ISSN 2523-6776

Volume 8, Issue 21 – e2024821 January – December – 2024

Journal of Technological Engineering

Journal of Technological Engineering, Volume 8, Issue 21: e2024821 – January - December 2024, is a Continuous publication - ECORFAN-Taiwan. Taiwan, Taipei. YongHe district, ZhongXin, Street 69. Postcode: 23445. WEB: www.ecorfan.org/taiwan, revista@ecorfan.org. Editor in Chief: Serrudo-Gonzales, Javier. BsC. ISSN: 2523-6776. Responsible for the last update of this issue of the ECORFAN Informatics Unit. Escamilla-Bouchán Imelda, Luna-Soto, Vladimir, updated December 30, 2024.

Journal of Technological Engineering

Definition of Journal

Scientific Objectives

Support the international scientific community in its written production Science, Technology and Innovation in the Field of Engineering and Technology, in Subdisciplines of sources innovation in electrical, engineering signal, amplification electrical, motor design science, materials in electrical power, plants management and distribution of electrical energies.

ECORFAN-Mexico, S.C. is a Scientific and Technological Company in contribution to the Human Resource training focused on the continuity in the critical analysis of International Research and is attached to CONACYT-RENIECYT number 1702902, its commitment is to disseminate research and contributions of the International Scientific Community, academic institutions, agencies and entities of the public and private sectors and contribute to the linking of researchers who carry out scientific activities, technological developments and training of specialized human resources with governments, companies and social organizations.

Encourage the interlocution of the International Scientific Community with other Study Centers in Mexico and abroad and promote a wide incorporation of academics, specialists and researchers to the publication in Science Structures of Autonomous Universities - State Public Universities - Federal IES - Polytechnic Universities - Technological Universities - Federal Technological Institutes - Normal Schools - Decentralized Technological Institutes - Intercultural Universities - S & T Councils - CONACYT Research Centers.

Scope, Coverage and Audience

Journal of Technological Engineering is a Journal edited by ECORFAN-Mexico, S. C. in its Holding with repository in Taiwan, is a scientific publication arbitrated and indexed with semester periods. It supports a wide range of contents that are evaluated by academic peers by the Double-Blind method, around subjects related to the theory and practice of sources innovation in electrical, engineering signal, amplification electrical, motor design science, materials in electrical power, plants management and distribution of electrical energies with diverse approaches and perspectives, that contribute to the diffusion of the development of Science Technology and Innovation that allow the arguments related to the decision making and influence in the formulation of international policies in the Field of Engineering and Technology. The editorial horizon of ECORFAN-Mexico® extends beyond the academy and integrates other segments of research and analysis outside the scope, as long as they meet the requirements of rigorous argumentative and scientific, as well as addressing issues of general and current interest of the International Scientific Society.

Editorial Board

Arbitration Committee

Assignment of Rights

The sending of an Article to Journal of Technological Engineering emanates the commitment of the author not to submit it simultaneously to the consideration of other series publications for it must complement the Originality Format for its Article.

The authors sign the Authorization Format for their Article to be disseminated by means that ECORFAN-Mexico, S.C. In its Holding Taiwan considers pertinent for disclosure and diffusion of its Article its Rights of Work.

Declaration of Authorship

Indicate the Name of Author and Coauthors at most in the participation of the Article and indicate in extensive the Institutional Affiliation indicating the Department.

Identify the Name of Author and Coauthors at most with the CVU Scholarship Number-PNPC or SNI-CONACYT- Indicating the Researcher Level and their Google Scholar Profile to verify their Citation Level and H index.

Identify the Name of Author and Coauthors at most in the Science and Technology Profiles widely accepted by the International Scientific Community ORC ID - Researcher ID Thomson - arXiv Author ID - PubMed Author ID - Open ID respectively.

Indicate the contact for correspondence to the Author (Mail and Telephone) and indicate the Researcher who contributes as the first Author of the Article.

Plagiarism Detection

All Articles will be tested by plagiarism software PLAGSCAN if a plagiarism level is detected Positive will not be sent to arbitration and will be rescinded of the reception of the Article notifying the Authors responsible, claiming that academic plagiarism is criminalized in the Penal Code.

Arbitration Process

All Articles will be evaluated by academic peers by the Double Blind method, the Arbitration Approval is a requirement for the Editorial Board to make a final decision that will be final in all cases. MARVID® is a derivative brand of ECORFAN® specialized in providing the expert evaluators all of them with Doctorate degree and distinction of International Researchers in the respective Councils of Science and Technology the counterpart of CONACYT for the chapters of America-Europe-Asia- Africa and Oceania. The identification of the authorship should only appear on a first removable page, in order to ensure that the Arbitration process is anonymous and covers the following stages: Identification of the Journal with its author occupation rate - Identification of Authors and Coauthors - Detection of plagiarism PLAGSCAN - Review of Formats of Authorization and Originality-Allocation to the Editorial Board-Allocation of the pair of Expert Arbitrators-Notification of Arbitration -Declaration of observations to the Author-Verification of Article Modified for Editing-Publication.

Instructions for Scientific, Technological and Innovation Publication

Knowledge Area

The works must be unpublished and refer to topics of sources innovation in electrical, engineering signal, amplification electrical, motor design science, materials in electrical power, plants management and distribution of electrical energies and other topics related to Engineering and Technology.

Presentation of Content

As first article we present, *Microbiological analysis of biosolids treated with different techniques for agricultural use*, by Ramírez-Jimenez, Alida, Salinas-Sánchez, Igor, Lara-Aguilar, Susana and Xolalpa-González, Juan Azael, with secondment at the Tecnológico Nacional de México (TecNM) / Instituto Tecnológico Superior de Irapuato (ITESI), as the second article we present, *Production parameters in radishes (Raphanus sativus L.) using organic inputs*, by Medina-Saavedra, Tarsicio, Mexicano-Santoyo Lilia, Arroyo-Figueroa Gabriela and Castro-Jácome, Tania Patricia, with affiliation at the Universidad de Guanajuato, as the third article we present, *Numerical modelling of hydrodynamic thrust in patients using the HidroWalk for gait rehabilitation*, by Gamiño-Ramírez, Edith Alejandra, Herrera-Díaz, Israel Enrique, Ugalde-Zanella, Valeria and Torres-Bejarano, Franklin Manuel with affiliation at the Universidad de Guanajuato and Universidad de Córdoba, as last article we present, *Design of digital ignition control of compact vehicle engine using fingerprint*, by Guzmán-Cortés, Agustín, Barbosa-Santillán, Luis Francisco, González-Contreras, Brian Manuel and Álvarez-González, Ricardo, with assignment at the Universidad Tecnológica de Puebla, Universidad Autónoma de Tlaxcala and Benemérita Universidad Autónoma de Puebla.

Content

Journal of Technological Engineering 8[21]1-8: e1821108
Article

Microbiological analysis of biosolids treated with different techniques for agricultural use

Análisis microbiológico de biosólidos tratados con diferentes técnicas para su aprovechamiento agrícola

Rivera-Mosqueda, Ma. Cruz*[a], Soto-Alcocer, José Luis [b], Arellano-Elizarraraz, Roberto[c] and Ayala-Islas, Alberto[d]

[a] Tecnológico Nacional de México (TecNM) / Instituto Tecnológico Superior de Irapuato (ITESI) • LIA-9083-2024• 0000-0001-7752-9226 • 333557
[b] Tecnológico Nacional de México (TecNM) / Instituto Tecnológico Superior de Irapuato (ITESI) • LHI-9302-2024• 0000-0003-3435-9057 • 80822
[c] Tecnológico Nacional de México (TecNM) / Instituto Tecnológico Superior de Irapuato (ITESI) • LHJ-5534-2024• 0009-0007-7395-1519 • 89791
[d] Tecnológico Nacional de México (TecNM) / Instituto Tecnológico Superior de Irapuato (ITESI) • LIA-9048-2024 • 0000-0001-8613-9297 • 162442

CONAHCYT classification:

Area: Biotechnology and Agricultural Sciences
Field: Agricultural Biotechnology
Discipline: Agricultural Biotechnology
Sub-discipline: Others

https://doi.org/10.35429/JTEN.2024.8.21.1.8
History of the article:
Received: January 27, 2024
Accepted: December 30, 2024

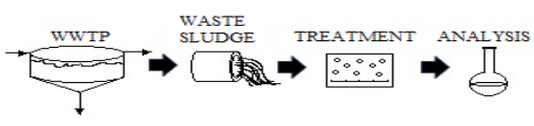
* ✉ [cruz.rm@irapuato.tecnm.mx]

Abstract

Microbiological analysis of four biosolid samples (A, B, C, D) was carried out in accordance with current regulations. In addition, microbiological tests were performed on water, with percentage of untreated biosolid (E) and on water with sludge treated with microalgae (F) after a period of 42 days. The results obtained show that samples B, C and D were within the L.M.P., sample A was found to be above with respect to Salmonella spp., with 1,100,000 NMP/g ST of Fecal Coliforms, 1,100,000 NMP/g ST of Salmonella spp., and 1 helminth egg in 2 g ST. Salmonella spp. was present in samples E and F. Subsequently, an analysis was carried out on a sample of sorghum and another of corn treated with biosolid for germination and growth, obtaining results of 250,000 CFU/g and 2,200,000 CFU/g respectively.

Objetive:	**Contribution:**	**Results:**
Use of sludge from a WWTP.	Environmental improvement.	Elimination of microorganisms by drying.

Metodology:



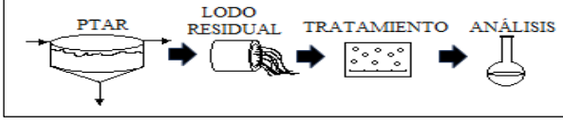
Coliforms, Fecal, *Salmonella*

Resumen

Se efectuó el análisis microbiológico de cuatro muestras de biosólidos (A, B, C, D) conforme a la normatividad vigente. Además, se realizaron pruebas microbiológicas al agua, con porcentaje de biosólido no tratado (E) y al agua con lodo tratado con microalgas (F) después de un periodo de 42 días. Los resultados obtenidos muestran que las muestras B, C y D estaban dentro de los L.M.P, la muestra A se encontró por encima con respecto a Salmonella spp., con 1 100 000 NMP/g ST de Coliformes Fecales, 1 100 000 NMP/g ST de *Salmonella spp*., y 1 huevos de helminto en 2 g ST. Hubo presencia de *Salmonella spp*., en la muestra E y F. Posteriormente se realizó el análisis de una muestra de sorgo y otra de maíz tratadas con biosólido para su germinación y crecimiento, obteniendo los resultados de 250,000 UFC/g y 2,200,000 UFC/g respectivamente.

Objetivo:	**Contribución:**	**Resultados:**
Aprovechamiento de lodos de una PTAR.	Mejoramiento del medio ambiente.	Eliminación de microorganismos mediante secado.

Metodología:



Coliformes, Fecales, *Salmonella*

Citation: Rivera-Mosqueda, Ma. Cruz, Soto-Alcocer, José Luis, Arellano-Elizarraraz, Roberto and Ayala-Islas, Alberto. [2024]. Microbiological analysis of biosolids treated with different techniques for agricultural use. Journal of Technological Engineering. 8[21]1-8: e1821108.

Introduction

Significant volumes of sludge are produced in WWTPs, which can be defined as urban waste from wastewater treatment whose organic matter can be used in agriculture and soil improvement (Porta-Casanellas *et al*., 2003), as they contain a nutritional value that improves soil fertility and crop production; they are rich in organic matter (60 to 70%) and essential nutrients for plant growth, such as nitrogen (N), phosphorus (P) and potassium (K) (Kara *et al*., 2003).

Their proper use would determine the solution of environmental problems such as the reduction of sludge disposal to landfills, as well as the reduction of excessive use of chemical fertilisers (Cogger *et al*., 2000). Due to the pollutants present in the biosolids, it is necessary to apply a treatment that focuses on two fundamental aspects such as volume reduction that can be obtained by simple thickening (the dryness of the product can in some cases reach 10 or very exceptionally 20%), dewatering by natural drainage, mechanical draining, thermal drying or also dewatering by incineration.

On the other hand, fermentation reduction or stabilisation consists of reducing its biological activity (tendency to putrefaction) and its content of disease-causing microorganisms, which can be obtained through processes such as: anaerobic or aerobic digestion, chemical stabilisation, pasteurisation, cooking, treatment with lime, etc. (Rojas-Remis & Mendoza-Espinosa, 2012).

Justification

The world is currently experiencing alarming environmental problems; one of these is the final disposal of large quantities of sewage sludge from the Intermunicipal System for Wastewater Treatment and Disposal Services for the Rincon Municipalities (SITRATA) (Soto-Alcocer *et al*., 2018).

Most are taken to landfills as they contain contamination characteristics such as heavy metals, toxic waste and pathogenic microorganisms, parasites and bacteria that can affect the environment and human health, however, they can be used in agriculture, as most contain elements such as nitrogen, phosphorus and trace elements that are beneficial for plant growth and development.

For this reason, it is reasonable to look for treatments for the sludge generated in SITRATA, evaluating its quality through microbiological characterisation in order to use it as fertiliser for short-stemmed crops, allowing its rational use and also having an economic benefit, as it reduces the use of commercial chemical fertilisers, offering the opportunity to rehabilitate soil at a low cost and complying with NOM-004-SEMARNAT-2002 and NOM-003-SEMARNAT-1997 standards.

General Objective

To carry out stabilisation treatment of sludge from the Intermunicipal System for Wastewater Treatment and Disposal Services for the Municipalities of El Rincón (SITRATA) in order to use it as fertiliser for vegetable crops.

Specific objectives

- To sample sludge from the Intermunicipal System for Wastewater Treatment and Disposal Services for the Municipalities of El Rincón.
- Determine the physicochemical and microbiological characteristics of the waste sludge.
- Treat the sludge in order to reduce the microbial load.
- Choose the best treatment according to the maximum permissible limits of NOM-004-SEMARNAT-2002 and NOM-003-SEMARNAT-1997.
- Evaluate the effect of the application of biosolids on vegetables.

Theoretical framework

Currently, different productive and domestic activities generate large quantities of wastewater, which contain a wide range of pollutants. These waters must be processed in Wastewater Treatment Plants (WWTP) for reuse or disposal with a higher quality (Guzmán & Campos, 2004).

In 2009, the generation of municipal wastewater was 237.5 ^{m3}/s, of which 209.1 ^{m3}/s was collected or drained and treated and 88.1 ^{m3}/s was collected. In 2012, Mexico had a total of 2289 WWTPs, with a capacity of 137082.13 L/s and a treated flow of 97640.22 L/s, reaching a municipal wastewater coverage of 46.5 % (Conagua, 2012).

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Rivera-Mosqueda, Ma. Cruz, Soto-Alcocer, José Luis, Arellano-Elizarraraz, Roberto and Ayala-Islas, Alberto. [2024]. Microbiological analysis of biosolids treated with different techniques for agricultural use. Journal of Technological Engineering. 8[21]1-8: e1821108.
https://doi.org/10.35429/JTEN.2024.8.21.1.8

Wastewater is basically made up of 99% water and 1% dissolved, suspended or colloidal solids (UNESCO, 2017), in the treatment and purification process of water, by-products such as sludge are generated, obtained during the mechanical, biological and chemical steps, these can be found in liquid, solid and semi-solid consistency (Amador-Díaz *et al*., 2015).

The treatment and disposal of sewage sludge resulting from municipal wastewater treatment is a very important part to consider in WWTPs, as it represents up to 50% of the infrastructure and cost as it must undergo treatment, just like water, for its final use or disposal (IMTA, 2016). Municipal wastewater sludge production was estimated at 640 million ton/year on a dry basis (Mantilla-Morales *et al*., 2017).

In Wastewater Treatment (WWT) waste sludge is produced at approximately 0.5 to 1.2 kg SSV/kg BOD removed, whose composition and production depends on the degree of treatment (primary, secondary or tertiary) (Terreros-Mecalco *et al*., 2009).

Methodology

To initiate the project, solid sludge samples were taken from the Intermunicipal System for Wastewater Treatment and Disposal Services for the Municipalities of El Rincón, according to the sampling methods for sludge and biosolids of NOM-004-SEMARNAT-2002, labelling them with the letters A, B, C, D, E and F.

For the sludge (B), 20 kg of sludge was placed in a plastic box with the top uncovered so that it received direct sunlight, kept homogenised, and removed with a shovel twice a day. It was kept under these conditions for a period of 11 days.

For sludge (C), 20 kg of sludge was again mixed with 500 g of lime and kept under the same conditions as sludge (B).

The sludge (D) was placed in an Armfield UOP8-A tray dryer, in which 400 g of sludge was evenly distributed on four trays, at a temperature of 42 °C for 6 hours (Soto-Alcocer *et al*., 2018).

Microbiological tests were performed on untreated biosolids (A) and biosolids B, C and D after treatment, for the quantification of faecal coliforms, *Salmonella spp.* and helminth eggs, according to the regulations (NMX-AA-042-SCFI-2015, NMX-AA-113-SCFI-2012 and NOM-210-SSA1-2014).

Finally, biosolids A, B, C and D were compared according to the maximum permissible limits of the NOM-004-SEMARNAT-2002 for viable helminth eggs and most probable number (MPN).

For other solid sludge samples taken at later dates from the same water treatment plant (SITRATA), tests were performed using the C-214 benchtop multi-parameter photometer kit to determine the concentration of phosphorus and nitrogen in the biosolid (Hanna-Instruments, 2001).

Next, the amount of sludge and inoculum (algae consortium), as well as the litres of water to be used in a 100 L photo-bioreactor was determined according to the concentration of nitrogen and phosphorus obtained from the sludge in relation to the concentration necessary for microalgae growth.

The concentrations of the compounds ($_{NaNO3}$, $_{KH2PO4}$) of the BBM medium used as a substrate for microalgae growth were taken as a reference.

The compound $_{NaNO3}$ corresponds to $2.^{94X10-3}$ mol/l with respect to the medium, so the calculation was made to obtain the concentration of 1 molecule of N = 14 g/1mol N, for the compound $_{KH2PO4}$ the same calculation was made.

It was considered that for the growth of microalgae it is necessary to take double concentration of these compounds.

Calculations were then carried out to obtain the ideal amount of nitrogen and phosphorus for 50 L of water, with the double concentration of N and P.

Calculations were then made to obtain the kg of sludge to be used from the ideal concentration and the concentration of N in 1 kg of sludge.

