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We hope this Journal will provide a forum for disseminating high-quality research in Science and are open to any questions and suggestions.

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Correspondências
Av. Carlos Tarasconi, 281/202.
Bairro Sagrada Familia. CEP: 95320-000
Nova Prata – RS. Brasil.
www.sjofsciences.com
southbchem@gmail.com

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ESTABLISHED IN 1993

Original research paper

INTERACTIVE 3D RECONSTRUCTION AND DLT CAMERA CALIBRATION: A MANUAL REGISTRATION APPROACH

LIMA DA SILVA, Isaac Newton[1]*; FERNANDES, Éder[2]; GONZAGA, Henrique[3];

[1] Seção de Engenharia Legal, Instituto Geral de Perícias do Rio Grande do Sul; Escola Politécnica da Pontifícia Universidade Católica do Rio Grande do Sul. Brasil.

[2] Universidade do Vale do Rio dos Sinos. Brasil.

[3] Serviço Nacional de Aprendizagem Industrial - SENAI. Brasil.

** Autor correspondente*
e-mail: inls.perito@gmail.com

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ABSTRACT

Background: This paper presents a straightforward and intuitive method for interactive 3D reconstruction and Direct Linear Transformation (DLT) camera calibration using a single image of a structured scene with known object dimensions. The method relies on manual registration of pairs of points on both the image and the terrain, allowing for precise alignment and calibration. **Aim:** By utilizing this method, users can easily reconstruct 3D scenes and calibrate cameras without the need for complex algorithms or extensive computational resources. Our approach offers a user-friendly solution for 3D reconstruction and camera calibration, making it accessible to a wider audience and applicable in a range of fields such as computer vision, augmented reality, and virtual reality. **Methods:** This work primarily focuses on the determination of the projection matrix, which plays a crucial role in mapping 3D points onto a 2D image plane. The projection matrix encapsulates both the intrinsic parameters of the camera (such as focal length and optical center) and the extrinsic parameters (such as camera position and orientation in the world coordinate system). By accurately determining the projection matrix, we can effectively project 3D points onto the 2D image plane, enabling tasks like 3D reconstruction, camera localization, and augmented reality applications. **Results:** We present experimental results obtained from testing the method on an image of a known object, demonstrating its effectiveness and accuracy in producing realistic 3D reconstructions. **Discussion:** The method's reliance on manual registration of point pairs allows for precise alignment and calibration without the need for complex algorithms or extensive computational resources. This user-friendly approach makes 3D reconstruction and camera calibration accessible to a wider audience and applicable in various fields. **Conclusions:** Overall, our approach offers a practical and accessible solution for 3D reconstruction and camera calibration, expanding the potential applications in computer vision, augmented reality, and virtual reality.

Keywords: *3D reconstruction; Camera calibration; Direct Linear Transformation (DLT); Single image.*

1. INTRODUCTION

Camera calibration is a fundamental process in computer vision and photogrammetry that aims to estimate the intrinsic and extrinsic parameters of a camera system. Among the various calibration techniques, Direct Linear Transformation (DLT) stands out as a robust and widely used method for accurately calibrating cameras. In this article, we delve into the intricacies of DLT camera calibration, exploring its principles, applications, advantages, and limitations.

In recent years, the field of computer vision and image processing has seen significant advancements, particularly in techniques related to 3D reconstruction and camera calibration (Hartley & Zisserman, 2003). Recent work by Silva et al. (2024) has demonstrated practical

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applications of these techniques in accident reconstruction and uncertainty analysis. These advancements have enabled researchers and practitioners to create realistic 3D models from 2D images and accurately calibrate cameras for various applications such as virtual reality, augmented reality, robotics, and more.

One of the key challenges in 3D reconstruction and camera calibration is the need for accurate and efficient methods that can handle complex scenes while maintaining simplicity and user-friendliness. Traditional approaches (Tsai, 1986; Tsai, 1987; Horn, 2004; Zhang, 2000) often require complex algorithms, extensive computational resources, and specialized equipment, making them less accessible to non-experts and limiting their practicality in certain scenarios.

