) road, affected by several landslides after the increase in rainfall in that part of the country. According to García Montes, general director of INVIAS, in Tolima they worked with a backhoe, four dump trucks, and a loader, while on the Quindío side they had two backhoes, two loaders, and four dump trucks, to attend to the emergency (Fig. 10).

Carlos added that, also, the respective road administration and the group of micro-entrepreneurs under his charge are involved, to achieve in the shortest time possible the removal of the landslides that interrupt the passage at the height of kilometers 36, 38, 39 and 40.

New contract for the completion of the tunnel

The Intertunel consortium is still on track to deliver the works in December 2018, but the delay in the publication of the process to choose the new contractor put at risk that this

Figure 10. Work to enable the passage through La Línea (Invias, 2017).

commitment could be achieved. The process to choose the new contractor was based on the fact that nobody wanted to take the risk of finishing the tunnel due to three problems: time, resources, and environmental license.

The UTSC, whose contract expired on November 30, 2016, after being granted four extensions that represented an additional 39 months, delivers the project with an 88 percent progress, so the Intertunel consortium will have an official budget of more than $238 billion, and will have an execution period of 12 months.

A geological fault in 2015 in the pilot tunnel reached greater proportions than the environmental ones. A zone of geological instability found was greater than had been reported, thus extending the delay of the work by six months.

References

Andreescu, R. (2016). Not in my backyard: The road to housing desegregation in yonkers, new york, from lisa belkin's show me a hero to its adaptation for television. *University of Bucharest Review: Literary and Cultural Studies Series*, *6*(2), 180-193.

Cirilovic, J., Vajdic, N., Mladenovic, G., & Queiroz, C. (2014). Developing cost estimation models for road rehabilitation and reconstruction: Case study of projects in europe and central asia. *Journal of Construction Engineering and Management*, *140*(3).

Clem, R. (2011). From the arab street to the silk road: Implications of the unrest in north africa for the central asian states. *Eurasian Geography and Economics*, *52*(2), 228-241.

Cronica del Quindio. (2017). *Cortolima ratifica contaminación de aguas por obras en el tunel de la línea.* Online. Retrieved from http://www.cronicadelquindio.com/noticia-completa-titulo-cortolima_ratifica_contaminacion_de_aguas_por_obras_en_el_tunel_de_la_linea-seccion--nota-49501.htm

Ejatlas. (2016). *Construcción tunel de la línea, colombia.* Online. Retrieved from https://ejatlas.org/conflict/construccion-tunel-de-la-linea-colombia

El Espectador. (2017). *En veremos obras finales del túnel de la línea.* Online. Retrieved from https://www.elespectador.com/economia/en-veremos-obras-finales-del-tunel-de-la.-linea-articulo-693324

El Tiempo. (2014). *Trabajadores del túnel de la línea amenazan con paro.* Online. Retrieved from http://www.eltiempo.com/archivo/documento/CMS-14655636

Herath, T. (2015). The role of the state in alleviation of poverty in south asia. *South Asia Economic Journal*, *16*(2), 257-277.

Icconstructores. (2017). *Construcción de caissons y pavimentos en concreto obras anexas al tunel de la línea.* Online. Retrieved from http://www.icconstructores.co/Portfolio/construccion-de-caissons-pantallas-y-.pavimentos-en-concreto-obras-anexas-al-.tunel-de-la-linea/

Invias. (2013). *Túnel de la línea.* Online. Retrieved from https://www.invias.gov.co/index.php/seguimiento-inversion/subdirecciones-invias/123-seguimiento-a-la-inversion/proyectos-invias/73-tunel-de-la-linea

Invias. (2017). *Continuan labores para habilitar el paso por la línea.* Online. Retrieved from https://www.invias.gov.co/index.php/mas/sala/noticias/2978-continuan-labores-para-habilitar-el-.paso-por-la-linea

La Republica. (2017). *Estos son los proyectos que estan en riesgo por la caducidad del tunel de la línea.* Online. Retrieved from https://www.larepublica.co/infraestructura/estos-son-los-proyectos-que-estan-en-.riesgo-por-la-caducidad-del-tunel-de-la-.linea-2214641

Limam, M. (2012). Detailed analysis of the phenomenon of political corruption in algeria: Causes, repercussions and reform. *Contemporary Arab Affairs*, *5*(2), 252-278.