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Rivera-Mosqueda, Ma. Cruz, Soto-Alcocer, José Luis, Arellano-Elizarraraz, Roberto and Ayala-Islas, Alberto. [2024]. Microbiological analysis of biosolids treated with different techniques for agricultural use. Journal of Technological Engineering. 8[21]1-8: e1821108.
https://doi.org/10.35429/JTEN.2024.8.21.1.8

Once the photo-bioreactor was assembled as shown in Figure 1, microbiological tests were carried out on the water with the percentage of biosolid E (untreated), for the quantification of faecal coliforms according to NMX-AA-042-SCFI-2015, helminth eggs according to NMX-AA-113-SCFI-2012, as well as confirmation of the presence or absence of *Salmonella spp.* using the methods of the NOM-210-SSA1-2014 standard.

Box 1

Figure 1

Photo-bioreactor for algae treatment

Source: Own elaboration

After a period of 42 days, the same microbiological tests were carried out again on the water with the percentage of biosolid F (after treatment with algae).

Finally, the water was compared with the percentage of biosolids E and F according to the maximum permissible limits for public services with direct contact of NOM-003-SEMARNAT-1997 for viable helminth eggs and most probable number (MPN) of faecal coliforms, as well as confirmation of the presence and absence of *Salmonella spp* .

Samples of maize and sorghum that were treated with biosolids for germination were collected from a crop located in San Bernardo, near Purísima del Rincón Gto., sampled at different points of the crop; 5 bunches of sorghum and maize from each corner and 5 from the centre.

Samples were collected in polypropylene bags, each one was shelled and mixed to obtain a homogeneous and representative sample.

Microbiological characterisation was carried out according to the methods of the Mexican Official Standard NOM-113-SSA1-1994, goods and services. Method for counting total coliform microorganisms on a plate and the Official Mexican Standard NOM-114-SSA1-1994, goods and services. Method for the determination of Salmonella in food.

Results

The results obtained in the microbiological determination of the samples are shown in Table 1, each of them underwent a drying treatment to reduce the load of microorganisms, where they are identified according to the labels: (A) biosolid without drying treatment, (B) biosolid dried in the open air, (C) biosolid dried with lime, (D) biosolid dried in tray dryer.

Box 2

Table 1

Microbiological determination of biosolids (A, B, C and D), with their L.M.P. according to NOM-004-SEMARNAT-2002

Biosolid	Bacteriological indicator of contamination	Pathogens	Parasites
	Faecal coliforms MPN/g dry basis	*Salmonella spp. MPN/g dry basis*	Helminth eggs/g on dry basis
A	1 100 000	1 100 000	1
B	46 000	240	2
C	< 3 000	240	4
D	4 300	240	8
CLASS	**L.M.P (NOM-004-SEMARNAT-2002)**		
C	< 2 000 000	<300	<35

On the other hand, for sludge treatment using an algae consortium it is necessary to know the concentration of Nitrogen and Phosphorus obtained in the biosolid E (untreated) which can be seen in Table 2.

Box 3

Table 2

Determination of Nitrogen and Phosphorus in biosolids

Determination	Water with biosolids (E)
Nitrogen	17.3 mg/L
Phosphorus	46.3 mg/L

Source: Own elaboration

Table 3 below shows the amounts of inoculum, sludge and water for the photobioreactor.

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Rivera-Mosqueda, Ma. Cruz, Soto-Alcocer, José Luis, Arellano-Elizarraraz, Roberto and Ayala-Islas, Alberto. [2024]. Microbiological analysis of biosolids treated with different techniques for agricultural use. Journal of Technological Engineering. 8[21]1-8: e1821108.
https://doi.org/10.35429/JTEN.2024.8.21.1.8

Box 4

Table 3

Amounts of inoculum, sludge and water in the photobioreactor

Inoculum (L)	Lodo (kg)	Water (L)
5.319	0.6	44.680

Source: Own elaboration

The results obtained in the microbiological determination of the photo-bioreactor (before and after treatment) are shown in Table 4, where the water with the percentage of biosolids is reported with the letter (E) and the water with the percentage of biosolids after a period of treatment with algae is reported with the letter (F).

The microbiological analyses carried out on sorghum and maize samples treated with biosolids for growth in the community of San

Bernardo, municipality of Purísima del Rincón, Gto. gave the results shown in Table 5.

According to the results obtained, considering what is established in NOM-004-SEMARNAT-2002, class C biosolids are those that are susceptible to use in agriculture, as well as in forestry areas and soil improvement.

Regarding the microbiological determination of the different biosolids labelled as (A, B, C and D), considering the L.M.P of faecal coliforms NMP/g on dry basis, all samples of treated biosolids comply, as they do not exceed the value established by the standard, which is <2 000 000.

On the other hand, for *Salmonella spp.*, NMP/g on dry basis, sample A exceeds the L.M.P of the standard which corresponds to <300 and taking into account the helminth eggs all the samples comply being <35 which is established by the standard; which can be seen in Table 1.

Based on the microbiological analysis of the photo-bioreactor, the water with the biosolid (E) is not within the L.M.P (240 NMP/100ml) of the standard, having a value of ≥2400 NMP/100 ml. However, it is important to consider the month and climatic conditions in which the sample was taken as this is a variable factor that influences the results, as can be seen in Table 4.

Box 5

Table 4

Microbiological determination of water with a percentage of biosolids (E and F), with its L.M.P. according to NOM-004-SEMARNAT-2002 (faecal coliforms and helminth eggs) and the presence and absence of Salmonella spp.

Water with biosolids	Bacteriological indicator of contamination	Parasites	Pathogens
	Faecal coliforms NMP/100ml	Helminth eggs/l	*Salmonella spp.*
E	≥2400	3	presencia
F	11	12	presencia
Public services with direct contact	L.M.P Norma Oficial Mexicana NOM-003-ECOL-1997		
	240	≤1	-

L.M.P Official Mexican Standard NOM-003-ECOL-1997

Source: Own elaboration

Box 6

Table 5

Microbiological determination of maize and sorghum

Grain sample	Total coliforms on plate (** and **.*)			Presence or absence of Salmonella spp. in 1 g sample) ***
	Representative dilution	Colonies counted on plate	UFC/g o ml	
Sorgo	1: 100 1: 1000 1: 10000	>250* 254* Extended growth	250000*	presence of Salmonella spp. in 1 g sample
Maize	1:100 1:1000 1:10000	Extended growth >250* 219	2200000	presence of Salmonella *spp.* in 1 g sample

Source: Own elaboration.

NOTE: The results that show the following sign (*) are of the "estimated value" because the values are outside the range of 25 to 250.

** Official Mexican Standard NOM-113-SSA1-1994, goods and services. Method to count total coliform microorganisms on plate.

**Mexican Official Standard NOM-092-SSA1-1994, goods and services. Method for aerobic bacteria count on plate (aerobic mesophilic* 35 ± 2ºC 48 ± 2 h).

*** Official Mexican Standard NOM-114-SSA1-1994, goods and services. Method for the determination of salmonella in food.

In the same table it can be seen that the number of pathogens in the water with the biosolid (F) with the treatment did not decrease, having a value of 12 helminth eggs/l, not falling within the L.M.P (≤1 helminth eggs/l) of the mentioned standard. In both sludges the confirmation of *Salmonella spp.* was positive.

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Rivera-Mosqueda, Ma. Cruz, Soto-Alcocer, José Luis, Arellano-Elizarraraz, Roberto and Ayala-Islas, Alberto. [2024]. Microbiological analysis of biosolids treated with different techniques for agricultural use. Journal of Technological Engineering. 8[21]1-8: e1821108.
https://doi.org/10.35429/JTEN.2024.8.21.1.8

The sorghum and maize samples that had a germination and growth process with the help of the SITRATA biosolid, obtained a result of 250000 CFU/g as shown in Table 5, which represents an estimated value for sorghum, while for maize 2200000 CFU/g were obtained, as well as the presence of *Salmonella spp.* in 1 g of sample in both cases, which represents a not very favourable result.

Conclusions

The treatments of open air drying, treatment with lime and constant temperature drying, are able to reduce faecal coliforms and *Salmonella spp.*, biosolids B, C and D analysed complying with the L.M.P. of class C, being important indicators for biosolids to be implemented as fertiliser in short stalk crops. It is considered that drying the sludge for a longer period of time can further reduce the content of microorganisms.

As well as the stabilisation treatment using algae (consortium), according to the maximum permissible limits for public services with direct contact established by NOM-003-SEMARNAT-1997, it is considered to be suitable for reducing the load of faecal coliforms (NMP/100 ml). of *Salmonella spp.* in both sludges, considering that they are important indicators for the biosolids treated for the treated biosolids to be implemented in short-stemmed crops, it can be considered that it is not advisable to implement them as fertiliser.

In order to use the biosolids as fertiliser in crops, according to the results obtained in Table 5, it is considered necessary to carry out a stabilisation treatment in order to avoid the presence of *Salmonella spp.* which is an important parameter in foodstuffs.

Declarations

Conflict of interest

The authors declare that they have no conflicts of interest. They have no known competing financial interests or personal relationships that might have appeared to influence the article reported in this paper.

Authors' contribution

Rivera-Mosqueda, Ma. Cruz: Development of the original Project idea and sample collection.

Soto-Alcocer, José Luis: Assistance in sample collection, transport and administration of the project.

Arellano-Elizarraraz, Roberto: Experimental analysis and editing.

Ayala-Islas, Alberto: Experimental analysis and editing.

Availability of data and materials

All data and procedures resulting from the research can be obtained from the lead author.

Funding

This research was not funded under any grant or other external support.

Acknowledgements

The Instituto Tecnológico Superior de Irapuato would like to thank the staff of the Sistema Intermunicipal para los Servicios de Tratamiento de Aguas Residuales para los Municipios del Rincón (SITRATA), of the municipality of Purísima del Rincón, Guanajuato and its general director: Ing. Diego Isaac Dávila Cano, for the facilities granted to carry out this work (Convenio ITESI/CONVENIOS/240-2017).

Abbreviations

M.P.L: Maximum permissible limit.
M.P.N.: Most Probable Number.
NMX: Mexican Standard.
NOM: Official Mexican Standard.
PTAR: Wastewater treatment plant.
SITRATA: Intermunicipal System for Wastewater Treatment and Disposal Services for the Municipalities of El Rincón.
spp.: Species.
CFU: Colony Forming Units.
WWTP: Wastewater Treatment Plant.

References

Antecedents

Amador-Díaz, A., Veliz-Lorenzo, E., & Bataller-Venta, M. (2015). Tratamiento de lodos, generalidades y aplicaciones. Revista CENIC. Ciencias Químicas, 46, 1-10.

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Rivera-Mosqueda, Ma. Cruz, Soto-Alcocer, José Luis, Arellano-Elizarraraz, Roberto and Ayala-Islas, Alberto. [2024]. Microbiological analysis of biosolids treated with different techniques for agricultural use. Journal of Technological Engineering. 8[21]1-8: e1821108.
https://doi.org/10.35429/JTEN.2024.8.21.1.8

Cogger, C. G., Sullivan, D. M., Henry, C. L., & Dorsey, K. P. (2000). Biosolids Management Guidelines for Washington State. Washington State Department of Ecology, 93(80), 1-235.

Conagua. (2012). Estadísticas del agua en México. México, D. F: SEMARNAT.

Guzmán, C., & Campos, C. (2004). Indicadores de contaminación fecal en biosólidos aplicados en agricultura. Universitas Scientiarum, 9(1), 59-67.

IMTA. (2016). Revisión y actualización del potencial de biomasa para generación de energía eléctrica a partir de plantas de aguas residuales presentado en el inventario Nacional de Energías Renovables (INERE). México: SUBCOORDINACIÓN DE TRATAMIENTO DE AGUAS RESIDUALES, COORDINACIÓN DE TRATAMIENTO Y CALIDAD DEL AGUA.

Kara, Y., Basaran, D., Kara, I., Zeytunluoglu, A., & Genç, H. (2003). BIOACCUMULATION OF NICKEL BY AQUATIC MACROPHYTA LEMNA MINOR (DUCKWEED). International Journal of Agriculture and Biology, 5(3), 281-283.

Mantilla-Morales, G., Sandoval-Yoval, L., Ramírez-Camperos, E. M., Gazca-Álvarez, S., Navarro-Franco, J., Hernández-Cruz, N., García-Rojas, J. L., Esquivel-Sotelo, A., & Calderón-Mólgora, C. G. (2017). Energía limpia del agua sucia: aprovechamiento de lodos residuales. Recuperado 19 de junio de 2023.

Porta-Casanellas, J., López-Acevedo-Reguerin, M., & Roquero de Laburu, C. (2003). Edafología para la agricultura y el medio ambiente (Tercera ed.). Madrid, España: Mundi-Presa.

Rojas-Remis, R., & Mendoza-Espinosa, L. G. (2012). Utilización de biosólidos para la recuperación energética en México. Scielo, 7(2), 74-94.

UNESCO. (2017). Informe Mundial de las Naciones Unidas sobre el Desarrollo de los Recursos Hídricos 2017. Brasil: ONU-Agua.

Basics

Hanna-Instruments. (2001). Instruction Manual EC214 EC215 EC215R Multi-Range Conductivity Meters for Laboratories.

Terreros-Mecalco, J., Olmos-Dichara, A., Noyola-Robles, A., Ramírez-Vives, F. & Monroy-Hermosillo O. (2009). DIGESTIÓN ANAEROBIA DE LODO PRIMARIO Y SECUNDARIO EN DOS REACTORES UASB EN SERIE. Revista Mexicana de Ingeniería Química, 8(2), 153-161.

NMX-AA-042-SCFI-2015, (2016). Análisis de Agua-Enumeración de Organismos Coliformes Totales, Organismos Coliformes Fecales (Termotolerantes) y Escherichia Coli-Método del Número más Probable en Tubos Múltiples (cancela a la NMX-AA-42-1987). Secretaría de Economía (Comités Técnicos de Normalización Nacional).

NMX-AA-113-SCFI-2012, (2013). Análisis de Agua-Medición del Número de Huevos de Helminto en Aguas Residuales y Residuales Tratadas por Observación Microscópica-Método de Prueba (cancela a la NMX-AA-113-SCFI-1999). Secretaría de Economía (Comités Técnicos de Normalización Nacional).

NOM-113-SSA1-1994, (1995) Bienes y servicios. Método para la cuenta de microorganismos coliformes totales en placa. Secretaría de Salud.

NOM-003-SEMARNAT-1997, (1998). Que establece los límites máximos permisibles de contaminantes para las aguas residuales tratadas que se reúsen en servicios al público: Secretaría de Medio Ambiente, Recursos Naturales y Pesca.

NOM-004-SEMARNAT-2002, (2003). Protección Ambiental. - Lodos y Biosólidos. - Especificaciones y Límites Máximos Permisibles de Contaminantes para su Aprovechamiento y Disposición Final. México: Secretaría de Medio Ambiente y Recursos Naturales.

Norma Oficial Mexicana NOM-092-SSA1-1994, bienes y servicios. Método para la cuenta de bacterias aerobias en placa. (Mesofílicos aerobios* 35 ± 2ºC 48 ± 2 h).

NOM-114-SSA1-1994, (1994). Bienes y servicios. Método para la determinación de salmonella en alimentos. Secretaría de Salud.

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Rivera-Mosqueda, Ma. Cruz, Soto-Alcocer, José Luis, Arellano-Elizarraraz, Roberto and Ayala-Islas, Alberto. [2024]. Microbiological analysis of biosolids treated with different techniques for agricultural use. Journal of Technological Engineering. 8[21]1-8: e1821108.
https://doi.org/10.35429/JTEN.2024.8.21.1.8

NOM-210-SSA1-2014, (2015). Productos y Servicios. Métodos de prueba microbiológicos. Determinación de microorganismos indicadores. Determinación de microrganismos patógenos. Secretaría de Salud.

Support

Soto-Alcocer, J. L., Rivera Mosqueda, Ma. C., González-Ponce, M. del R., & Peña-Ramírez, R. (2018). Determinación de las curvas de secado del lodo del sistema intermunicipal para los servicios de tratamiento y disposición de aguas residuales para los Municipios del Rincón, a Nivel Laboratorio. Revista de Ingeniería Tecnológica, 2, 31-37.

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Journal of Technological Engineering 8[21]1-9: e2821109
Article

Production parameters in radishes (*Raphanus sativus L.*) using organic inputs

Parámetros productivos en rábanos (*Raphanus sativus* L.) mediante el uso de insumos orgánicos

Medina-Saavedra, Tarsicio *[a], Mexicano-Santoyo Lilia [b], Arroyo-Figueroa Gabriela [c] and Castro-Jácome, Tania Patricia [d]

[a] Universidad de Guanajuato, Departamento de Ingeniería Agroindustrial • DWP-2217-2022 • 0000-0003-2730-6918 • 355510
[b] Universidad de Guanajuato, Departamento de Ingeniería Agroindustrial • KJB-2290-2024 • 0000-0002-5220-8773 • 823318
[c] Universidad de Guanajuato, Departamento de Ingeniería Agroindustrial • DVJ-7189-2022 • 0000-0002-4187-4367 • 57295
[d] Grupo Educativo del Valle • LUY-7112-2024 • 0000-0003-0859-0140 • 405624

CONAHCYT classification:

Area: Biotechnology and Agricultural Sciences
Field: Agricultural Sciences
Discipline: Horticulture
Subdiscipline: Vegetables

https://doi.org/10.35429/JTEN.2024.8.21.1.9
History of the article:
Received: February 27, 2024
Accepted: December 10, 2024

* ✉ [tarsicioms@hotmail.com]

Abstract

The objective was to measure productive parameters in radishes grown using organic inputs. With a randomized block design and three repetitions. The treatments: commercial cultivation (RaT0); biofertilizer, worm leachate and bocashi (RaT1); biofertilizer and Mountain Microorganisms (RaT2). The parameters bulb circumference, bulb length, root length, stem to leaf length, stem circumference, number of leaves and weight. ANOVA and Principal Component Analysis (PCA) were performed. The PCA shows that RaT1 has the greatest positive impact on the diameter and length of the bulb and the weight of radish. Biofertilizers stimulate rooting and provide plant growth-promoting bacteria (GPCV), worm leachates provide humic acids and promote better absorption of minerals, and bocashi favors the availability of minerals due to the fermentation it undergoes during its preparation.