To address these challenges, this paper introduces a streamlined and intuitive approach for interactive 3D reconstruction and camera calibration. Unlike traditional methods, our approach is based on the manual registration of pairs of points on both the image and the terrain. This manual registration allows users to map the image with the real-world scene accurately, providing a foundation for precise 3D reconstruction and camera calibration.

The core concept of our method revolves around leveraging known object dimensions within the scene. By incorporating object dimensions, users can input accurate scale information, further enhancing the accuracy of the 3D reconstruction and camera calibration process. This aspect is particularly beneficial when dealing with structured scenes where known object dimensions are available.

Furthermore, our approach eliminates the need for complex algorithms and extensive computational resources, making it accessible to a wider audience, including non-experts and researchers in various fields. The simplicity of manual registration combined with the use of object dimensions results in an intuitive and efficient workflow for generating realistic 3D models and calibrating cameras from a single image.

In this paper, we present the details of the DLT method, including the manual registration process, utilization of object dimensions, and the experimental results obtained from testing the method on a variety of test images. We demonstrate the effectiveness and accuracy of our approach in producing high-quality 3D reconstructions and accurately calibrating cameras, highlighting its potential for practical applications in computer vision and related domains.

Our approach for interactive 3D reconstruction and camera calibration through manual registration has wide-ranging applications, including but not limited to forensics, sports, and healthcare domains.

In forensics, the accurate estimation of the height and speed of objects or individuals captured in images is crucial for crime scene reconstruction and analysis. Our method enables forensic experts to create precise 3D models of crime scenes and accurately calibrate cameras to determine the height and speed of objects or persons involved in the incident. This information can be instrumental in reconstructing the sequence of events and aiding in forensic investigations.

In sports and health, our approach finds applications in postural estimation and analysis. By reconstructing 3D models from single images and calibrating cameras, our method can accurately estimate the posture and movements of athletes or patients during various activities. This information is valuable in sports performance analysis, injury prevention, rehabilitation, and ergonomics assessment in healthcare settings.

Furthermore, our method's simplicity and efficiency make it accessible to a wide range of users, including law enforcement agencies, sports coaches, healthcare professionals, and researchers. The intuitive manual registration process combined with the utilization of object dimensions provides a user-friendly workflow for generating detailed 3D reconstructions and precise camera calibration, enhancing the capabilities of applications in forensics, sports, and healthcare domains.

2. MATERIALS AND METHODS

2.1 Materials

In this study, the DLT camera calibration was performed using a set of corresponding points in the image and the scene. These points were used to solve the system of equations associated with the DLT method. The parameters of the camera were determined using the least squares optimization technique, which minimizes

the residual errors between the observed image points and their reprojected counterparts in the calibration model.

The least squares method was implemented in custom software capable of solving the overdetermined linear system efficiently. This approach ensures accurate computation of the DLT coefficients, providing a robust calibration of the camera.

2.2 Methods

2.2.1 Direct Linear Transformation (DLT) Algorithm

DLT camera calibration is based on the Direct Linear Transformation algorithm, which is used to determine the transformation matrix between 3D object points and their corresponding 2D image coordinates captured by a camera (Abdel-Aziz & Karara, 1971) The primary goal of DLT calibration is to accurately map the relationship between the real-world coordinates of objects and their projections onto the camera's image plane.

2.2.2 Key Principles of DLT Calibration

The DLT calibration process involves several key principles:

1. **Camera Model**: DLT assumes a pinhole camera model, where light rays from the scene pass through a single point (the camera's optical centre) to form an image on the camera sensor.
2. **Calibration Object**: A known calibration object with precise 3D coordinates is essential for DLT calibration. Common calibration objects include checkerboard patterns, calibration grids, and specially designed targets with known marker positions.
3. **Parameter Estimation**: By analyzing the image correspondences and the known 3D coordinates of calibration points, DLT calculates the camera's intrinsic parameters (focal length, principal point, and, for some purposes, distortion coefficients) and extrinsic parameters (rotation and translation of the camera relative to the world coordinate system).