Loomis, A. (2010). *Poverty, state weakness, and civil war*.

Meduri, S., & Annamalai, T. (2013). Unit costs of public and ppp road projects: Evidence from india. *Journal of Construction Engineering and Management*, *139*(1), 35-43.

Rose, S. (2008). Corruption and government. *International Peacekeeping*, *15*(3), 328-343.

Sectorial. (2014). *Panorama vial en colombia: Grandes proyectos de infraestructura con importantes retrasos*

ISSN 1692-8407

en las obras. Online. Retrieved from https://www.sectorial.co/articulos-especiales/item/51017-panorama-vial-en-colombia-grandes-.proyectos-de-infraestructura-con-importantes.-retrasos-en-las-obras

Walcher, A., Stempkowski, R., & Apfalter, M. (2012). Prevent corruption - measures to increase integrity in organizations. In (p. 2411-2418).

Instrucciones para los autores

Tekhnê

Tecnología al servicio de la sociedad

Universidad Distrital Francisco José de Caldas - Facultad Tecnológica

Revista Tekhnê
Universidad Distrital Francisco José de Caldas
Facultad Tecnológica

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 no debe superar las 25 páginas en su totalidad. En la parte inicial de la primera página se debe incluir: (1) Un título del manuscrito (en español e inglés), 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 español e inglés) del manuscrito con un tamaño máximo de 250 palabras, que establezca el objetivo, la metodología, los resultados y principales conclusiones. (4) Palabras claves, máximo cinco, en minúsculas y separadas por comas.

En cuanto al formato de documento solicitado a los autores, se pide no utilizar estilos de los procesadores de textos. El manuscrito debe estar a una columna, a espacio sencillo entre líneas de texto y sin dejar espacio entre párrafos y entre títulos y texto. Se debe seleccionar papel tamaño carta (21 cm de ancho por 29.7 cm de largo), en forma vertical. Los márgenes deben ser 2 cm en todos los lados (izquierda, derecha, arriba y abajo). Se debe usar letra Times New Roman (si no se posee, utilizar una de tipo serif similar) sin reducción de espacio entre caracteres, con tamaño de 12 puntos. Por ningún motivo se aceptarán trabajos que incluyan letras, palabras o símbolos manuscritos en el texto. Las tablas y figuras deben ser claras y nítidas, insertadas (no pegadas) en el documento como un único objeto (no agrupación de varios) con la mayor calidad posible. Se pide que estas figuras sean remitidas en un archivo comprimido por separado. Si se usan líneas o figuras en colores, no se debe usar colores claros (amarillos, celestes y similares). El Editor se reserva el derecho de eliminar toda figura o tabla que no cumpla las normas. Toda figura, tabla, ecuación o referencia incluida en el manuscrito debe estar referenciada/citada en el cuerpo del documento. No se debe usar sangría en ninguna sección del artículo. 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 cuanto al formato del archivo fuente, se puede utilizar cualquier procesador de textos, siempre y cuando el contenido sea completo y editable (no se permite archivos *.txt). Los formatos recomendados son: *.rtf, *.doc, *.docx, *.odt, *.wpd y *.tex. En caso de utilizar LaTeX, se deben remitir todos los archivos fuente. 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. Esto es realizado en la diagramación, y es transparente para los autores.

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:

- La carta de presentación.
- La carta de cesión de derechos (según formato).