Productive parameters in radishes (*Raphanus sativus* L.) through the use of organic inputs		
Objetivo	Metodología	Contribución
The objective of the study was to perform the measurement of productive parameters in radishes cultivated using organic inputs. A randomized block design with three replications was performed.	The direct seeding system was used, with irrigation at field capacity. The treatments applied were RaT0: commercial cultivation; RaT1: biofertilizer, earthworm and bocashi leachate; RaT2: biofertilizer, and Mountain Microorganisms. Parameters measured were bulb circumference, bulb length, root length, stem-to-leaf length, stem circumference, number of leaves, and weight. For data analysis, an ANOVA and Principal Component Analysis (PCA) were performed.	The data showed that the highest weight, bulb circumference with RaT0 and RaT1 and the highest bulb length with RaT1. On the other hand, the PCA shows that RaT1 has a greater positive impact on the diameter and length of the bulb and the weight of the radish. Biofertilizers stimulate rooting and provide plant growth promoting bacteria (BPCV), earthworm leachates provide humic acids and favor better absorption of minerals, and bocashi favors the availability of minerals due to the fermentation it undergoes during its preparation.

Bocashi, humic acids, *Eisenia foetida*, Mountain microorganisms, Biofertilizer, Auxins

Resumen

El objetivo fue medir parámetros productivos en rábanos cultivados mediante insumos orgánicos. Con un diseño de bloques al azar y tres repeticiones. Los tratamientos: cultivo comercial (RaT0); biofertilizante, lixiviado de lombriz y bocashi (RaT1); biofertilizante y Microorganismos de Montaña (RaT2). Los parámetros circunferencia del bulbo, longitud del bulbo, longitud de la raíz, longitud del tallo a las hojas, circunferencia de los tallos, número de hojas y peso. Se realizó un ANOVA y un Análisis de Componentes Principales (ACP). El ACP muestra que RaT1 tiene mayor impacto positivo sobre el diámetro y longitud del bulbo y el peso de rábano. Los biofertilizantes estimulan el enraizamiento y aportan bacterias promotoras de crecimiento vegetal (BPCV), los lixiviados de lombriz aportan ácidos húmicos y favorecen una mejor absorción de minerales y el bocashi favorece la disponibilidad de los minerales debido a la fermentación que tiene durante su preparación.

Parámetros productivos en rábanos (*Raphanus sativus* L.) mediante el uso de insumos orgánicos		
Objetivo	Metodología	Contribución
El objetivo del estudio fue to measure production parameters in radishes grown using organic inputs.	Se utilizó un diseño de bloques al azar con tres repeticiones. Se empleó el sistema de siembra directa, con riego a capacidad de campo. Los tratamientos aplicados fueron: cultivo comercial (RaT0); biofertilizante, lixiviado de lombriz y bocashi (RaT1); biofertilizante y Microorganismos de Montaña (RaT2). Los parámetros medidos fueron circunferencia del bulbo, longitud del bulbo, longitud de la raíz, longitud del tallo a las hojas, circunferencia de los tallos, número de hojas y peso. Para el análisis de los datos se realizó un ANOVA y un Análisis de Componentes Principales (ACP).	Los datos mostraron que el mayor peso, circunferencia del bulbo con RaT0 y RaT1 y la mayor longitud del bulbo con RaT1. Por otra parte, el ACP muestra que RaT1 tiene mayor impacto positivo sobre el diámetro y longitud del bulbo y el peso de rábano. Los biofertilizantes estimulan el enraizamiento y aportan bacterias promotoras de crecimiento vegetal (BPCV), los lixiviados de lombriz aportan ácidos húmicos y favorecen una mejor absorción de minerales y el bocashi favorece la disponibilidad de los minerales debido a la fermentación que tiene durante su preparación.

Bocashi, ácidos húmicos, *Eisenia foetida*, Microorganismos de montaña, biofertilizante, Auxinas

Citation: Medina-Saavedra, Tarsicio, Mexicano-Santoyo Lilia, Arroyo-Figueroa Gabriela and Castro-Jácome, Tania Patricia. [2024]. Production parameters in radishes (Raphanus sativus L.) using organic inputs. Journal of Technological Engineering. 8[21]1-9: e2821109.

ISSN: 2523-6776 / © 2009 The Author[s]. Published by ECORFAN-Mexico, S.C. for its Holding Taiwan on behalf of Journal of Technological Engineering. This is an open access article under the **CC BY-NC-ND** license [http://creativecommons.org/licenses/by-nc-nd/4.0/]

Peer review under the responsibility of the Scientific Committee MARVID®- in the contribution to the scientific, technological and innovation Peer Review Process through the training of Human Resources for continuity in the Critical Analysis of International Research.

RENIECYT Registro Nacional de Instituciones y Empresas Científicas y Tecnológicas
1702902 CONAHCYT

Introduction

Radishes (*Raphanus sativus L*) originate from China, although it is found in the wild in some Mediterranean localities (Giaconi and Escaff, 2004), it has rudimentary stems with large leaves and elongated peduncle (Martínez *et al*., 2003).

According to c, radish production takes place in the months of August-October and February-May, however, it can be sown all year round. It develops and grows best in temperate or cool temperate climates. In terms of soil requirements, it favours fertile and deep soils (Ruíz *et al*., 2013).

Medium or light textured soils produce good development of this crop, although it can also develop in heavy textured soils (Ruíz *et al*., 2013). On the other hand, Martínez *et al*. (2003) report that the most suitable soils for this vegetable are loam and clay loam. Organic agriculture uses methods such as crop rotation, compost, worm humus, green manures, rock meal, among others, which contribute to soil nutrition (Consuegra, 2004; WHO, 2007), always seeking the least environmental impact (Consuegra, 2004; WHO, 2007)

In this sense, organic fertilisers improve soil structure and are made from the decomposition of materials of plant origin (plant remains, crop waste) and animal origin (excrements) (FONAG, 2010; Yugsi, 2011) whose aim is to provide the soil with the nutrients necessary for plant growth (FONAG, 2010; Méndez *et al*., 2013), by contributing to improve soil health (Rosales *et al*., 2013) and reducing the use of fertilisers .

Organic fertilisers are classified into solid and liquid fertilisers. Among the liquid fertilisers are biofertilisers, which are used as foliar fertilisers (FONAG, 2010), which are regularly made from animal excrement and leguminous plant residues (Yugsi, 2011) and require an anaerobic fermentation process (Álvarez, 2010).

This type of fertiliser contributes to plant nutrition by providing minerals and phytohormones (Álvarez, 2010), which promotes foliage development, flowering and rooting (MAGAP, 2014), as well as protection against pests and diseases (INIA, 2008; FONAG, 2010).

In particular, earthworm leachate (*Eisenia foetida*), considered a liquid biofertiliser, is obtained by the vermicomposting technique, which consists of extracting liquids from the disintegration of organic matter (Morales, 2011; Pilar, 2013).

This biofertiliser provides minerals necessary for plant growth such as phosphorus (P), potassium (K), magnesium (Mg), sodium (Na) and nitrogen (N) (Rosales *et al*., 2013).

Among the solid organic fertilisers is bocashi, which is made by fermenting plant remains and animal manure aerobically and anaerobically (Yugsi, 2011).

This type of compost favours better plant growth and development because it contributes to the increase of organic matter and microorganisms in the soil, provides natural phytohormones and phyto-regulators, as well as improving soil texture (Herrera et al., 2015; Ross et al., 2000).

On the other hand, beneficial microorganisms such as mountain microorganisms (MM) are a consortium of fungi, bacteria and yeasts that help control pathogenic microorganisms present on plants and in the soil (Suchini, 2012), in addition to promoting germination, flowering and fruiting (MAGAP, 2014). The objective of the present research was to measure the agronomic parameters of bulb and stem circumference; bulb, root and stem length; leaf number and bulb weight of radishes (*Raphanus sativus L*) grown using organic inputs.
Methodology

The present work was carried out in the greenhouse of the facilities of the University of Guanajuato at the Salvatierra campus (20°12'45.51 ‘N and 100°52'30.09 ’W). The direct sowing system of red radish was used in beds 6 m long, 1 m wide, 25 cm high, chosen in completely randomised blocks with three replications.

Irrigation was carried out at field capacity every third day, using a drip irrigation system with a drip tape with perforations every 30 cm. Radishes were harvested one month after sowing to measure the agronomic parameters of bulb circumference, bulb length, root length, stem to leaf length, stem circumference, number of leaves and weight.

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Medina-Saavedra, Tarsicio, Mexicano-Santoyo Lilia, Arroyo-Figueroa Gabriela and Castro-Jácome, Tania Patricia. [2024]. Production parameters in radishes (Raphanus sativus L.) using organic inputs. Journal of Technological Engineering. 8[21]1-9: e2821109.
https://doi.org/10.35429/JTEN.2024.8.21.1.9

Bulb circumference was represented by the circular space covered by the bulb of the bulb, bulb length by the distance from the bottom of the bulb to the top of the bulb and as for the weight of the radishes, only the bulb was taken into account if the root, leaves and stems.

Preparation of inputs

a) *Biofertiliser.* For the preparation of the biofertiliser, it was carried out according to the recommendations of Restrepo (2007) with some modifications; a 20-litre plastic jug was used in which 300 g of rock flour, 300 g of ash and water without chlorine were added up to half of the container, 1 kg of carrots chopped into small pieces, 3 kg of fresh cow dung and 1 litre of fresh cow milk was added. Separately, 200 ml of molasses was dissolved in 1 litre of water to be added to the other ingredients and 20 litres of water was added to make up the 20 litres. It was left to stand for 40 days under anaerobic conditions as indicated by INIA (2008).

b) *Worm leachate*. The preparation of the earthworm leachate (*Eisenia foetida*) was carried out in accordance with Morales (2011), collecting the leached liquids from the Californian red worm rearing system.

c) *Bocashi*. Bocashi was made according to the methodology proposed by Restrepo (2007) with some modifications in the ingredients, using 2 sacks of sheep manure, 2 sacks of black soil, 2 sacks of ground stubble (sack of 70 cm high x 40 cm wide), 50 kg of bran, 10 kg of ash, 5 kg of charcoal, 250 g of yeast and 2 litres of molasses.

The already mixed materials were moistened to such a degree that when a portion of material is taken and squeezed by hand, no water should drip out, and care was taken that the temperature did not exceed 50 ºC during the 15 days of processing.

d) *Mountain micro-organisms.* For the elaboration of the mountain microorganisms (MM), decomposing leaf litter was collected from the Tetillas hill (20 ° 12‘ 54‘‘ North, 100 ° 52’ 41‘‘ West), in sites little affected by anthropic factors as mentioned by Ramírez (2012), The mixture was then mixed with 500 ml of molasses, 1 kg of maize flour, 1 kg of ground bran and 1 litre of whey, the previous mixture was enough to be compacted in a 20-litre plastic bucket and sealed anaerobically for a period of 30 days.

To activate the MM in the liquid phase, 200 g of the previous mixture is placed in a cloth sack, to be immersed in a 20-litre plastic bucket of water with 200 ml of dissolved molasses, stirring two to three times a day for four days.

Experimental design

A randomised block experimental design with three replicates was used. Radishes were direct sown in 6 m long by 50 cm wide beds.

a) *Treatments.* The treatments applied consisted of a commercial crop with a 10-20-10 fertiliser and commercial foliar fertilisation (RaT0); a crop with biofertiliser, earthworm leachate and bocashi (RaT1) and a crop with 5% biofertiliser and Mountain Microorganisms (MM) in liquid phase in the soil (RaT2).

For RaT0 the 10-20-10 fertiliser was used 250 g per^{m2} during soil preparation and foliar fertiliser was applied every 8 days. For RaT1 the biofertiliser used was diluted at 5% with non-chlorinated water and foliar applied every 8 days in the morning, the earthworm leachate at 5% with non-chlorinated water applied to the soil once a week during crop development as a field capacity irrigation system and the bocashi 3 kg per^{m2} during soil preparation.

For RaT2 the 3 iofertilizer used was diluted at 5% with non-chlorinated water applied foliarly every 8 days in the morning and the mountain micro-organisms (MM) were activated in liquid phase at 5% with non-chlorinated water and applied to the soil twice during crop development in the early morning.

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Medina-Saavedra, Tarsicio, Mexicano-Santoyo Lilia, Arroyo-Figueroa Gabriela and Castro-Jácome, Tania Patricia. [2024]. Production parameters in radishes (Raphanus sativus L.) using organic inputs. Journal of Technological Engineering. 8[21]1-9: e2821109.
https://doi.org/10.35429/JTEN.2024.8.21.1.9

b) *Data analysis.* The results obtained for the measured parameters (bulb circumference, bulb length, root length, stem to leaf length, stem circumference, number of leaves and weight) were analysed by analysis of variance (ANOVA), followed by a Tukey test in order to check the existence or not of significant differences between the different treatments. In addition, a Principal Component Analysis (PCA) was performed to determine the variables with the greatest impact and their correlation in OriginPro 2017 software. Data were expressed as the mean ± standard deviation.

Results

The results show that the treatment with the largest bulb circumference was obtained with the control (RaT0) followed by RaT1 (Figure 1), however, no significant statistical differences were observed (P>0.05), indicating that production with organic fertilizers is an alternative to conventional production. In this sense, Romero *et al*. (2012) and Cabrera *et al.* (2012) report that the use of biofertilisers increases vegetable production and yield.

Box 1

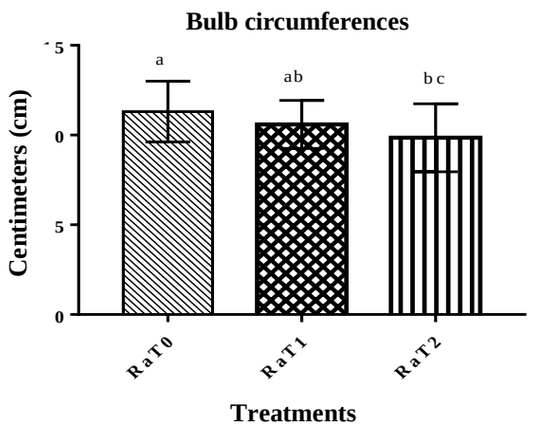


Figure 1

Circumference of radish bulb: commercial control (RaT0), biofertiliser, earthworm (Eisenia foetida) leachate and bocashi (RaT1), biofertiliser and mountain micro-organisms. (RaT2).

Box 2

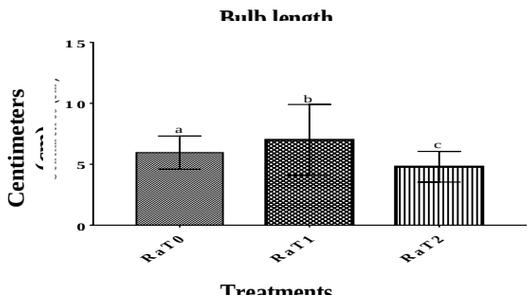


Figure 2

Bulb length of radishes with the treatments: commercial control (RaT0), biofertiliser, earthworm leachate (Eisenia foetida) and bocashi (RaT1), biofertiliser and mountain microorganisms. (RaT2).

Box 3

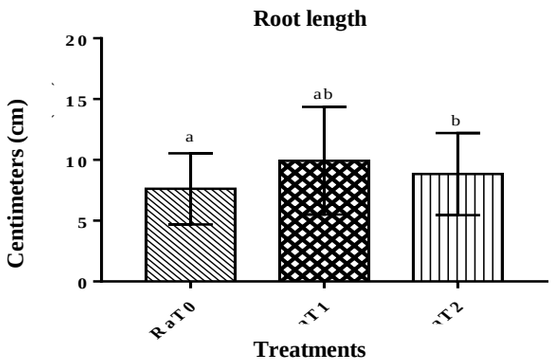


Figure 3

Root length of radishes with the treatments: commercial control (RaT0), biofertiliser, earthworm leachate (Eisenia foetida) and bocashi (RaT1), biofertiliser and mountain microorganisms. (RaT2).

Box 4

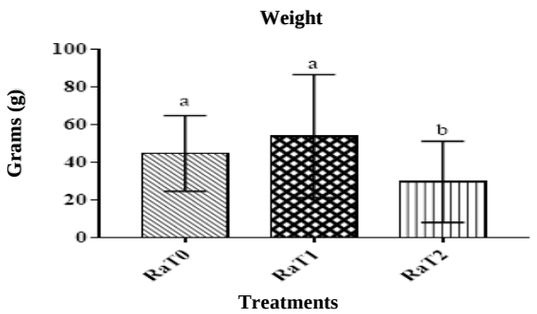


Figure 4

Bulb weight of radishes with the treatments: commercial control (RaT0), biofertiliser, earthworm leachate (Eisenia foetida) and bocashi (RaT1), biofertiliser and mountain microorganisms. (RaT2).

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Medina-Saavedra, Tarsicio, Mexicano-Santoyo Lilia, Arroyo-Figueroa Gabriela and Castro-Jácome, Tania Patricia. [2024]. Production parameters in radishes (Raphanus sativus L.) using organic inputs. Journal of Technological Engineering. 8[21]1-9: e2821109.
https://doi.org/10.35429/JTEN.2024.8.21.1.9

In Figures 1, 2, 3 and 4 it can be seen that there are statistical differences between the different treatments applied (P<0.05), it is highlighted that the greatest bulb length was obtained with the RaT1 treatment (Figure 2). In agreement with Gómez et al. (2008) and Luna et al. (2015) who obtained similar results in terms of bulb length in radishes and better development of vegetables when using organic fertilizers.

Abou-El-Hassan and Desoky (2013) report that organic fertilisers improve plant growth because they provide macro and micronutrients. In addition, fertilisers such as bocashi contain beneficial microorganisms that stimulate the production of gibberellin in plants, which in turn stimulates fruit development (Camelo et al., 2011).

In relation to root length, it was found that the best treatments were RaT1 and RaT2 (Figure 3). However, no significant statistical differences were observed between RaT2 and RaT0 treatments. On the other hand, significant statistical differences were observed between RaT1 and RaT0 treatment (P<0.05), such that, the best treatment was RaT1, suggesting that root length was favoured by plant growth-promoting bacteria (PGRB) present in the organic inputs through lateral root propagation (Barberi et al, 1988; Barberi et al., 1986; Kolb and Martin; Tien et al., 1979), thus enhancing nutrient and water uptake (Bashan and Honguin, 1998). Another way in which microorganisms can favour plant root growth is through the generation of plant hormones (auxins) that have the capacity to elongate roots, contributing to the uptake of nutrients and water from the soil (Romero, et. al., 2012).

The radishes with the highest weight were those of the RaT0 and RaT1 treatments (Figure 4). The RaT1 treatment did not show significant statistical differences with respect to the RaT0 treatment (P>0.05) but did show significant differences with respect to the RaT2 treatment (P<0.05).