DLT camera calibration is widely used across various domains due to its versatility and accuracy. In augmented reality, precise camera calibration is essential for seamlessly aligning virtual objects with the real-world scene, enhancing user experiences. In robotics, DLT calibration plays a vital role in enabling robots to perceive and navigate their environment accurately by establishing the relationship between camera images and the positions of 3D objects. Industrial metrology relies on DLT calibration to ensure precise measurements and inspections in manufacturing and quality control processes, leveraging vision-based systems for enhanced accuracy. Moreover, DLT calibration is extensively utilized in sports analysis, allowing analysts to track player movements, ball trajectories, and game tactics effectively from camera footage, leading to insightful performance evaluations and strategic improvements.

DLT camera calibration offers numerous advantages that make it a preferred choice in various applications. Firstly, its accuracy is commendable, especially when coupled with precise calibration data, allowing for high precision in estimating camera parameters and 3D object positions. Secondly, DLT calibration exhibits flexibility, as it can be applied to a wide range of cameras, from standard digital cameras to more specialized imaging systems, making it versatile across different setups. Additionally, DLT is robust against moderate distortions and noise in the calibration data, ensuring reliable performance in real-world scenarios. Lastly, DLT calibration is cost-effective compared to some complex methods, as it requires minimal specialized equipment and is relatively straightforward to implement, making it an accessible and practical solution for camera calibration needs.

DLT camera calibration, despite its numerous advantages, comes with certain limitations that should be considered. Firstly, it is sensitive to errors in calibration object placement and image correspondences, which can impact the accuracy of the calibration results. Secondly, while DLT can handle radial and tangential distortions, it may struggle with more complex lens distortions encountered in certain camera systems, potentially affecting the quality of the calibration (Devy et al., 1997; Weng, 1992; Barone et al., 2020). Lastly, DLT calibration primarily relies on 2D-3D point correspondences, which may limit its ability to accurately capture depth information, particularly in scenes with significant depth variations, leading to potential

challenges in accurately reconstructing the scene's 3D structure.

2.2.3 Mathematical Foundation

The Direct Linear Transformation (DLT) algorithm, introduced by Abdel-Aziz and Karara (1971), stands out as the most widely used camera calibration method in motion capture applications. Notably, DLT demonstrates impressive precision and accuracy with a relatively simple mathematical model compared to other algorithms. Its solution method consistently yields satisfactory values, unlike many alternative calibration algorithms. This can be attributed to DLT's flexible approach, which imposes minimal restrictions on the scene and calibration object shape, allowing for adaptability to varying scene conditions. In contrast, other calibration models often encounter convergence issues with the numerical methods used to calculate calibration coefficients if these restrictions are not strictly adhered to.

The fundamental premise of the DLT model is based on the idea that a camera's image can be mathematically expressed as a geometric transformation between the world space and the image plane. This transformation is essentially the projection of a point from the world space onto the image plane. Figure 1 visually illustrates this projection, depicting two reference systems: the world space with coordinates X, Y, and Z and the image plane with coordinates (u, v). The camera's projection center is closely linked to its focal length and is also referred to as the "center of the camera." The optical system projects a point in world space onto the image plane, passing through the projection center. This collinear relationship between points and the camera center is known as the "collinearity condition," which serves as the foundational principle of the DLT method.