La carta de presentación 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 en formato PDF. Se carga al OJS un único archivo sin comprimir.
2. Registro de los datos. Se regista en el OJS los datos básicos de los autores y del artículo.
3. Envío de Archivos Complementarios. Todos los archivos complementarios se envían en un único archivo comprimido. Estos archivos complementarios incluyen: los archivos fuente del documento, tanto texto como imagenes en alta calidad, archivo BibTeX con todas las referencias utilizadas, la carta de presentación, y la carta de cesión de derechos.

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
- Entrega de ejemplares a autores

Contacto

Para cualquier solicitud de información adicional puede comunicarse con:

Prof. Fredy H. Martínez S.
Editor y director revista Tekhnê
Sala de Revistas, Bloque 5, Oficina 301
Facultad Tecnológica
Universidad Distrital Francisco José de Caldas
Transversal 70B No. 73A-35 sur
Teléfono: (571) 3238400 Ext. 5003
Celular: (57) 3005585481
Bogotá D.C., Colombia
E-Mail: fhmartinezs@udistrital.edu.co
Url: http://revistas.udistrital.edu.co/ojs/index.php/tekhne/indexl

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
Facultad Tecnológica

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

Regarding the structure, should be evident the sections of introduction, methodology, results, conclusions and references. The rest of the document must conform in accordance with its contents. The length should not exceed 25 pages in full. In the initial part of the first page should include: (1) A manuscript title (in Spanish and English), short, descriptive of the content and attractive to the reader. (2) Full name of the authors and institutional affiliation details, including email. (3) Abstract (in Spanish and English) of the manuscript with a maximum size of 250 words, which set the objective, methodology, results and major conclusions. (4) Keywords, up to five, lowercase and separated by commas.

Regarding the document format requested, authors are asked not to use styles of word processors. The manuscript must be on a column, single space between lines of text without space between paragraphs and between titles and text. Must be selected letter size paper (21 cm wide by 29.7 cm long) vertically. Margins should be 2 cm on all sides (left, right, up and down). Must be used Times New Roman (if the font is not available, use a similar serif type) without reducing character spacing, of 12 points. No articles including letters, words or symbols handwritten in the text will be accepted. Tables and figures should be clear, inserted (not pasted) in the document as a single object (no grouping of several) with the highest possible quality. It is requested that these figures are sent in a separate zipped file. If lines or color figures are used, you should not to use light colors (yellow, light blue...). The Editor reserves the right to remove any figure or table that does not meet the standards. Every figure, table, equation or references in the manuscript should be referenced/cited in the document body. Should not be indented any section of the article. References should handle right APA format 6th Edition. Do not use footnotes, and maximum to use three levels for titles. You can include an Acknowledgments section (highly recommended), written soberly, of no more than four lines, right after the Conclusions.

Regarding the source file format, you can use any word processor, as long as the content is complete and editable (*.txt files are not allowed). Recommended formats are: *.rtf, *.doc, *.docx, *.odt, *.wpd y *.tex. When using LaTeX, the author must submit all source files. 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. This is done in the layout, and is transparent to the authors.

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:

- The presentation letter.
- The transfer of rights letter (according to format).

The presentation 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. Sending the article in PDF format. OJS is charged with a single uncompressed file.
2. Data recording. the basic data of the authors and article are registered in the OJS.
3. Complementary files. All additional files are sent in a single compressed file. These complementary files include: the source of the document, both text and images in high quality, BibTeX file with all references used, the presentation letter, and the transfer of rights letter.

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
- Delivery of copies to authors

Contact

For any request for additional information please contact:

Prof. Fredy H. Martínez S.
Editor and director Tekhnê Journal
Sala de Revistas, Bloque 5, Oficina 301
Facultad Tecnológica
Universidad Distrital Francisco José de Caldas
Transversal 70B No. 73A-35 sur
Phone: (571) 3238400 Ext. 5003
Cell phone: (57) 3005585481
Bogotá D.C., Colombia
E-Mail: fhmartinezs@udistrital.edu.co
Url: http://revistas.udistrital.edu.co/ojs/index.php/tekhne/index