In this sense, the earthworm leachates could have contributed to increase the weight of the radishes due to the action of humic acids that favour a better absorption of minerals (Velasco et al., 2016) and bocashi by providing sufficient nutrients for the growth of the radishes (Velasco et al., 2016) (Restrepo, 2007; MAGAP, 2014).

Box 5

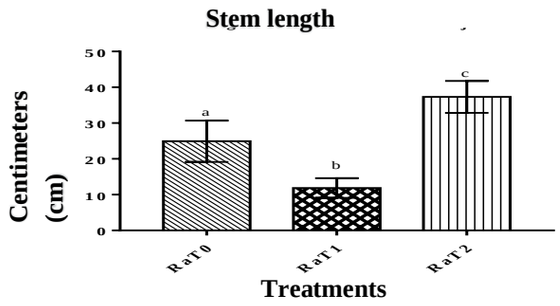


Figure 5

Stem to leaf length in radishes with the treatments: commercial control (RaT0), biofertiliser, earthworm leachate (Eisenia foetida) and bocashi (RaT1), biofertiliser and mountain microorganisms. (RaT2).

Figure 5 shows stem to leaf length, stem circumference and number of leaves in treated radishes. The treatment with the highest stem length was RaT2, being statistically different compared to RaT0 and RaT1 (P<0.05). Cassán *et al*. (2008) report that auxins are phyto-regulators that act on stem cells and promote stem elongation.

In the same way, MM have the ability to produce phytohormones in plants, which could contribute to the development of foliage that is reflected in an increase in stem length and an increase in the number of leaves (Tenecio, 2015). Therefore, the beneficial microorganisms present in the applied organic products induce the production of hormones in radish plants and promote better development and growth, which results in better photosynthetic capacity by the plants, reflecting the physiological state, productivity and health of a plant (Ospina *et al.*, 2018).

Box 6

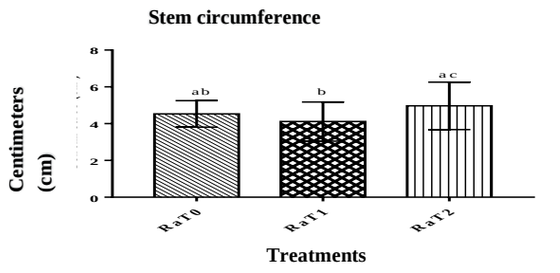


Figure 6

Stem circumference in radishes with the treatments: commercial control (RaT0), biofertiliser, earthworm (Eisenia foetida) leachate and bocashi (RaT1), biofertiliser and mountain microorganisms (RaT2).

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Medina-Saavedra, Tarsicio, Mexicano-Santoyo Lilia, Arroyo-Figueroa Gabriela and Castro-Jácome, Tania Patricia. [2024]. Production parameters in radishes (Raphanus sativus L.) using organic inputs. Journal of Technological Engineering. 8[21]1-9: e2821109.
https://doi.org/10.35429/JTEN.2024.8.21.1.9

In terms of stem circumference, it was found that the treatments with the largest stem diameter were RaT0 and RaT2 (Figure 6), with no statistical differences between treatments. However, significant statistical differences were observed between treatments RaT0 and RaT2 compared to the control treatment (RaT1) (P< 0.05).

These results suggest that organic products such as MM and biofertilisers promote growth due to their phytohormone content (Herrera et al., 2015), which favoured an increase in radish bulb thickness (Tenecio, 2015). In addition, the production of Gibberellin by beneficial bacteria promotes stem growth and bud emergence (Camelo et al., 2011).

Box 7

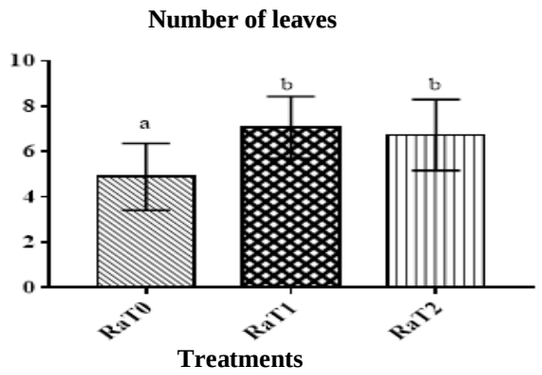


Figure 7

Number of leaves on radishes with the treatments: commercial control (RaT0), biofertiliser, earthworm leachate (Eisenia foetida) and bocashi (RaT1), biofertiliser and mountain microorganisms. (RaT2).

Finally, the number of leaves forming the stems of the radish plants. The radishes with the highest number of leaves were obtained with the organic treatments RaT1 and RaT2 (Figure 7), no statistical differences were observed between treatments.

The results suggest that organic inputs favour leaf production in radishes, probably due to the effect of phytohormones present (Herrera et al., 2015) that help to increase foliage growth.

Box 8

Table 1

Proportion of the overall variance, vectors and eigenvalues of the first four principal components

Variable	Significance	CP1	CP2	CP3	CP4
Bulb circumference	5	0.34289	0.38054	-0.5549	-0.02082
Bulb length	3	0.54176	0.04468	-0.17821	*0.30584*
Length of root	7	0.27244	-0.02949	0.1997	0.75664
Stem length	1	-0.50952	0.4541	0.01033	0.2297
Stem circumference	2	-0.14533	0.70439	0.05043	0.13893
Number of leaves	6	0.24309	0.17839	0.77417	-0.06275
Weight of radishes	4	0.411818	0.34368	0.13586	-0.50747
Eigenvalue	-	1.78484	1.40987	1.10572	1.06259
Explained variance (%)	-	25.5	20.14	15.8	13.18
Cumulative variance (%)	-	25.5	45.64	61.43	76.61

Table 1 shows the 4 principal components that describe the greatest variation in the data, the absolute and cumulative proportion values, describing 76.61 % of the total variation of the information obtained in this study and the importance of each variable, with the variable marked with the number 1 as the one with the greatest impact and number 7 as the one with the least.

For principal component 1 (PC1), the associated variables are bulb length and radish weight, where 25.50 % of the total variability is explained.

For CP2 the variables are stem diameter, stem length and bulb diameter, explaining 20.14% of the total variability.

CP3 is related to the number of leaves and CP4 to root length explaining 15.8 % and 13.18 % of the total variability, respectively.

Figure 8a shows a two-dimensional diagram formed by principal components 1 and 2 (45.64% of the total variability), with the most important variables being stem length and stem diameter, which are also positively associated with each other.

Figura 8. Resultados del análisis de componentes principales. (a) Proyección de variables y (b) comportamiento del Biplot con variables y tratamientos.

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Medina-Saavedra, Tarsicio, Mexicano-Santoyo Lilia, Arroyo-Figueroa Gabriela and Castro-Jácome, Tania Patricia. [2024]. Production parameters in radishes (Raphanus sativus L.) using organic inputs. Journal of Technological Engineering. 8[21]1-9: e2821109.
https://doi.org/10.35429/JTEN.2024.8.21.1.9

Box 9

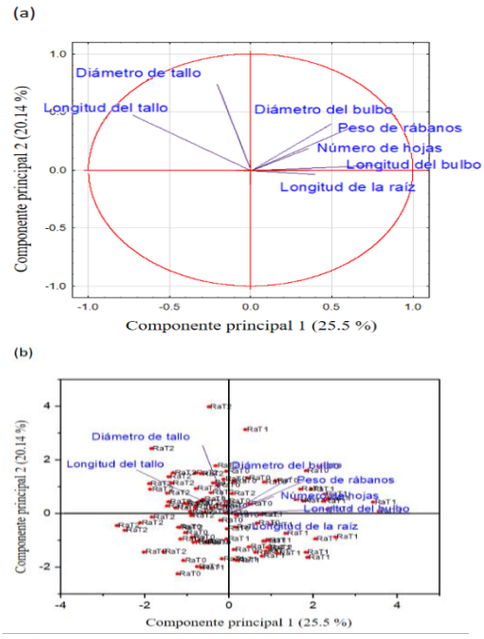


Figure 8

In relation to the parameters bulb diameter, bulb length, root length, number of leaves and radish weight, they were found to be associated with each other, however, they have a negative association with the variables stem diameter and stem length.

That is, by increasing stem diameter and stem length, bulb diameter, bulb length, root length, number of leaves and radish weight will decrease.

In this sense, when looking at Figure 8b, where the variables are found together with the control (RaT0) and the treatments (RaT1 and RaT2). It was observed that RaT1 has a greater positive impact on bulb diameter, bulb length and radish weight.

In contrast, RaT2 has a positive impact on stem diameter and stem length. All this when compared with RaT0 results are in agreement with the above statistical tests (ANOVA and Tukey), showing that RaT1 and RaT2 stimulate plant growth in different parts of the fruit.

Conclusions

The use of organic inputs such as biofertiliser, earthworm leachate (*Eisenia foetida*), bocashi and mountain microorganisms (MM) stimulate fruit development and provide plant growth-promoting bacteria (GGPB) that stimulate root development, as well as containing phytohormones that promote foliage development.

Organic production is an alternative to conventional production in radish cultivation, as it favoured the measured parameters (bulb circumference, bulb length, root length, stem length, stem circumference, number of leaves and weight), because it provides balanced nutrition.

Conflict of interest

The authors declare that they have no conflicts of interest. They have no known competing financial interests or personal relationships that might have appeared to influence the article reported in this paper.

Authors' contribution

Medina-Saavedra Tarsicio: I contributed to the idea of the project and the development of the research.

Mexicano-Santoyo Lilia: I contributed with the research development, data analysis, revision and editing.

Arroyo-Figueroa Gabriela: I contributed with the revision and editing.

Castro-Jácome Tania Patricia: I contributed to the research method and data analysis.

Availability of data and materials

The data obtained in this research are available.

Funding

The research did not receive funding.

References

Basic

FONAG (Fund for Water Protection) (2010). Organic fertilisers protect the soil and ensure healthy food. USAID, 518-A-00-07-00056-00.

Herrera, BM, Agüero, RD, Terry, AE. (2015). Production and use of organic fertilizer bocashi type. An alternative for crop nutrition and soil quality. Mayabeque, Cuba: INCA (National Institute of Agricultural Sciences). ISBN: 978-959-7023-78-4.

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Medina-Saavedra, Tarsicio, Mexicano-Santoyo Lilia, Arroyo-Figueroa Gabriela and Castro-Jácome, Tania Patricia. [2024]. Production parameters in radishes (Raphanus sativus L.) using organic inputs. Journal of Technological Engineering. 8[21]1-9: e2821109.
https://doi.org/10.35429/JTEN.2024.8.21.1.9

INIA. 2008. Innovative techniques appropriate to in situ conservation of agrodiversity. Production and use of biol. Lima, Peru: Ministry of Agriculture. ISBN: 978-9972-44-020-5.

Pilar, R., Martínez, MM, Pantoja, A. (2013). Farmer's composting manual. Experiences in Latin America. Santiago de Chile: FAO. ISBN: 97-92-5-307844-8.

Ramírez, GS. (2012). Agricultural innovations for sustainable agricultural production in the Trifinio region, CATIE. ISBN: 978-9977-559-9.

Restrepo, RJ. (2007). El ABC de la agricultura orgánica y harina de rocas. Managua: Servicio de Información Mesoamericano sobre Agricultura Sostenible (SIMAS). ISBN:978-99924-55-27-2.

Rosales, GS, AM, Romero, MJ, Castillo, RM, Barragán, SR. (2013). Guide to good excreta practices: Use of earthworm humus leachates for green fodder production. Mexico: INIAP. ISBN: 978-607-37-0217-1

Ross, JJ, Neilli, O, Smith, J, Kerckhoffs, L, Eliott, R. (2000). Evidence that auxin promotes the gibberellin A1 biosynthesis in pea. Australia, Plant Journal 21: 547-552.

Suchini, RJ. (2012). Agroecological innovations for sustainable agricultural production in the Trifinio region. Costa Rica: CATIE. ISBN: 978-9977-57-559-9.

Yugsi, L. (2011). Elaboration and Use of Organic Fertilizers. Training of Trainers Module. Quito, Ecuador: INIAP.

Background

Boza, MS. (2011). Development challenges: agriculture as part of a rural poverty alleviation strategy in Mexico. Noesis: Journal of Social Sciences and Humanities, 95, vol. 19, no. 37. ISBN: 0188-9834.

Consuegra, PN (2004). Ecological pest management. Havana Cuba: Centro de Estudios de Desarrollo Agrario y Rural (CEDAR), Universidad Agraria de La Habana. ISBN: 959-246-083-3.

Giaconi, V., Escaff, M. (2004). Cultivo de hortalizas. Santiago de Chile: Universitaria.

Martínez, A., Lee, AR, Chaparro, D., Páramo, S. (2003). Potscosecha y mercado de hortalizas de clima frío bajo prácticas de producción sustentable. Colombia: PRONATTA. ISBN: 958-9029-58-2.

Ruíz, CJ, Medina, GG, González, AI, Byerly, MH, Martínez, PR. (2013). Agroecological crop requirements. Mexico: SAGARPA and INIAP. ISBN: 978-37-0188-4.

Support

Abou-El-Hassan, S., Desoky, A.H. (2013) Effect of Compost and Compost Tea on Organic Production of Head Lettuce. Journal of Applied Sciences Research, 9(11): p. 5650-5655.
Basics. Alvarez, F. (2010). Manual. Preparation and uses of biol. Lima, Peru: Fontagro, 2010-10444.

Cabrera GO, Franco, DA, Cabriales, PJ, Nuñez, VJ. (2012). Impact of biofertilizers in Agriculture. Journal of Agricultural Sciences, vol.3, No. 6., 1261-1274.

Gómez, ÁR, Lázaro, GJ, Najera, LJ. (2008). Production of beans (*Phaseolus vugaris L*) and radish (*Rabanus sativus L*) in biointensive gardens in the humid tropics of Tabasco. University and Science, Pp.11-20, vol. 21, no. 1.

Luna, MR, Reyes, PJ, Reyes, BM, López, BR, Murillo, CG, Samaniego, AC, Travéz, TR. (2015). Organic fertilizers and their effect on tomato (*Solanum lycopersicum L*.) crop growth and development. Centro Agrícola, 42(4): 67-74. ISBN on line: 2072-2001.

Romero, ME, Guerrero, LM, Guerrero, OE. (2012). Theoretical-practical manual. Biofertilizers and their use in agriculture. Mexico: SAGARPA-COFUPRO-UNAM.

Discussions

Barberi, P., Bernardi, A., Galli, E., Zanetti. G. (1988). Effects of Inoculation with Different Strains of *Azospirillum Brasilense* on Wheat Root Development. Berlin. ISBN: 978-3-642-73072-6.

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Medina-Saavedra, Tarsicio, Mexicano-Santoyo Lilia, Arroyo-Figueroa Gabriela and Castro-Jácome, Tania Patricia. [2024]. Production parameters in radishes (Raphanus sativus L.) using organic inputs. Journal of Technological Engineering. 8[21]1-9: e2821109.
https://doi.org/10.35429/JTEN.2024.8.21.1.9

Barberi, P., Zanellia, T., Galli, E., Zanettib, G. (1986). Wheat inoculation with Azospirillum brasilense Sp6 and some mutants altered in nitrogenfixation and indole-3-acetic acid production. vol. 36, FEMS Microbiol. Lett. 36: 87-90.

Bashan, YG, Honguin, G. (1998). A proposal for the division of 'plant growth-promoting rhizobacteria' into two classifications: biocontrol-plantgrowth-promoting bacteria and plant growth-promoting bacteria. Soil Biol. Biochem. 30: 1225-1228.

Camelo, RM, Bonilla, BR, Vera, MS (2011). Mechanisms of action of plant growth-promoting rhizobacteria. Corpoica. Ciencia y Tecnológia Agropecuaria, vol. 12, Pp. 159-166. ISBN: 0122-6706.

Cassán, F., Sgroy, V., Perring, D., Masciarelli, O., Luna, V. (2008). Phytohormone production by *Azospirillum* sp. Technological physiological aspects of plant growth promotion. Scielo Colombia, Pp. 61-86.

Goites, ED. (2008). Manual de cultivos para la huerta orgánica familiar. Buenos Aires: Instituto Nacional de Tecnología Agropecuaria (INTA). ISBN 978-987-521-324-1. ISBN:956-11-1513-1.

Gómez, TL, Cruz, GM. (2017). Organic agriculture: technical bases. Mexico: Centro de Investigaciones Interdisciplinarias para el Desarrollo Rural Integral (CIIDRI). ISBN:978-607-12-0450-9.

Kolb, W., Martin, P. (1985). Response of Plant Roots to Inoculation with Azospirillum Brasilense and to Application of Indole Acetic Acid. In: Klingmüller W. (eds) Azospirillum III. Springer. Berlin: 978-3-642-70791-9, Pp.215-221.

López, R., Contreras, F. (2007). Agricultural production systems in the Venezuelan Andes: Organic Agriculture. Avances en Química, vol. 2, no. 3. Pp. 23-33.

MAGAP (Ministry of Agriculture, Livestock, Aquaculture and Fisheries) (2014). Elaboration, use and management of organic fertilisers. Quito Ecuador.

Méndez, RC, Almaguer, CM, Caballero, DM (2013). Organic fertilizers: An alternative to increase maize yields. Tamaulipas: INIFAP. ISBN: 978-607-37-0058-0.

Morales, MR. (2011). Workshop on vermicomposting: because having worms benefits us all. Mexico: Universidad Iberoamericana. ISBN: 978-607-417-141-9.

WHO (World Health Organization). 2007. Codex Alimentarius. Organically Produced Foods. Rome, Italy. ISBN: 978-92-5-305835-9.

Ospina, SD, Benavides, BJ, Zúñiga, EO, Muñoz. PC. (2018). Photosynthesis and biomass yield in chilli pepper, radish and maize subjected to magnetically treated water. Corpoica Ciencia y Tecnología Agropecuaria, 19(2), 291-305. ISBN 0122-8906.

Tenecio, CR. (2015). Reproduction and application of microorganisms (MM) in agricultural and livestock activities. Costa Rica: Ministerio de Agricultura y Ganadería Región Central Oriental.

Tien, TM, Gaskis, MH, Hubbeli, DH. (1979). Plant Growth Substances Produced by *Azospirillum brasilense* and Their Effect on the Growth of Pearl Millet (*Pennisetum americanum L.*). Environ. Microbiol. 37: 1016-1024.

Velasco, J, Aguirre, G, Ortuno, N. (2016). Liquid humus and microorganisms to promote lettuce (*Lactuca sativa var. Crespa*) production in hydroponic cultivation. Journal of the Selva Andina Biosphere, Pp.71-83. ISBN: 2308-3859.