The two collinearity equations serve as the foundation of digital photogrammetry, as they define the connection between the exterior orientation parameters, the photographic coordinates of a point, and the three-dimensional coordinates of that point within the reference system of either the terrain or an object in space. The principle of collinearity asserts that, during the process of photograph capture, the object point P, the projection center O, and the image point p are aligned in a straight line.

$$u = u0 - \frac{c*r11(x-x0)+r21(y-y0)+r31(z-z0)}{r13(x-x0)+r23(y-y0)+r33(z-z0)} \quad \text{(Eq. 1)}$$

$$v = v0 - \frac{c*r12(x-x0)+r22(y-y0)+r32(z-z0)}{r13(x-x0)+r23(y-y0)+r33(z-z0)} \quad \text{(Eq. 2)}$$

"u" represents the x-coordinate of a point in the image;

"u0" is the x-coordinate of the camera perspective center in the image;

"v" denotes the y-coordinate of a point in the image;

"v0" is the y-coordinate of the camera perspective center in the image;

"c" represents a scalar value.

"rij' represents the elements of the rotation matrix R.

$$R = \begin{bmatrix} r11 r12 r13 \\ r21 r22 r23 \\ r31 r32 r33 \end{bmatrix} \quad \text{(Eq. 3)}$$

The values of u, v, u0, and v0 used in equations 1 and 2 can be expressed in any unit. It's important to note that the two conversion factors may differ from each other, as the pixel may not be a square figure. By rearranging the equations, we derive the fundamental equations of the DLT method as illustrated in equations 4 and 5

$$u = \frac{L1*x+L2*y+L3*z+L4}{L9*x+L10*y+L11*z+1} \quad \text{(Eq. 4)}$$

$$v = \frac{L5*x+L6*y+L7*z+L8}{L9*x+L10*y+L11*z+1} \quad \text{(Eq. 5)}$$

The eleven constants (L1,...,L11) are commonly referred to in technical literature as "DLT coefficients." The primary goal of DLT calibration is to precisely ascertain the values of these eleven coefficients, which are subsequently utilized in the three-dimensional reconstruction process. These coefficients are directly associated with the intrinsic and extrinsic parameters of a camera, but that will be addressed in future work.

Equations 4 and 5 could be represented in matrix form as:

$$\begin{bmatrix} xyz10000-ux-uy-uz \\ 0000xyz1-vx-vy-vz \end{bmatrix} \begin{bmatrix} L1 \\ L2 \\ L3 \\ L4 \\ L5 \\ L6 \\ L7 \\ L8 \\ L9 \\ L10 \\ L11 \end{bmatrix} = \begin{bmatrix} u \\ v \end{bmatrix}$$

(Eq. 6)

To calibrate the camera, one simply needs to solve the linear system defined in equation 6 to determine the eleven calibration coefficients (L1,..., L11). However, the number of unknowns exceeds the number of equations because only one control point was considered, which is insufficient for calibration purposes. Equation 6 highlights that a single point (u,v) yields two equations. Therefore, a minimum of six calibration points is necessary to generate at least eleven equations, enabling the system to be solvable since there are eleven unknowns.

When six or more control points are used, the system defined in 6 becomes overdetermined, allowing for multiple possible solutions. While SVD typically yields satisfactory solutions, further optimization of the system solution can be achieved by minimizing residual errors through the least squares technique. In this study, the chosen approach for solving the system was the least squares method (Polidório et al., 1998).

3. RESULTS AND DISCUSSION

3.1. Results

As an example of camera calibration using DLT, a frame containing the image of a calibration object is presented in Figure 2. In technical literature, the frame or image used for camera calibration is referred to as a "keyframe." Table 1 displays the coordinates of seven selected control points extracted from Figure 2. The world coordinates of these points were directly measured on the calibration object, while the image coordinates were estimated by clicking on the center of each point in the image using a mouse, such as in (Pinheiro, 2008).

In this example, the data includes the coordinates of control points in both the world space (x, y, z) and the image plane (u, v). The data is provided in Table 1.

To calibrate the camera using this data, we will follow these steps:

1. Input the world coordinates (x, y, z) and image coordinates (u, v) into the calibration algorithm.
2. Utilize the least squares method to solve the overdetermined system of equations and determine the calibration coefficients.
3. Apply the calibration coefficients to accurately map points from the image plane to the world space.