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Medina-Saavedra, Tarsicio, Mexicano-Santoyo Lilia, Arroyo-Figueroa Gabriela and Castro-Jácome, Tania Patricia. [2024]. Production parameters in radishes (Raphanus sativus L.) using organic inputs. Journal of Technological Engineering. 8[21]1-9: e2821109.
https://doi.org/10.35429/JTEN.2024.8.21.1.9

Journal of Technological Engineering 8[21]1-9: e3821109
Article

Numerical modelling of hydrodynamic thrust in patients using the HidroWalk for gait rehabilitation

Modelación numérica del empuje hidrodinámico en pacientes que emplean el HidroWalk para rehabilitación de la marcha

Gamiño-Ramírez, Edith Alejandra*[a], Herrera-Díaz, Israel Enrique[b], Ugalde-Zanella, Valeria[c] and Torres-Bejarano, Franklin Manuel[d]

[a] Universidad de Guanajuato • KWU-1191-2024 • 0009-0003-6669-7277 • 825936
[b] Universidad de Guanajuato • KHC-5238-2024 • 0000-0002-2117-7548 • 207880
[c] Universidad de Guanajuato • KXQ-9802-2024 • 0009-0004-1714-7022 • 1041479
[d] Universidad de Córdoba • HFZ-8986-2022 • 0000-0003-3144-7289

CONAHCYT classification:

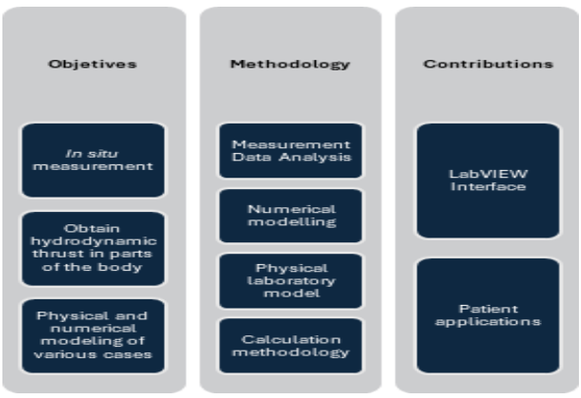
Area: Medicine and Health Sciences
Field: Medical Sciences
Discipline: Work Medicine
Subdiscipline: Rehabilitation (medical)

https://doi.org/10.35429/JTEN.2024.8.21.3.9
History of the article:
Received: February 16, 2024
Accepted: December 30, 2024

* ✉ [eherrera@ugto.mx]

Abstract

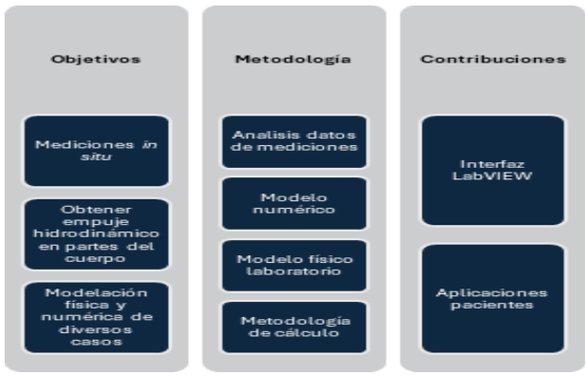
This study employs a quantitative experimental methodology to investigate the relationship between flow rate, velocity, and depth with the hydrodynamic thrust exerted on a person using the HidroWalk for physical rehabilitation at CLUSI, Celaya-Salvatierra Campus. Hydrodynamic variables such as flow rate, velocity, depth, temperature, slope, and geometry are manipulated in a scaled variable-slope channel prototype located at the Applied Mechanics Laboratory in DICIVA, Irapuato-Salamanca Campus, which simulates the conditions of the HidroWalk. Computational tools and sensors were used for real-time measurements in both the HidroWalk and the prototype. Additionally, the FLOW3D software was used for the numerical analysis of the velocity and pressure fields generated in a person using the HidroWalk, and software such as ARDUINO and LabVIEW was utilized for developing the user interface installed in the HidroWalk. The study population includes gait alteration patterns simulated with two mannequins of 11 and 30 cm, providing a deep understanding of the relationship between hydrodynamic thrust and the force a user needs to exert for gait rehabilitation.



Hydrowalk, hydrodynamic-thrust, walk-rehabilitation

Resumen

El presente estudio emplea una metodología experimental cuantitativa para investigar la relación entre el caudal, la velocidad y la profundidad con el empuje hidrodinámico ejercido sobre una persona que utiliza el HidroWalk para rehabilitación física en la CLUSI del Campus Celaya-Salvatierra. Se manipulan variables hidrodinámicas como caudal, velocidad, profundidad, temperatura, pendiente y geometría en un prototipo de canal de pendiente variable a escala, ubicado en el Laboratorio de Mecánica Aplicada en la DICIVA Campus Irapuato-Salamanca, que simula las condiciones del HidroWalk. Se utilizaron herramientas computacionales y sensores para mediciones en tiempo real tanto en el HidroWalk como en el prototipo. Además, se empleó el software FLOW3D para el análisis numérico del campo de velocidades y presiones generadas en una persona que usa el HidroWalk, y software como ARDUINO y LabVIEW para el desarrollo de la interfaz de usuario instalada en el HidroWalk. La población de estudio incluye patrones de alteraciones de la marcha, simulados con dos maniquíes de 11 y 30 cm, lo que permitió una comprensión profunda de la relación entre el empuje hidrodinámico y la fuerza que necesita ejercer un usuario en la rehabilitación de la marcha.



Hidrowalk, empuje-hidrodinámico, rehabilitación-marcha

Citation: Gamiño-Ramírez, Edith Alejandra, Herrera-Díaz, Israel Enrique, Ugalde-Zanella, Valeria and Torres-Bejarano, Franklin Manuel. [2024]. Numerical modelling of hydrodynamic thrust in patients using the HidroWalk for gait rehabilitation. Journal of Technological Engineering. 8[21]1-9: e3821109.

Introduction

Currently, there are several types of neuromusculoskeletal injuries that affect gait in patients of all ages (Chan et al., 2012). These injuries require a physical rehabilitation process to re-educate gait and avoid permanent sequelae (Baskwill, 2007). Hydrotherapy is a prominent option due to the unique properties of water (Bartels et al., 2007; Bartels et al., 2016).

The use of a hydraulic channel such as the HydroWalk (see Fig. 1) provides a variable thrust according to the depth and speed of the water, which allows for gradual graduation and increase of resistance for patient rehabilitation.

Box 1

Figure 1
HidroWalk Channel (data sheet)

Hydrotherapy, or aquatic therapy, has been used throughout history for therapeutic and rehabilitative purposes. Hydrotherapy equipment such as tanks or pools are specially designed to carry out therapeutic activities in a controlled aquatic environment (Baskwill, 2007). Here is some general background to the use of hydrotherapy equipment:

Ancient History: Ancient cultures, such as the Romans and Greeks, used thermal baths and pools to promote health and well-being. Thermal baths were considered a common practice for the treatment and prevention of disease.

19th century: In the late 19th century, Austrian physician Sebastian Kneipp popularised hydrotherapy as part of his holistic approach to treatment, using hot and cold water baths as an integral part of his healing method (Bartels et al., 2007).

First Half of the 20th Century: During the First World War, hydrotherapy was used to rehabilitate wounded soldiers.

Immersion baths and other aquatic therapeutic methods were applied to improve mobility and reduce pain.

Development of Modern Hydrotherapy:

Throughout the 20th century, hydrotherapy evolved with the introduction of more advanced technologies and an understanding of the physiological benefits of water in the treatment of various conditions (Bartels et al., 2016; Silva et al., 2008).

Recent Decades: In recent decades, modern hydrotherapy equipment, equipped with jets, temperature control systems and specific accessories, have become common in physical rehabilitation settings, physiotherapy clinics and wellness centres.

Therapeutic applications: Hydrotherapy is used to treat a variety of conditions, such as muscle injuries, post-operative rehabilitation, arthritis and neuromuscular disorders.

Hydrotherapy in Sport: Athletes also turn to hydrotherapy for muscle recovery, reduction of inflammation and relief of joint stress (Bidonde et al., 2014; Häkkinen et al., 2008; Walter et al., 2014).

Hydrotherapy tanks are common in professional sports settings.

Scientific research: Interest in scientific research on hydrotherapy has grown, seeking to better understand the specific benefits and mechanisms behind aquatic therapy.

Hydrotherapy remains an evolving field, and hydrotherapy equipment continues to be a valuable tool in medical care and rehabilitation. Specific equipment such as the HydroWalk has features designed for specific purposes that require more detailed and up-to-date research.

Hydrotherapy remains an evolving field, and hydrotherapy equipment continues to be a valuable tool in medical care and rehabilitation. The specific application of equipment such as the Hydrowalk has particular features designed for specific purposes that require more detailed and up-to-date research.

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Gamiño-Ramírez, Edith Alejandra, Herrera-Díaz, Israel Enrique, Ugalde-Zanella, Valeria and Torres-Bejarano, Franklin Manuel. [2024]. Numerical modelling of hydrodynamic thrust in patients using the HidroWalk for gait rehabilitation. Journal of Technological Engineering. 8[21]1-9: e3821109.
https://doi.org/10.35429/JTEN.2024.8.21.3.9

Currently, there are several types of neuromusculoskeletal injuries that result in gait impairment in patients of all ages (Chan et al., 2012).

These injuries require a physical rehabilitation process to re-educate gait and avoid permanent sequelae in individuals. Hydrotherapy is considered an excellent option due to the unique properties of water.

The use of a hydraulic channel such as the HidroWalk exerts a variable thrust according to the depth and speed of the water to which the patient is subjected, allowing the resistance to be graduated and increased gradually for rehabilitation.

It is essential to previously model the hydrodynamic behaviour in order to establish the depth and speed of the most suitable channel for each patient, according to their pathology and rehabilitation programme, seeking an optimal result that reduces discomfort during the process.

Materials and Methods

Hydrodynamic numerical model

Flow-3D is a computational fluid dynamics (CFD) software, which uses numerical techniques to solve the equations of motion of fluids, aiming to obtain three-dimensional transient solutions for 3 ultiphysics and multiscale flow problems. The equations in Flow-3D are formulated with area and volume functions.

These functions allow the representation of fractional volume/area obstacles called $FAVOR\ TM$ and are used to model complex geometric surfaces.

The general equation of mass continuity is:

$$V_F\frac{\partial \rho}{\partial t}+\frac{\partial}{\partial x}(\rho u A_x)+R\frac{\partial}{\partial y}(\rho v A_y)+\frac{\partial}{\partial z}(\rho w A_z)=R_{DIF}+R_{SOR} \quad [1]$$

The fluid velocity components at the three coordinates (u, v, w) are calculated from the equations of motion:

$$\frac{\partial u}{\partial t}+\frac{1}{V_F}\left\{uA_x\frac{\partial u}{\partial x}+vA_yR\frac{\partial u}{\partial y}+wA_z\frac{\partial u}{\partial z}\right\}=-\frac{1}{\rho}\frac{\partial p}{\partial x}+G_x+f_x-b_x-\frac{R_{SOR}}{\rho V_F}(u-u_w-\delta u_s) \quad [2]$$

$$\frac{\partial v}{\partial t}+\frac{1}{V_F}\left\{uA_x\frac{\partial v}{\partial x}+vA_yR\frac{\partial v}{\partial y}+wA_z\frac{\partial v}{\partial z}\right\}=-\frac{1}{\rho}\left(R\frac{\partial p}{\partial y}\right)+G_y+f_y-b_y-\frac{R_{SOR}}{\rho V_F}(v-v_w-\delta v_s) \quad [3]$$

$$\frac{\partial w}{\partial t}+\frac{1}{V_F}\left\{uA_x\frac{\partial w}{\partial x}+vA_yR\frac{\partial w}{\partial y}+wA_z\frac{\partial w}{\partial z}\right\}=-\frac{1}{\rho}\frac{\partial p}{\partial z}+G_z+f_z-b_z-\frac{R_{SOR}}{\rho V_F}(w-w_w-\delta w_s) \quad [4]$$

The fluid-object interface, defined by the fluid volume method ($VOOF$), consists of three main components: the definition of the fluid function volume (Science, 2018) is set by:

$$\frac{\partial F}{\partial t}+\frac{1}{V_F}\left[\frac{\partial}{\partial x}(FA_xu)+R\frac{\partial}{\partial y}(FA_yv)+\frac{\partial}{\partial z}(FA_zw)\right]=F_{DIF}+F_{SOR} \quad [5]$$

Laboratory model

The laboratory flume used (fig. 2) has a variable slope and a constant rectangular section with a length of 2.32 m by 0.25 m wide and 0.18 m high. It has a 22-litre feed tank, a 2 hp pump and a 90-litre storage tank.

The walls of the channel are made of 0.012 m thick acrylic sheet, and the gate is made of the same material with a thickness of 0.006 m, 0.24 m wide and 0.15 m high, which was located in the middle of the length of the channel in order to avoid oscillations caused by the inlet and outlet spillways.

Box 2

Figure 2
Variable slope laboratory flume with acrylic electro-gate, DICIVA-UG

The Hidrowalk channel used (fig. 3) is made with a stainless steel structure, side panels and door with 10 mm tempered glass, temperature adjustable up to 35°C and dimensions 1.70 x 1.65 x 0.84 mts.

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Gamiño-Ramírez, Edith Alejandra, Herrera-Díaz, Israel Enrique, Ugalde-Zanella, Valeria and Torres-Bejarano, Franklin Manuel. [2024]. Numerical modelling of hydrodynamic thrust in patients using the HidroWalk for gait rehabilitation. Journal of Technological Engineering. 8[21]1-9: e3821109.
https://doi.org/10.35429/JTEN.2024.8.21.3.9

Box 3

Figure 3

Hydrotherapy equipment HidroWalk, DCSI-UG

Methodology to be developed

1. Purpose: A quantitative methodology with controlled experiments is proposed that allows the manipulation of certain hydrodynamic variables to obtain causal relationships such as hydrodynamic flow-thrust.

2. Research Design: Type of Study: Experimental with manipulation of independent variables.

Population and Sample: At least three cases of gait disturbance in need of rehabilitation using the Hidrowalk, with different anthropometric measurements (different sizes or ages).

3. Study Variables: Independent Variables: Flow or Flow Rate; average velocity; Depth or draft; water temperature; Slope of the channel and Hidrowalk, geometry and scale of the prototype.

Dependent Variables: The hydrodynamic force (thrust) provided by the fluid on an object.

4. Instruments and Materials: A FLOW3D numerical model is used to analyse the hydrodynamics of the model and the prototype, as well as LabVIEW software, ARDUINO and Mega 2560 boards, temperature sensors and digital velocity measurement equipment.

5. Procedures: Control Groups: A scenario without a patient is available for the purpose of measuring and obtaining hydrodynamic fields. A scenario with a non-running volunteer is available for measurement of hydrodynamic fields with an object.

6. Data analysis and processing: FLOW3D software will be used for visualisation and calculation only, and LabVIEW software will be used for measurement, instrumentation and operation of the Hidrowalk, providing the Flow-Thrust relationship for each patient.

Results

For the results section, as a first step, the results of the in situ measurement of the velocity components, depth before the fluid interacts with the patient and after it as shown in figure (4) are shown).

Box 4

Figure 4

In-situ velocity measurements at different depths

With the magnitudes of the velocities for different depths, the hydrodynamic forces or thrust generated in the patients were determined (table 1).).

Box 5

Table 1

Measurement results taken at the Hidrowalk

Speed	Prof A Top	Prof A Below	Download Esp.	Force	
(m/s)	(m)	(m)	(m^2/s)	(N)	(kgf)
1.31	1.05	0.91	1.59	86.702	8.843
1.29	0.91	0.83	1.27	45.532	4.644
1.18	0.78	0.72	0.92	31.234	3.185
1.07	0.55	0.51	0.59	14.072	1.435
0.83	0.37	0.32	0.31	11.438	1.166
0.79	0.20	0.16	0.15	3.494	0.356

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Gamiño-Ramírez, Edith Alejandra, Herrera-Díaz, Israel Enrique, Ugalde-Zanella, Valeria and Torres-Bejarano, Franklin Manuel. [2024]. Numerical modelling of hydrodynamic thrust in patients using the HidroWalk for gait rehabilitation. Journal of Technological Engineering. 8[21]1-9: e3821109.
https://doi.org/10.35429/JTEN.2024.8.21.3.9

Once the values of the in situ measurement were obtained, the numerical simulation was carried out with the FLOW-3D software; the simulation conditions are 120 seconds and depth equals 1.60 m, the results of the variables of the pressure field (figure 5) and velocities generated by the circulation in the Hidrowalk are shown in figure (6).

Box 6

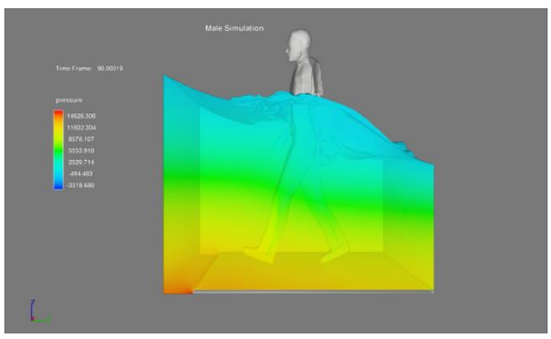


Figure 5

Numerical simulation of the pressure exerted by the flow over the patient using Hidrowalk

Box 7

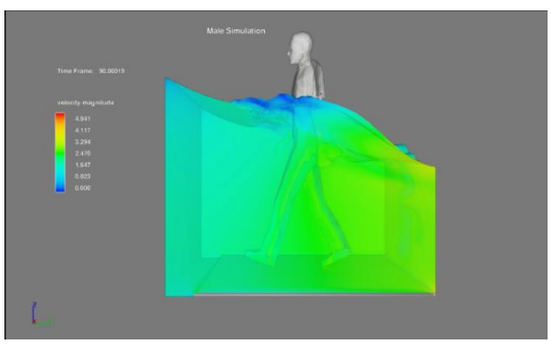


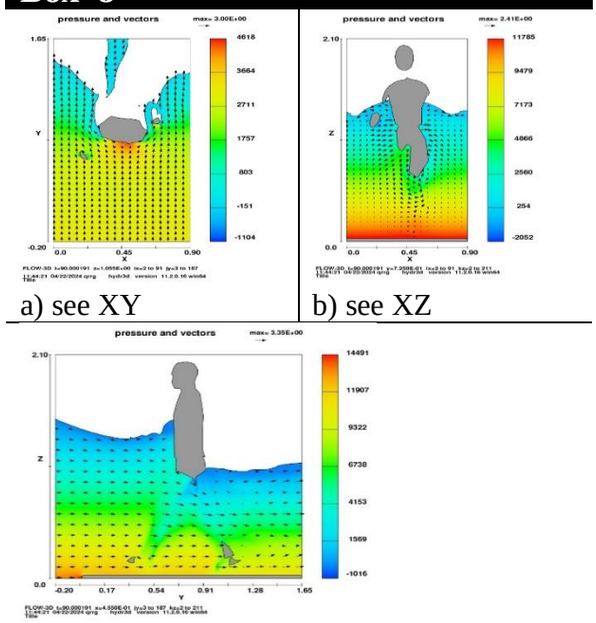
Figure 6

Numerical simulation of flow velocity over the patient using Hidrowalk

The simulations provide information on the thrust generated in the calves, thighs, abdomen and forearms under different hydrodynamic conditions and monitor the velocities and depths in the Hidrowalk with the sensors in real time.