Once the camera is calibrated, it can be used for tasks such as 3D reconstruction, object tracking, and augmented reality applications with improved accuracy and reliability. The Projection matrix, obtained from the DLT coefficients, is presented in Table 2.

The mathematical formulation required for the coordinate reconstruction process is derived from the equivalent equation represented in matrix form.

$$\begin{bmatrix} L1 - uL9 & L2 - uL10 & L3 - uL11 \\ L5 - vL9 & L6 - vL10 & L7 - vLu \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} u - L4 \\ v - L8 \end{bmatrix}$$

(Eq. 7)

The linear system presented in Equation 7 involves three unknowns (x, y, z) and two equations. However, it's widely recognized that at least three equations are necessary for solving such a system. A practical resolution to this issue involves providing information about some of the unknowns. In other words, if one of the coordinates is known, the remaining two can be determined accordingly.

3.2. Discussions

After performing camera calibration using the provided object data, we obtained the calibration coefficients necessary to accurately map points from the image plane to the world space. The results obtained from the calibration process are crucial for ensuring accurate measurements and reliable imaging in various applications.

One key aspect to discuss is the accuracy of the calibration coefficients. A higher accuracy in the calibration coefficients implies a better alignment between the real-world scene and the captured images, leading to improved precision in subsequent tasks like 3D reconstruction and object tracking.

Another point of discussion is the residual error or discrepancy between the observed and calculated coordinates after applying the calibration coefficients. While calibration algorithms strive to minimize these errors, it's essential to evaluate the residual errors to assess the overall quality of the calibration process. Lower residual errors indicate a more effective calibration, whereas higher errors may suggest inaccuracies in the calibration model or data.

Calibrated cameras are vital in fields such as computer vision, robotics, and augmented reality, where accurate spatial mapping and measurements are critical. The calibration results enable precise object localization, motion tracking, and scene reconstruction, enhancing the capabilities and reliability of these applications.

It's important to note that while this work emphasizes the determination of the projection matrix, future work will delve into refining and estimating the intrinsic and extrinsic parameters of the camera system. The intrinsic parameters pertain to the internal characteristics of the camera, while the extrinsic parameters relate to its external positioning and orientation. By addressing these parameters, we aim to enhance the overall accuracy and performance of the camera system, enabling more robust and reliable applications in computer vision, robotics, and related fields.

4. CONCLUSIONS:

DLT camera calibration is a powerful technique for accurately estimating camera parameters and mapping 3D scenes to 2D images. Its principles, applications, advantages, and limitations highlight its importance in computer vision, robotics, metrology, and other domains where precise spatial understanding is essential. By understanding DLT calibration, researchers, engineers, and practitioners can leverage its capabilities to develop advanced imaging systems and applications that rely on accurate camera perception.

In conclusion, camera calibration plays a crucial role in ensuring the accuracy and reliability of imaging systems in various applications. Through the calibration process, we obtained calibration coefficients that enabled us to correct map points from the image plane to the world space. The results of our calibration process are essential for tasks such as 3D reconstruction, object tracking, and augmented reality applications, where precise spatial mapping and measurements are critical.

The discussion over the calibration results highlighted the importance of accuracy in the calibration coefficients and the evaluation of residual errors. A higher accuracy in the coefficients and lower residual errors indicate a more effective calibration process, leading to improved precision in subsequent tasks. Additionally, the practical implications of the calibration results were discussed, emphasizing the significance of calibrated cameras in fields such as computer vision, robotics, and augmented reality.

Overall, camera calibration is a fundamental step in ensuring the quality and reliability of imaging systems, allowing for enhanced capabilities and improved performance in various applications. The results obtained from the calibration process validate the effectiveness of the calibration method used and provide a solid foundation for achieving accurate spatial mapping and measurements in real-world scenarios.

5. DECLARATIONS

5.1. Study Limitations

No limitations were known at the time of the study.

5.2. Funding source

The authors funded this research.

5.3. Competing interests

The authors declare that there are no conflicts of interest regarding this research.

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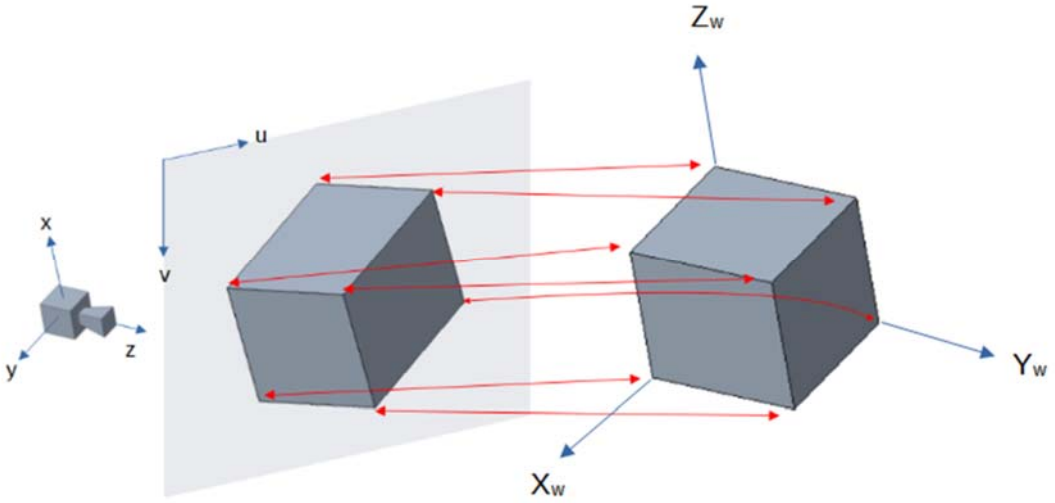

Figure 1. Perspective projection of points onto the image plane.