Figures (7a, 7b and 7c) show the pressure exerted by the fluid on the patient in more detail, where it should be noted that the areas with greater thrust are the thighs because they have a larger contact area, likewise, the abdomen region shows the interaction of water with air (free surface) and therefore lower pressure and velocity.

Box 8



a) see XY b) see XZ

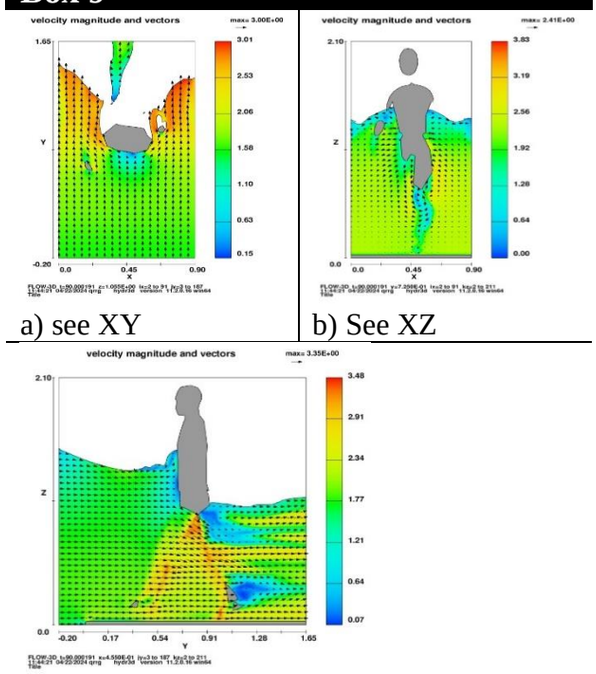
c) see YZ

Figure 7

Pressure field results: a) top view XY; b) front view XZ and c) side view YZ

Similarly, figure (8) shows the results of the velocity field for the different views, likewise, it can be observed that the velocities with the greatest magnitude are in the thighs and which present a greater work in rehabilitation.

Box 9



a) see XY b) See XZ

c) See YZ

Figure 8

Velocity field results: a) top view XY; b) front view XZ and c) side view YZ

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Gamiño-Ramírez, Edith Alejandra, Herrera-Díaz, Israel Enrique, Ugalde-Zanella, Valeria and Torres-Bejarano, Franklin Manuel. [2024]. Numerical modelling of hydrodynamic thrust in patients using the HidroWalk for gait rehabilitation. Journal of Technological Engineering. 8[21]1-9: e3821109.
https://doi.org/10.35429/JTEN.2024.8.21.3.9

Once the simulation was completed, the scaled simulation was carried out in the variable slope channel for two cases, the first with an 11 cm dummy (figure 9a) and the second with a 30 cm dummy (figure 9b). The use of two dummies for the experimental simulation was due to having two patients with different heights (child and adult), where they are subjected to the same flow rate provided by the modified Hidrowalk at a scale of 1:11 respecting the hydraulic similarity conditions.

Box 10

a) 11 cm mannequin b) 30 cm mannequin

Figure 9

Manikin for laboratory channel simulation:a) de 11 cm y b) de 30 cm

Figure (10a) shows the scale model for the 11 cm dummy, which was placed in the variable slope channel (figure 10b).

Box 11

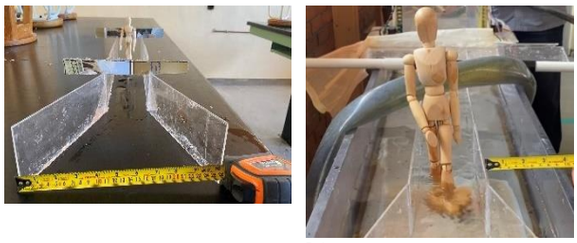
a) variable slope channel model b) 11cm mannequin

Figure 10

Operation of the variable slope channel for the 11 cm manikin

Similarly, figure (11) shows the operation of the channel for the 30 cm dummy.

Box 12



a) variable slope channel model b) 11cm mannequin

Figure 11

Operation of the variable slope chute for the 30 cm dummy

The speed was measured with a Vernier current meter (figure 12) for each dummy, where the records obtained are shown in figure (13) for the 11 cm dummy and in figure (14) for the 30 cm dummy.

Box 13

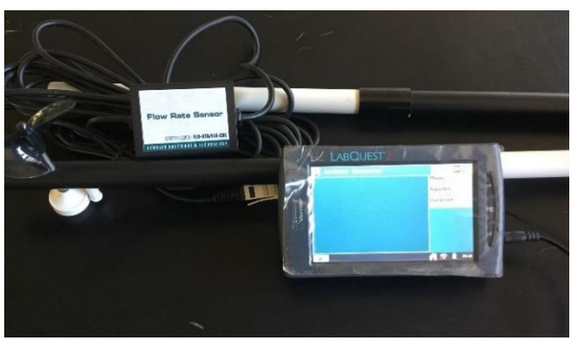


Figure 12

Vernier flow meter (Flow-meter)

Box 14

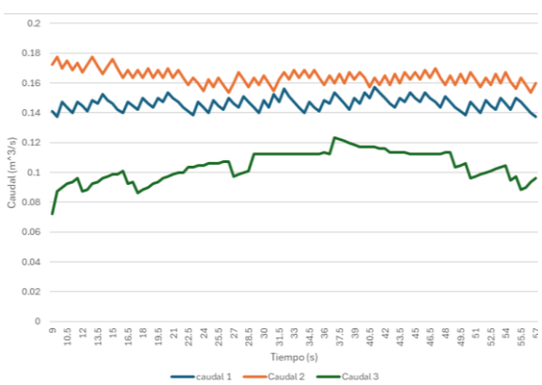


Figure 13

Measurement of the average flow rate for the 11 cm dummy

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Gamiño-Ramírez, Edith Alejandra, Herrera-Díaz, Israel Enrique, Ugalde-Zanella, Valeria and Torres-Bejarano, Franklin Manuel. [2024]. Numerical modelling of hydrodynamic thrust in patients using the HidroWalk for gait rehabilitation. Journal of Technological Engineering. 8[21]1-9: e3821109.
https://doi.org/10.35429/JTEN.2024.8.21.3.9

Box 15

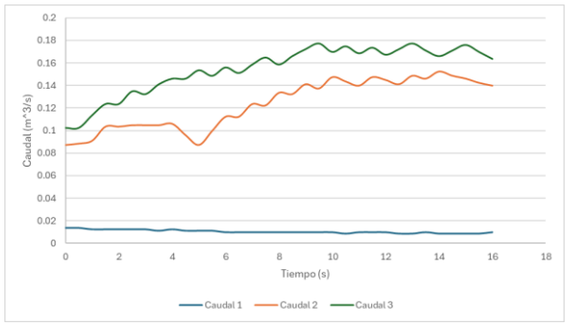


Figure 14

Measurement of the average flow rate for the 30 cm dummy

The measurement results are shown in table (2) for the different dummy sizes.

Box 16

Table 2

Measurement results taken in the variable slope channel for the 11 cm and 30 cm dummies.

Maniquí	Caudal (m^3/s)	Force (kgf)
11 cm	0.155	3.867
30 cm	0.168	4.025

Subsequently, the programme was developed in Arduino (figure 15) and the user interface in LabVIEW (figure 16), which will allow adjustments to be made both in flow velocity and depth measurement to calculate the hydrodynamic thrust generated in patients with the calibration of the hydrodynamic variables and the velocity field obtained from the FLOW3D for different cases.

Box 17

```
void setup() {
  // put your setup code here, to run once:
Serial.begin(9600);


//FIN VOID SETUP
}

void loop() {
  // put your main code here, to run repeatedly:
//PRIMER SENSOR

//INSTRUCCIONES SENSOR 1
pinMode(trigs1,OUTPUT);
pinMode(echos1,INPUT);
digitalWrite(trigs1,LOW);
digitalWrite(trigs1,HIGH);
delayMicroseconds(10);
digitalWrite(trigs1,LOW);

t=pulseIn(echos1,HIGH);
ds1=long(0.01715*t);
```

Figure 15

Arduino code section for depth sensor control and value calculation

The purpose of this code is to calculate the flow rate, interpolated velocities, drag coefficients, and hydrodynamic force or thrust at different depths where the required body parts are located.

This code was incorporated into a user interface executable in LabVIEW (figure 16), where it was installed on a computer connected to the Hidrowalk and which allows the Hidrowalk to be operated and its sensors to monitor its operation.

Box 18

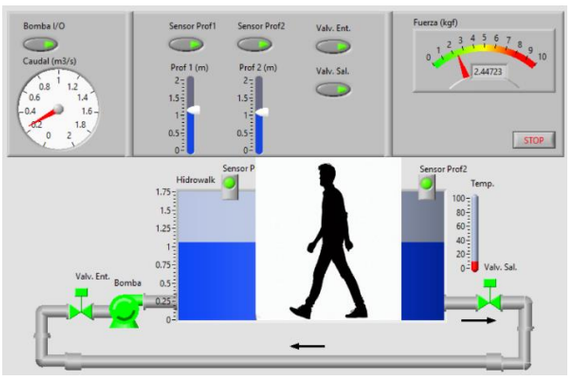


Figure 16

Hidrowalk Control Interface in LabVIEW

This interface allows to calculate the speed through the opening of valves either manually or motorised, with it the necessary hydrodynamic thrust is obtained for each patient according to their condition and to help them in their gait rehabilitation process before the subject enters the Hidrowalk.

Conclusions

In this study, a comprehensive investigation combining in situ measurements, numerical simulations and scale experiments was conducted to evaluate the hydrodynamic thrust generated in patients during rehabilitation in an aquatic environment. The results obtained revealed important findings:

1. The in situ measurements provided accurate data on flow velocities and depths before and after the interaction with the patient, as well as the determination of hydrodynamic forces on different parts of the body.

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Gamiño-Ramírez, Edith Alejandra, Herrera-Díaz, Israel Enrique, Ugalde-Zanella, Valeria and Torres-Bejarano, Franklin Manuel. [2024]. Numerical modelling of hydrodynamic thrust in patients using the HidroWalk for gait rehabilitation. Journal of Technological Engineering. 8[21]1-9: e3821109.
https://doi.org/10.35429/JTEN.2024.8.21.3.9

2. Numerical simulations with FLOW-3D software allowed visualisation and quantification of the pressure field and velocities generated by the circulation in the aquatic environment, providing valuable information on the thrust distribution in specific areas such as calves, thighs, abdomen and forearms.

3. Scaled experiments in a variable slope channel with dummies of different sizes provided comparative data on flow velocity and hydrodynamic buoyancy under conditions similar to those of the Hidrowalk, validating the results obtained in the simulations.

4. The development of an Arduino program and user interface in LabVIEW enabled the calibration and control of the Hidrowalk, facilitating the adaptation of flow velocity and depth measurement to calculate the hydrodynamic thrust required for each patient's rehabilitation.

Taken together, these findings highlight the importance of understanding and quantifying hydrodynamic buoyancy in aquatic environments to improve rehabilitation processes and design of devices such as the Hidrowalk, thus contributing to the advancement of quality of life and well-being of rehabilitation patients.

Conflict of interest

The authors declare that they have no conflicts of interest. They have no known competing financial interests or personal relationships that might have appeared to influence the article reported in this paper.

Authors' contribution

Gamiño-Ramírez, Edith Alejandra: Contributed to the project with the idea, or need, and the Hidrowalk team.

Herrera-Díaz, Israel Enrique: Contributed with the in situ measurement, programming in Arduino and the development of the interface and calculation memory in LabVIEW.

Ugalde-Zanella, Valeria: Contributed with the methodology of using the results with the subjects and interpretation of results.

Torres-Bejarano, Franklin Manuel: Contributed with the numerical modelling in Flow3D for the comparison of results and validation of the calculation memory.

Availability of data and materials

Data obtained in this research are available upon request from the authors.

Funding

Financial support for this project is gratefully acknowledged to the Convocatoria Institucional de Investigación Científica (CIIC) 2024 of the University of Guanajuato Mexico.

Acknowledgement

The UG Campus Celaya-Salvatierra is thanked for the facilities for the measurements at the CLUSI facilities and for the use of the Hidrowalk.

Abbreviations

Ax: Is the fractional area open to flow in the x direction
(Ay, Az): Are similar area fractions for the flow in the y- and z-directions, respectively
(bx, by, bz): Are flow losses in porous media or through porous baffle plates
cF: Is the constant whose reciprocal is sometimes referred to as the turbulent Schmidt number
(fx, fy, fz): Are viscous accelerations
(Gx,Gy,Gz): Are bodily accelerations
Rdif: Is the turbulent diffusion term
Rsor: Is the mass source term
VF: Is the fractional volume open to flow
(u, v, w): Are the velocity components are in the co-ordinate directions of (x, y, z) o (r, θ, z).
ρ: Is the density of the fluid
υF: Is the diffusion coefficient

References

Backgroud

Reid M. (1997). Hydrotherapy: Principles and Practice. Editorial Butterworth-Heinemann; 1er edición. ISBN-13: 978-0750622615.

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Gamiño-Ramírez, Edith Alejandra, Herrera-Díaz, Israel Enrique, Ugalde-Zanella, Valeria and Torres-Bejarano, Franklin Manuel. [2024]. Numerical modelling of hydrodynamic thrust in patients using the HidroWalk for gait rehabilitation. Journal of Technological Engineering. 8[21]1-9: e3821109.
https://doi.org/10.35429/JTEN.2024.8.21.3.9

Hall, J. (1997). Hydrotherapy: Principles and practice. Physiotherapy, Volume 83, Issue 11, 1997, Page 601. ISSN 0031-9406.

Bartels, E. M., Lund, H., Hagen, K. B., Dagfinrud, H., Christensen, R., & Danneskiold-Samsøe, B. (2016). Aquatic exercise for the treatment of knee and hip osteoarthritis. Cochrane Database of Systematic Reviews, (4).

Bartels, E. M., Juhl, C. B., Christensen, R., Hagen, K. B., Danneskiold-Samsøe, B., & Dagfinrud, H. (2016). Aquatic exercise for the treatment of knee and hip osteoarthritis.

Bidonde, J., Busch, A. J., Schachter, C. L., Overend, T. J., Kim, S. Y., & Goes, S. M. (2014). Aquatic exercise training for fibromyalgia. Cochrane Database of Systematic Reviews, (10).

Di Stasi SL, Snyder-Mackler L. (2012). The effects of neuromuscular training on the gait patterns of ACL-deficient men and women. Clin Biomech (Bristol). 2012 May;27(4):360-5. doi: 10.1016/j.clinbiomech.2011.10.008. Epub 2011 Nov 5. PMID: 22061048; PMCID: PMC3288430.

Castro AM, Matarán GA, Lara I., Saavedra M., Arroyo M., Moreno C. (2011) Hydrotherapy for the treatment of pain in people with multiple sclerosis: a randomized controlled trial, Journal of Neurology.

Medrado LN, Mendonça MLM, Budib MB, Oliveira-Junior SA, Martinez PF. (2022). Effectiveness of aquatic exercise in the treatment of inflammatory arthritis: systematic review. Rheumatol Int. 2022 Oct;42(10):1681-1691.

Silva KM, Tucano SJ, Kümpel C, Castro AA, Porto EF. (2012) Effect of hydrotherapy on quality of life, functional capacity and sleep quality in patients with fibromyalgia, PubMed.

Stanciu LE, Iliescu MG, Vlădăreanu L, Ciota AE, Ionescu EV, Mihailov CI. (2023) Evidence of Improvement of Lower Limb Functioning Using Hydrotherapy on Spinal Cord Injury Patients Biomedicines. 2023 Jan 21;11(2):302. doi: 10.3390/biomedicines11020302. PMID: 36830837; PMCID: PMC9953065.

Mooventhan A, Nivethitha L. (2014) Scientific Evidence-Based Effects of Hydrotherapy on Various Systems of the Body Med Sci. 2014 May;6(5):199-209.

Support

Science, F. (2018). FLOW-3D® Version 12.0 User's Manual (2018). FLOW-3D [Computer software]. Santa Fe, NM: Flow Science, Inc.