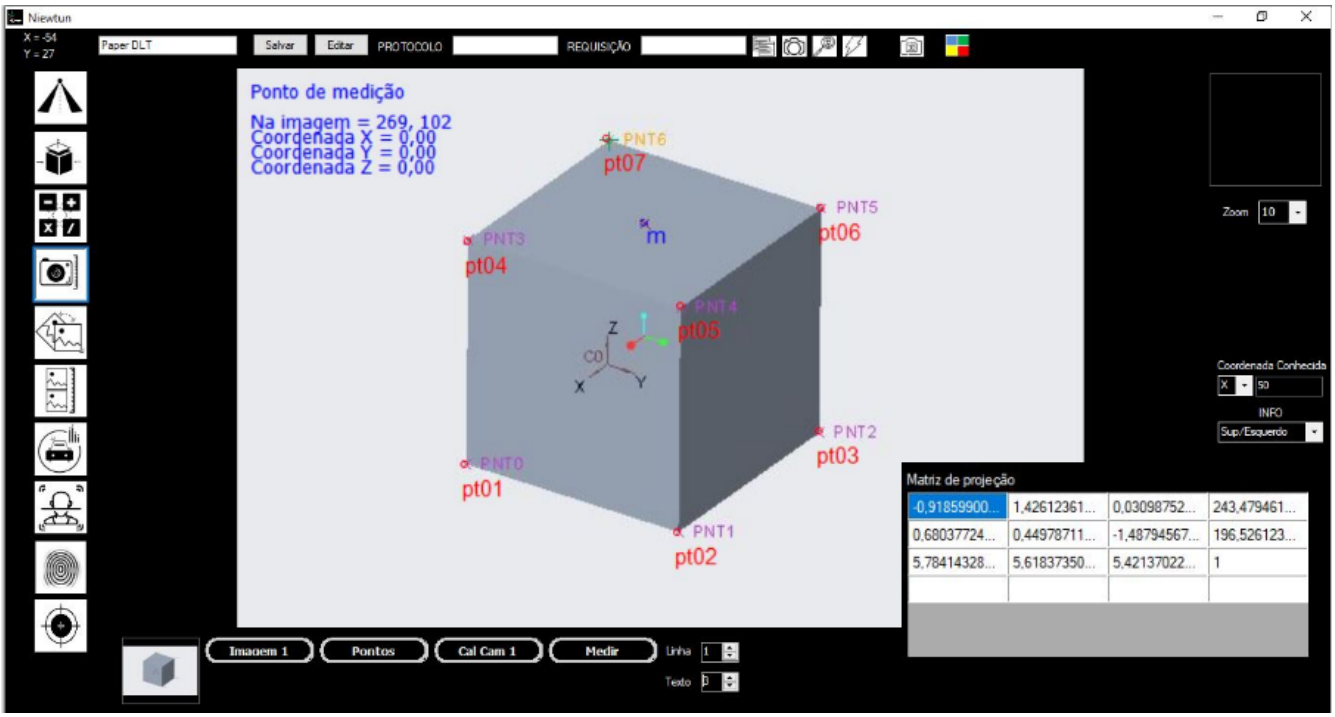

Figure 2. The keyframe for the camera calibration process.