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Gamiño-Ramírez, Edith Alejandra, Herrera-Díaz, Israel Enrique, Ugalde-Zanella, Valeria and Torres-Bejarano, Franklin Manuel. [2024]. Numerical modelling of hydrodynamic thrust in patients using the HidroWalk for gait rehabilitation. Journal of Technological Engineering. 8[21]1-9: e3821109.
https://doi.org/10.35429/JTEN.2024.8.21.3.9

Journal of Technological Engineering 8[21]1-7: e4821107
Article

Design of digital ignition control of compact vehicle engine using fingerprint

Diseño de control digital de encendido de motor de vehículo compacto mediante huella digital

Guzmán-Cortés, Agustín *[a], Barbosa-Santillán, Luis Francisco [b], González-Contreras, Brian Manuel [c] and Álvarez-González, Ricardo [d]

Universidad Tecnológica de Puebla • Y-2752-2018 • 0000-0003-4571-224X • 222213
[b] Universidad Tecnológica de Puebla • LUY-7348-2024 • 0000-0001-6550-0901 • 49306
[c] Universidad Autónoma de Tlaxcala • AGE-7390-2022 • 0000-0003-1556-8435 • 99192
[d] Benemérita Universidad Autónoma de Puebla • LUY-7560-2024 • 0000-0002-4597-0727 • 87036

CONAHCYT Classification:

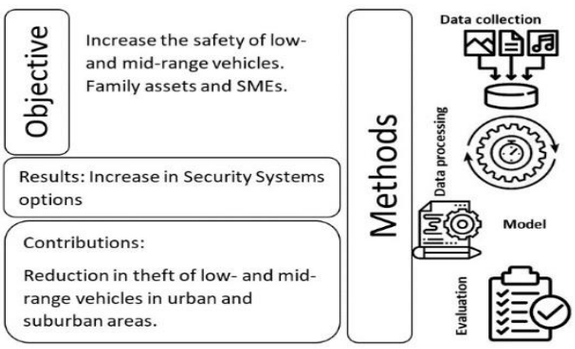
Area: Engineering
Field: Engineering
Discipline: Systems engineer
Subdiscipline: Automation

https://doi.org/10.35429/JTEN.2024.8.21.1.7
History of the article:
Received: January 27, 2024
Accepted: December 30, 2024

* ✉ [agustin.guzman@utpuebla.edu.mx]

Abstract

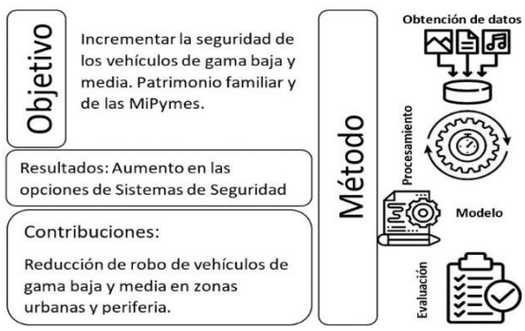
Over the past decade, vehicle thefts in México have increased, mainly due to the lack of accessible and effective security systems. Most engine ignition control systems are available only in high-end cars, while more than 90% of the population uses mid-range or low-end compact vehicles that lack this technology. To address this need, the design of a security system that uses a fingerprint reader, together with a commercial control card and communication modules, to offer an intuitive method of engine ignition control in low-end vehicles is proposed. This approach seeks to improve automotive security at a reasonable cost.



System, Automotive Engine, Fingerprint

Resumen

En la última década, los robos de vehículos en México han aumentado, principalmente debido a la falta de sistemas de seguridad accesibles y efectivos. La mayoría de los sistemas de control de encendido del motor están disponibles solo en autos de gama alta, mientras que más del 90% de la población utiliza vehículos compactos de gama media o baja que carecen de esta tecnología. Para abordar esta necesidad, se propone el diseño de un sistema de seguridad que utilice un lector de huella digital, junto con una tarjeta de control comercial y módulos de comunicación, para ofrecer un método intuitivo de control de encendido del motor en vehículos de gama baja. Este enfoque busca mejorar la seguridad automotriz a un costo razonable.



Sistema, Motor Automotriz, Huella Digital

Citation: Guzmán-Cortés, Agustín, Barbosa-Santillán, Luis Francisco, González-Contreras, Brian Manuel and Álvarez-González, Ricardo. [2024]. Design of digital ignition control of compact vehicle engine using fingerprint. Journal of Technological Engineering. 8[21]1-7: e4821107.

Introduction

Today's cars are equipped with many computers, as mentioned by (Mohammad, et. al. 2023), which allow the development and execution of various systems, such as the autonomous system, to assist the driver and improve the driving experience, said system is identified by its acronym in English DAS (Driving Assistance System), Engine ignition by means of fingerprint identification, previously registered in a system, Autonomous Driving, among other systems. Something in common with these systems is that they all incorporate different technologies for their development, but most conventional cars are not equipped with these systems, and the option to be able to equip them is very expensive.

The ECU (Electronic Control Unit) is responsible for controlling all the electronic systems on board a car. The market regularly identifies these cars as being at least ten years old, as explained by (Autopresta, 2024) due to the issue of depreciation to the current date (2023).

They are not exactly considered obsolete, but rather, non-current cars, that is, they do not have recent digital technology. The general classification of vehicles is known as low-end (compact size between 3 and 3.7 meters, cost between $170,000 and $280,000, type A, four cylinders, 1,000 to 1,400 cm3, with or without electrical functions such as raising and lowering windows), medium and high, in the USA (United States of America) the classification is done by size, specifically in Mexico the AMIA (Mexican Association of the Automotive Industry) classifies them in: Subcompact, Compact, Luxury Cars and Sports, in the same way there are various electronic devices such as development cards of the Arduino platform, including the following modules, as mentioned (Zein, et. al., 2018) GPS modules, LCD (Liquid Crystal Display), including audible and visual alarms, as well as specific communication modules such as Bluetooth or others for specific purposes such as Driving Motor, Steering Motor and LM239 H-Bridge.

In the development of vehicle anti-theft and access control systems (R. Thanuj, et. al. 2023), programming languages such as C language, present in the Arduino integrated development environment (IDE), are used or involved.

The code to enable the enable/disable functionalities of ports / sensors / actuators or other system operations, which involves the application and execution of instructions within a microcontroller, for projects that require a friendly and versatile development environment in their programming, allowing developers to write, compile and upload code easily.

In addition, Arduino offers a wide range of libraries and resources that facilitate the programming of electronic devices and the integration of different components into a complete system.

Specifically for the topic of biometric authentication (Bharania, P. J. et al 2023), it mentions that it is an excellent system, combined with the use of ZigBee communication technology, which is a wireless communication standard designed for low-power and short-range applications.

It is based on the IEEE 802.15.4 standard and is mainly used in sensor networks and devices that require efficient and reliable communication. In its system it describes the improvement in the access and operation of trains, which prevents unauthorized persons from turning them on.

An anti-theft security system for vehicles that uses biometric technology (Brijet, Z et al 2017), specifically a fingerprint sensor, in combination with an Arduino UNO board to control the ignition of the engine. This system is designed to ensure that only authorized persons can start the vehicle, which significantly improves security and reduces the risk of theft, the operation of the system is based on a R305 fingerprint module that is connected to an Arduino UNO board. When a user tries to start the vehicle, he or she must scan his or her fingerprint.

The fingerprint sensor verifies the user's identity by comparing the scanned fingerprint with the fingerprints previously stored in the system.

If the fingerprint matches the preloaded data, the system activates a relay that supplies voltage to the ignition system, allowing the engine to start. In case the fingerprint does not match, the relay is not activated and the engine is started.

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Guzmán-Cortés, Agustín, Barbosa-Santillán, Luis Francisco, González-Contreras, Brian Manuel and Álvarez-González, Ricardo. [2024]. Design of digital ignition control of compact vehicle engine using fingerprint. Journal of Technological Engineering. 8[21]1-7: e4821107.
https://doi.org/10.35429/JTEN.2024.8.21.1.7

Remains off, preventing unauthorized access. Advantages of the System: First, it is considered more secure than other traditional security methods, as fingerprints are unique to each individual, making it difficult to duplicate or bypass the system. In addition, the system is low-cost, highly efficient and compact, making it accessible and practical for implementation in a wide range of vehicles.(Juwariyah, Tatik, et al 2019) proposes an innovative motorcycle security system that uses Internet of Things (IoT) technologies to prevent theft, a common problem in urban areas such as Jakarta.

The system is designed to be an effective and accessible solution, using components such as the Arduino Mega2560 microcontroller, a fingerprint sensor, and the ESP8266 communication module, along with the Blynk application for notifications on smartphones, the main objective of the system is to provide an additional layer of security to motorcycles by biometric verification of the user. This is achieved by ensuring that only authorized persons can start the motorcycle engine, which is verified through a fingerprint sensor.

Theoretical framework

In the last decade, vehicle theft has been steadily increasing, which is increasingly noticeable, since each of us has been a victim or knows someone who has experienced it, the impacts of vehicle theft have drastically affected social security and the economic condition of the whole world due to the lack of an adequate system that can integrate technology in commercial cars, or that the majority of the population has (low-end) (Das, et al 2021).

The project focuses on the areas of car security and technology. Today, high rates of insecurity are causing a significant increase in vehicle theft, which is undermining the economy of Mexicans, as well as SMEs (Small and Medium Enterprises), due to the absence of an effective anti-vehicle theft system, see table 1.

According to the AMIS (Mexican Association of Insurance Institutions) report from 2020, published in (AMIS, n.d.). An average of 167 vehicles are stolen every day in Mexico.

From October of last year to September 2020,60,905 insured vehicles were stolen in the country, according to the most recent figures shown in Table 1, although people's mobility increased in 2019 compared to 2020, after the relaxation of health measures, vehicle theft fell 2.7% compared to the previous 12 months.

In this period, AMIS estimates that 26,554 stolen vehicles were recovered, which meant an annual decrease of 8.2%, however, out of every 10 thefts, six were carried out with the use of violence, as shown by figures provided by the organization. Among the states with the most types of thefts from insured vehicles, the State of Mexico is in first place, followed by Jalisco, Mexico City, Puebla, Guanajuato and Veracruz.

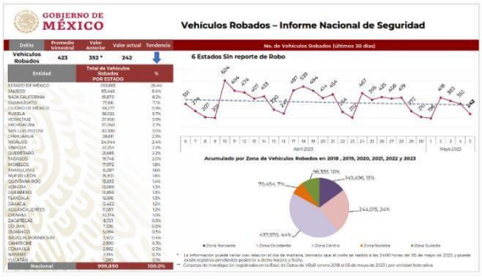
Among the 10 most stolen models, four are from the Nissan brand (Versa, Tsuru, March and Sentra), two from General Motors (Aveo and Beat), two from Honda (CR-V and HR-V) and two more from Volkswagen (Jetta and Vento).

In Mexico there is the Specialized Unit for the Investigation of Assault and Theft of Vehicles (UEIARV), which is attached to the Specialized Subprosecutor's Office for the Investigation of Organized Crime (SEIDO) and on its official website it mentions that for several years the crime of vehicle theft has increased, due to the fact that criminal organizations increasingly use stolen vehicles (which they themselves steal in different states of the Republic), to carry out their illicit activities.

Box 1

Table 1

Theft of insured vehicles



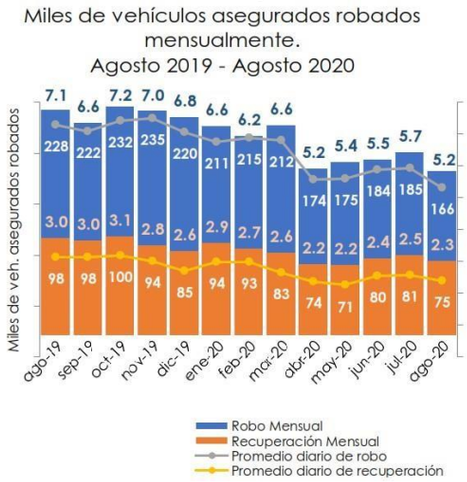
Source: report sept2019-ago2020 AMI

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Box 2

Table 2

Stolen vehicles as of May 2023



Source: January 2018 to May 5, 2023

Methodology to be developed

Electronic circuit design

One of the best alternatives to develop the Project is to use the Arduino Platform, which is one of the most versatile on the market, affordable and open source, in addition to having one of the largest collaboration networks, through forums and channels on different social networks, in Figure 1.

The variants of Arduino commercial cards are shown.

Box 3

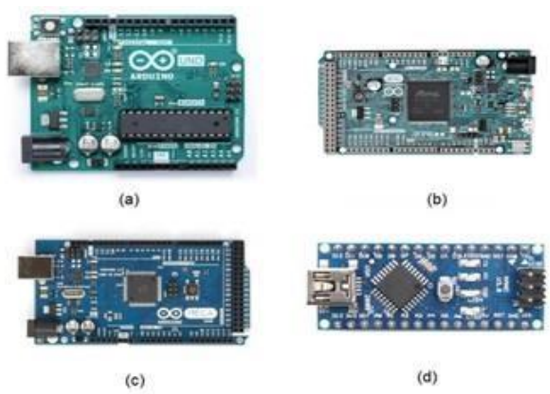


Figure 1

Arduino variant boards (a) Ard. UNO (b) Ard. Due (c) Ard. Mega (d) Ard. Nano

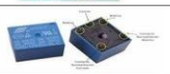
Source: own elaboration

To complement the list of components to assemble the control circuit for the Project, the following components are added:

Box 4

Table 3

Components for the control circuit

Cantidad	Descripción	Imagen	Costo
1	Arduino		$140.00
1	Relevador		$80.00
1	Sensor de Huella AS606		$236.00
1	Batería de 12V		$850.00
1	Motor 12V		$80.00
1	Buzzer		$7.00

Source: own elaboration

The electrical circuit connection diagram is shown in Figure 2, where we can see an Arduino UNO card, a fingerprint reader, basically, but a power supply is also required (for this stage of project development, a 12 Volt DC power supply is being used, but it is intended to use the automotive battery of the same vehicle in which the system is tested), a 12 volt relay, which is enough to have a control circuit as mentioned (R. Thanuj, et. al. 2023), in addition to its respective code.

Box 5

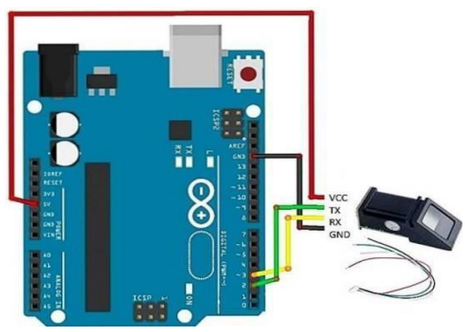


Figure 2

Electrical diagram of the control circuit

Source: own elaboration

The fundamental part of the control circuit is the microcontroller (Veeramanickam, et. al. 2022), which is intended to process the different signals, according to the model, particularly for the project, are the signals sent by the fingerprint sensor, who will be in charge of receiving (scanning) and emitting status validation signals (comparing against the previous record in the database), part of the fingerprint reading control code, is shown in Figure 3.

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Box 6

```
finger.getTemplateCount();
Serial.print("El sensor contine"); Serial.print(finger.templateCount);
Serial.println("plantillas");
Serial.println("Esperando por una huella valida...");
}
void loop()
{ analogo5=analogRead(A5);
If(analogo5<=800){
Serial.print("Salida
Interna *** ");
encenderm ();
}
getFingerprintIDez ();
delay(50);
```

Figure 3

Fingerprint reading control code fragment

Source: own elaboration

Physical installation of the components

The fingerprint sensor was installed in a model, simulating the dashboard of a vehicle, for practical, economic and fast data generation reasons, where the steering wheel and the fingerprint reader are presented, which scans the user's fingerprint beforehand registered.

As well as the complete circuit including all the components described in Table 3, as shown in Figures 4 and 5.

Box 7

Figure 4

Automotive dashboard simulation test model

Box 8

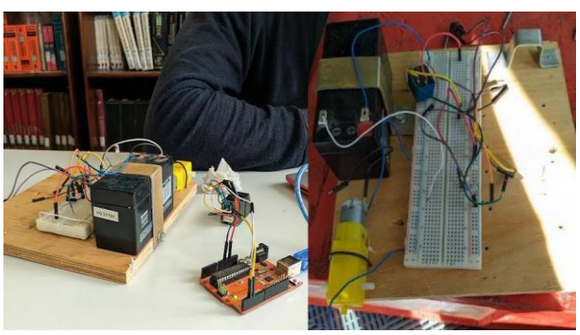


Figure 5

Fingerprint ignition control circuit

Results

As a result of the integration of different digital technologies and applications between different systems, users of low- and mid-range compact cars can prevent and avoid the theft of a conventional car, in vehicles that do not have any built-in electrical system (low-range), and even some that only have built-in presence sensors (mid-range), as well as cars depreciated with respect to 2024.

Specifically for the particular case of vehicle theft prevention, the most important thing is to prevent the vehicle engine from being started, which is why the design of digital ignition control of compact vehicle engine, was developed with the elements described in the Table 3, but during development the problem of code integration arose, since there is a main code, but the manufacturer of the fingerprint sensor also offers a code with which the fingerprints of the users who want to have access to the vehicle's engine ignition control system must be enrolled (registered).

Box 9

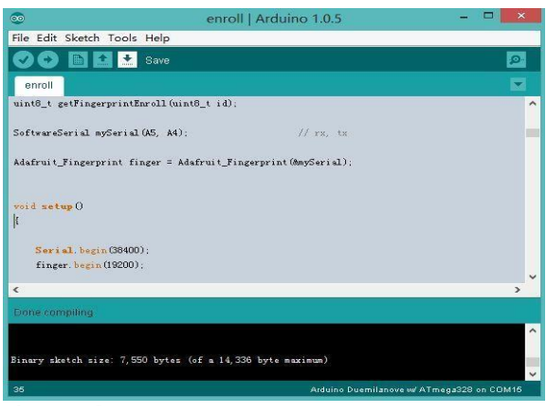


Figure 6

Arduino code snippet for fingerprint enrollment

Source: own elaboration

The time to register a new fingerprint is approximately 5 minutes, but it is highly recommended that before registering, the user properly cleans the surface of the finger that he wants to register; it is sufficient to wash it with soap and water beforehand; and also to make sure that it does not have any scratches, wounds or ink stains or any substance or material foreign to human tissue.

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Guzmán-Cortés, Agustín, Barbosa-Santillán, Luis Francisco, González-Contreras, Brian Manuel and Álvarez-González, Ricardo. [2024]. Design of digital ignition control of compact vehicle engine using fingerprint. Journal of Technological Engineering. 8[21]1-7: e4821107.
https://doi.org/10.35429/JTEN.2024.8.21.1.7

Acknowledgements

To the company NitKom, for all its collaboration and support, to the Technological University of Puebla, specifically to the Automotive Systems Division for all the facilities provided for the development of the project and to the Autonomous University of Tlaxcala.

Conclusions

As part of the actions to prevent vehicle theft, conditions can be implemented, such as having a garage with a very good lock, steering wheel immobilizers, audible or visual alarms, among others, but current conditions of insecurity require the use of technologies and, much better, combining and integrating them to strengthen an anti-theft protection or prevention system, which is intended to be designed based on commercial and low-cost technologies such as the Arduino platform, using fingerprint sensors and open source programming, which can be simulated before implementing in prototypes or final systems, as well as the design, creation and integration of applications that are compatible with the Arduino platform.

The main objective of this work was to develop an engine ignition control system for a vehicle that has very limited or no factory technology conditions, depending on the model and make, such as low-end vehicles, and which is a quite vulnerable and abandoned sector, which causes such cars to depreciate much faster than expected, but above all the system was designed with the mission of offering a technological security alternative for the vehicle, of the average owner in Mexico, which is economical, intuitive and up-to-date that can integrate and complement any vehicle that the owner has, without the need to invest in specific models or brands and above all obtaining the same technological security advantages as if you had a high-end vehicle. In a future project, the implementation of this engine ignition control system is being considered. The selected vehicle is a Nissan Tsuru model, with VIN number: 3NIEB3IS03K506364.

All the researchers working on this project are pleased to know that we have managed to contribute to reducing the high theft rates that are increasing every day, alerting and worrying Mexicans, due to the low blow that this represents for their family economy and for the MSMEs.

Declarations

Conflict of interest

The authors declare that they have no conflicts of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

Authors' contribution

Guzmán-Cortés, Agustín: Prototype, Contributed with the main idea and the writing of the article.

Barbosa-Santilla, Luis Francisco: Implementation, contributed with the implementation of the technology.

Gonzalez-Contreras, Brian Manuel Methodology, contributed with the methodology applied for the development of the research.

Alvarez-Gonzalez, Ricardo: Translation, contributed with the translation of the article

Data availability

Registration is required to access the databases consulted

Funding

The Technological University of Puebla only contributed to the payment of the publication of the article

Abbreviations

DAS (Driving Assistance System)
ECU (Electronic Control Unit)
AMIA (Mexican Association of the Automotive Industry)
LCD (Liquid Crystal Display)
GPS (Global Positioning System)
IDE (integrated development environment)
IoT (Internet of Things)
SEIDO (Specialized Subprosecutor's Office for the Investigation of Organized Crime)
UEIARV Specialized Unit for the Investigation of Assault and Theft of Vehicles
SMEs (Small and Medium Enterprises)

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Guzmán-Cortés, Agustín, Barbosa-Santillán, Luis Francisco, González-Contreras, Brian Manuel and Álvarez-González, Ricardo. [2024]. Design of digital ignition control of compact vehicle engine using fingerprint. Journal of Technological Engineering. 8[21]1-7: e4821107.
https://doi.org/10.35429/JTEN.2024.8.21.1.7

Referencias

Background

Bharani, P.J., et al. "A Prototype of Fingerprint And ZigBee Based Train Ignition System." *Advanced Engineering Forum*, vol. 6-7, Sept. 2012, pp. 1129–1134,

Brijet, Z, et al. "Vehicle Anti-Theft System Using Fingerprint Recognition Technique." *Open Academic Journal of Advanced Science and Technology*, vol. 1, no. 1, 2017, pp. 36–41,

Mohammed, M. S., Abduljabar, A. M., Faisal, M. M., Mahmmod, B. M., Abdulhussain, S. H., Khan, W., Liatsis, P., & Hussain, A. (2023). Low-cost autonomous car level 2: Design and implementation for conventional vehicles. *Results in Engineering*, *17*, 100969.

Cárdenas Patiño Cristhian Gustavo, Villacrés Campoverde Diego Francisco (2021). Diseño e implementación de un sistema de seguridad antirrobo por inmovilización del motor mediante corte de combustible y señal de alerta por llamada de voz a dispositivo móvil, complementado con señal de ubicación del vehículo por GPS.

Zein, Y., Darwiche, M., & Mokhiamar, O. (2018). GPS tracking system for autonomous vehicles. *Alexandria Engineering Journal*, *57*(4), 3127-3137.

Support

R. Thanuj, et al. "Anti-Theft Vehicle Tracking and Remote-Control System." *International Journal of Vehicle Structures and Systems*, vol. 15, no. 7, Dec. 2023, pp. 935–939,

Juwariyah, Tatik, et al. "Purwa Rupa Sistem Pengaman Sepeda Motor Berbasis IoT (Internet of Things." *Jurnal Otomasi Kontrol Dan Instrumentasi*, vol. 11, no. 1, 28 May2019,p.49

Veeramanickam, M. R. M., Venkatesh, B., Bewoor, L. A., Bhowte, Y. W., Moholkar, K., & Bangare, J. L. (2022). IoT based smart parking model using Arduino UNO with FCFS priority scheduling. *Measurement: Sensors*, *24*, 100524.

Smołka, Jakub, et al. "Performance Analysis of Mobile Applications Developed with Different Programming Tools." *MATEC Web of Conferences*, vol. 252, 2019, p. 05022,

Basics

Autopresta, (4 de enero de 2024), ¿Cómo calcular la depreciación de un automóvil?.autopresta.mx Recuperado el 6 de abril de 2024, de

AMIS, (s.f.), Reporte y estudios: Autos. Sitio.amis.com.mx Recuperado el 5 de noviembre de 2023, de Das, Debashis, et al. "A Decentralized Vehicle Anti-Theft System Using Blockchain and Smart Contracts." *Peer-To-Peer Networking and Applications*, vol. 14, Feb. 2021, pp. 2775–2788

ISSN: 2523-6776.
RENIECYT-CONAHCYT: 1702902

Guzmán-Cortés, Agustín, Barbosa-Santillán, Luis Francisco, González-Contreras, Brian Manuel and Álvarez-González, Ricardo. [2024]. Design of digital ignition control of compact vehicle engine using fingerprint. Journal of Technological Engineering. 8[21]1-7: e4821107.
https://doi.org/10.35429/JTEN.2024.8.21.1.7

Instructions for Scientific, Technological and Innovation Publication

[[Title in TNRoman and Bold No. 14 in English and Spanish]

Surname, Name 1st Author*[a], Surname, Name 1st Co-author[b], Surname, Name 2nd Co-author[c] and Surname, Name 3rd Co-author[d] [No.12 TNRoman]

[a] Affiliation institution, Researcher ID, ORC ID, SNI-CONAHCYT ID or CVU PNPC [No.10 TNRoman]
[b] Affiliation institution, Researcher ID, ORC ID, SNI-CONAHCYT ID or CVU PNPC [No.10 TNRoman]
[c] Affiliation institution, Researcher ID, ORC ID, SNI-CONAHCYT ID or CVU PNPC [No.10 TNRoman]
[d] Affiliation institution, Researcher ID, ORC ID, SNI-CONAHCYT ID or CVU PNPC [No.10 TNRoman]

All ROR-Clarivate-ORCID and CONAHCYT profiles must be hyperlinked to your website.
Prot- University of South Australia • 7038-2013• 0000-0001-6442-4409 • 416112

CONAHCYT classification:
https://marvid.org/research_areas.php [No.10 TNRoman]
Area:
Field:
Discipline:
Subdiscipline:

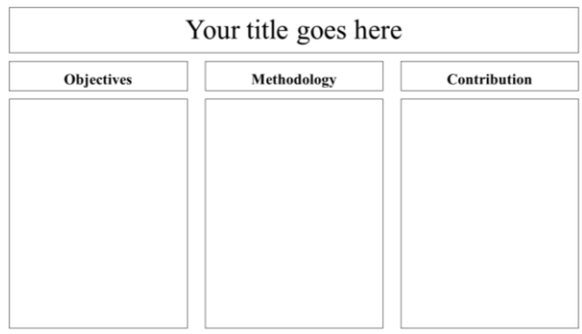
DOI: https://doi.org/
Article History:
Received: [Use Only ECORFAN]
Accepted: [Use Only ECORFAN]
Contact e-mail address:
* ✉ [example@example.org]

Abstract [In English]
Must contain up to 150 words
Graphical abstract [In English]

Authors must provide an original image that clearly represents the article described in the article. Graphical abstracts should be submitted as a separate file. Please note that, as well as each article must be unique. File type: the file types are MS Office files.No additional text, outline or synopsis should be included. Any text or captions must be part of the image file. Do not use unnecessary white space or a "graphic abstract" header within the image file.

Keywords [In English]
Indicate 3 keywords in TNRoman and Bold No. 10

Abstract [In Spanish]
Must contain up to 150 words
Graphical abstract [In Spanish]



Authors must provide an original image that clearly represents the article described in the article. Graphical abstracts should be submitted as a separate file. Please note that, as well as each article must be unique. File type: the file types are MS Office files.No additional text, outline or synopsis should be included. Any text or captions must be part of the image file. Do not use unnecessary white space or a "graphic abstract" header within the image file.

Keywords [In Spanish]
Indicate 3 keywords in TNRoman and Bold No. 10

Citation: Surname, Name 1st Author, Surname, Name 1st Co-author, Surname, Name 2nd Co-author and Surname, Name 3rd Co-author. Article Title. ECORFAN Journal-Mexico. Year. V-N: Pages [TN Roman No.10].

Introduction

Text in TNRoman No.12, single space.

General explanation of the subject and explain why it is important.

What is your added value with respect to other techniques?

Clearly focus each of its features.

Clearly explain the problem to be solved and the central hypothesis.

Explanation of sections Article.

Development of headings and subheadings of the article with subsequent numbers

[Title No.12 in TNRoman, single spaced and bold]

Products in development No.12 TNRoman, single spaced.

Including figures and tables-Editable

In the article content any table and figure should be editable formats that can change size, type and number of letter, for the purposes of edition, these must be high quality, not pixelated and should be noticeable even reducing image scale.

[Indicating the title at the bottom with No.10 and Times New Roman Bold]

Box

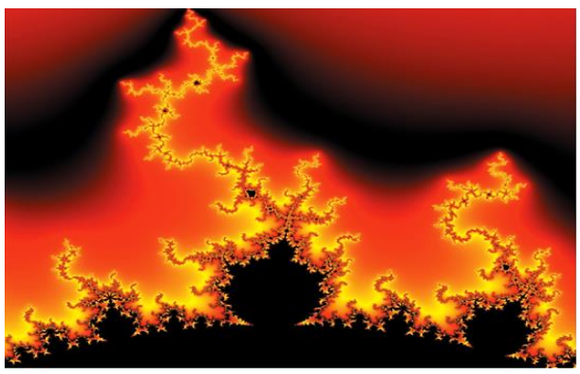


Figure 1

Title [Should not be images-everything must be editable]

Source [in italic]

Box

Table 1

Title [Should not be images-everything must be editable]

Source [in italic]

The maximum number of Boxes is 10 items

For the use of equations, noted as follows:

$$Y_{ij} = \alpha + \sum_{h=1}^{r} \beta_h X_{hij} + u_j + e_{ij} \quad [1]$$

Must be editable and number aligned on the right side.

Methodology

Develop give the meaning of the variables in linear writing and important is the comparison of the used criteria.

Results

The results shall be by section of the article.

Conclusions

Clearly explain the results and possibilities of improvement.

Annexes

Tables and adequate sources.

The international standard is 7 pages minimum and 14 pages maximum.

Declarations

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

ISSN: 2524-2121.
RENIECYT-CONAHCYT: 1702902

Author contribution

Specify the contribution of each researcher in each of the points developed in this research.

Prot-
Benoit-Pauleter, Gerard: Contributed to the project idea, research method and technique.

Availability of data and materials

Indicate the availability of the data obtained in this research.

Funding

Indicate if the research received some financing.

Acknowledgements

Indicate if they were financed by any institution, University or company.

Abbreviations

List abbreviations in alphabetical order.

Prot-

ANN	Artificial Neural Network

References

Use APA system. Should not be numbered, nor with bullets, however if necessary numbering will be because reference or mention is made somewhere in the Article.

Use the Roman alphabet, all references you have used should be in Roman alphabet, even if you have cited an article, book in any of the official languages of the United Nations [English, French, German, Chinese, Russian, Portuguese, Italian, Spanish, Arabic], you should write the reference in Roman alphabet and not in any of the official languages.

Citations are classified the following categories:

Antecedents. The citation is due to previously published research and orients the citing document within a particular scholarly area.

Basics. The citation is intended to report data sets, methods, concepts and ideas on which the authors of the citing document base their work.

Supports. The citing article reports similar results. It may also refer to similarities in methodology or, in some cases, to the reproduction of results.

Differences. The citing document reports by means of a citation that it has obtained different results to those obtained in the cited document. This may also refer to differences in methodology or differences in sample sizes that affect the results.

Discussions. The citing article cites another study because it is providing a more detailed discussion of the subject matter.

The URL of the resource is activated in the DOI or in the title of the resource.

Prot-
Mandelbrot, B. B. [2020]. Negative dimensions and Hölders, multifractals and their Hölder spectra, and the role of lateral preasymptotics in science. Journal of Fourier Analysis and Applications Special. 409-432.

Intellectual Property Requirements for editing:

- Authentic Signature in Color of Originality Format Author and Coauthors.
- Authentic Signature in Color of the Acceptance Format of Author and Coauthors.
- Authentic Signature in blue color of the Conflict of Interest Format of Author and Co-authors.

ISSN: 2524-2121.
RENIECYT-CONAHCYT: 1702902

Reservation to Editorial Policy

Journal of Technological Engineering reserves the right to make editorial changes required to adapt the Articles to the Editorial Policy of the Journal. Once the Article is accepted in its final version, the Journal will send the author the proofs for review. ECORFAN® will only accept the correction of errata and errors or omissions arising from the editing process of the Journal, reserving in full the copyrights and content dissemination. No deletions, substitutions or additions that alter the formation of the Article will be accepted.

Code of Ethics - Good Practices and Declaration of Solution to Editorial Conflicts

Declaration of Originality and unpublished character of the Article, of Authors, on the obtaining of data and interpretation of results, Acknowledgments, Conflict of interests, Assignment of rights and Distribution

The ECORFAN-Mexico, S.C. Management claims to Authors of Articles that its content must be original, unpublished and of Scientific, Technological and Innovation content to be submitted for evaluation.

The Authors signing the Article must be the same that have contributed to its conception, realization and development, as well as obtaining the data, interpreting the results, drafting and reviewing it. The Corresponding Author of the proposed Article will request the form that follows.

Article title:

– The sending of an Article to Journal of Technological Engineering emanates the commitment of the author not to submit it simultaneously to the consideration of other series publications for it must complement the Format of Originality for its Article, unless it is rejected by the Arbitration Committee, it may be withdrawn.

– None of the data presented in this article has been plagiarized or invented. The original data are clearly distinguished from those already published. And it is known of the test in PLAGSCAN if a level of plagiarism is detected Positive will not proceed to arbitrate.

– References are cited on which the information contained in the Article is based, as well as theories and data from other previously published Articles.

– The authors sign the Format of Authorization for their Article to be disseminated by means that ECORFAN-Mexico, S.C. In its Holding Taiwan considers pertinent for disclosure and diffusion of its Article its Rights of Work.

– Consent has been obtained from those who have contributed unpublished data obtained through verbal or written communication, and such communication and Authorship are adequately identified.

– The Author and Co-Authors who sign this work have participated in its planning, design and execution, as well as in the interpretation of the results. They also critically reviewed the paper, approved its final version and agreed with its publication.

– No signature responsible for the work has been omitted and the criteria of Scientific Authorization are satisfied.

– The results of this Article have been interpreted objectively. Any results contrary to the point of view of those who sign are exposed and discussed in the Article.

Copyright and Access

The publication of this Article supposes the transfer of the copyright to ECORFAN-Mexico, SC in its Holding Taiwan for its Journal of Technological Engineering, which reserves the right to distribute on the Web the published version of the Article and the making available of the Article in This format supposes for its Authors the fulfilment of what is established in the Law of Science and Technology of the United Mexican States, regarding the obligation to allow access to the results of Scientific Research.

Article Title:

Name and Surnames of the Contact Author and the Co-authors	Signature
1.	
2.	
3.	
4.	

Principles of Ethics and Declaration of Solution to Editorial Conflicts

Editor Responsibilities

The Publisher undertakes to guarantee the confidentiality of the evaluation process, it may not disclose to the Arbitrators the identity of the Authors, nor may it reveal the identity of the Arbitrators at any time.

The Editor assumes the responsibility to properly inform the Author of the stage of the editorial process in which the text is sent, as well as the resolutions of Double-Blind Review.

The Editor should evaluate manuscripts and their intellectual content without distinction of race, gender, sexual orientation, religious beliefs, ethnicity, nationality, or the political philosophy of the Authors.

The Editor and his editing team of ECORFAN® Holdings will not disclose any information about Articles submitted to anyone other than the corresponding Author.

The Editor should make fair and impartial decisions and ensure a fair Double-Blind Review.

Responsibilities of the Editorial Board

The description of the peer review processes is made known by the Editorial Board in order that the Authors know what the evaluation criteria are and will always be willing to justify any controversy in the evaluation process. In case of Plagiarism Detection to the Article the Committee notifies the Authors for Violation to the Right of Scientific, Technological and Innovation Authorization.

Responsibilities of the Arbitration Committee

The Arbitrators undertake to notify about any unethical conduct by the Authors and to indicate all the information that may be reason to reject the publication of the Articles. In addition, they must undertake to keep confidential information related to the Articles they evaluate.

Any manuscript received for your arbitration must be treated as confidential, should not be displayed or discussed with other experts, except with the permission of the Editor.

The Arbitrators must be conducted objectively, any personal criticism of the Author is inappropriate.

The Arbitrators must express their points of view with clarity and with valid arguments that contribute to the Scientific, Technological and Innovation of the Author.

The Arbitrators should not evaluate manuscripts in which they have conflicts of interest and have been notified to the Editor before submitting the Article for Double-Blind Review.

Responsibilities of the Authors

Authors must guarantee that their articles are the product of their original work and that the data has been obtained ethically.

Authors must ensure that they have not been previously published or that they are not considered in another serial publication.

Authors must strictly follow the rules for the publication of Defined Articles by the Editorial Board.

The authors have requested that the text in all its forms be an unethical editorial behavior and is unacceptable, consequently, any manuscript that incurs in plagiarism is eliminated and not considered for publication.

Authors should cite publications that have been influential in the nature of the Article submitted to arbitration.

Information services

Indexation - Bases and Repositories

RESEARCH GATE (Germany)
GOOGLE SCHOLAR (Citation indices-Google)
MENDELEY (Bibliographic References Manager)
REDIB (Ibero-American Network of Innovation and Scientific Knowledge- CSIC)
HISPANA (Information and Bibliographic Orientation-Spain)

Publishing Services

Citation and Index Identification H
Management of Originality Format and Authorization
Testing Article with PLAGSCAN
Article Evaluation
Certificate of Double-Blind Review
Article Edition
Web layout
Indexing and Repository
ArticleTranslation
Article Publication
Certificate of Article
Service Billing

Editorial Policy and Management

69 Street. YongHe district, ZhongXin. Taipei-Taiwan. Phones: +52 1 55 6159 2296, +52 1 55 1260 0355, +52 1 55 6034 9181; Email: contact@ecorfan.org www.ecorfan.org

Journal of Technological Engineering

2523 6776
ISSN 2523 - 6776
www.ecorfan.org