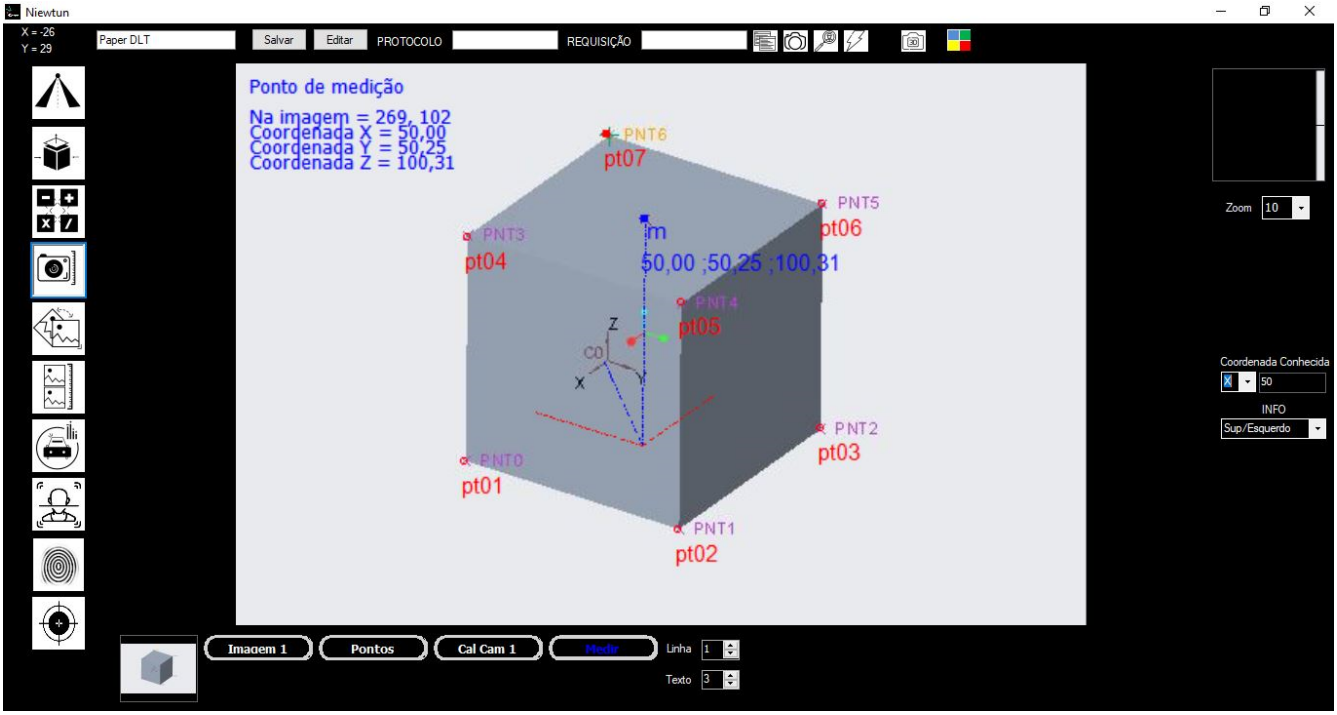

Figure 3. A measuring point showing the result of the centre point of the top face of the object at the calculated coordinates of (50, 50, 100).

Table 1. The control points.

Point	x (world)	y (world)	z (world)	u (image)	v (image)
PT01	100	0	0	151	263
PT02	100	100	0	292	308
PT03	0	100	0	386	241
PT04	100	0	100	153	115
PT05	100	100	100	294	158
PT06	0	100	100	387	93
PT07	0	0	100	245	47

Table 2. The calculated Projection Matrix.

Projection Matrix			
-0.91859901	1.42612362	0.03098753	243.47946167
0.68037724	0.44978711	-1.48794568	196.52612305
0.00005784	0.00000562	0.00005421	1.00000000

SOUTHERN JOURNAL OF SCIENCES

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Original research paper

DENSE CLUSTERS OF RAW SEWAGE LOCATIONS ON MINNA NEIGHBOURHOOD GIS MAPS ARE POINTERS TO VERITABLE URBAN DECAY AND MOSQUITO-BREEDING GROUNDS

JONAH, Sunday Adole[1*]; OLORUNTAYO, Freeman Olorunfemi[2]; EBIJE, Emmanuel Adah[3]; MOSES, Jesse[4]; NKEMJIKA, Victory Chukwuemere[5]; WADA, Mark Andrew[6]; SAIDU, Salihu[7]; SUNDAY, Joy Ada[8]

[1,2,3,4,5,6]Federal University of Technology, School of Physical Science, Department of Physics, Minna, Nigeria

[7]Federal University of Technology, School of Physical Science, Department of Geography, Minna, Nigeria

[8]Benue State University, Faculty of Health Sciences, Department of Medicine and Surgery, Makurdi, Benue State

**Corresponding author:*
sajonah2003@yahoo.com

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ABSTRACT

Background: The lack of comprehensive baseline data on raw sewage pollution in Minna, Nigeria's Niger State capital, represents a significant gap in public health information. This deficiency necessitates a systematic study to establish a database documenting sewage pollution patterns in Minna's urban environment. **Aim**: To employ georeferencing tools and descriptive observations for identifying and mapping potential mosquito breeding sites related to sewage discharge within Minna's built-up areas and to develop an interactive Geographic Information System (GIS) map as an environmental audit tool for public health officials. **Methods**: The study area was divided into five sectors: Greater Bosso, Minna Central, Greater Maitumbi, Tunga, and Greater Chanchaga. Following initial site familiarization and GIS equipment testing, systematic surveys were conducted. Field teams documented locations of household sewage discharge points, collecting geographic coordinates, temporal data (date, time, weather conditions), and site characteristics. Each identified location was photographed and recorded in standardized data sheets, including household information where available. **Results**: Using ArcGIS®10.8 software, comprehensive sewage pollution layers were created for each sector by integrating collected field data with Minna's township built-up and settlement shapefiles. The mapping revealed distinct pollution patterns and clusters across different neighborhoods. **Discussion**: Analysis of the spatial distribution showed a clear correlation between socioeconomic status and sewage management practices, with higher concentrations of improper sewage discharge in low-income areas. **Conclusions**: This database serves as a valuable resource for public health interventions targeting mosquito breeding grounds. Regular monitoring through periodic sewage pollution audits and expanded geographical coverage is recommended for improved urban health management.

Keywords: *Sewage-pollution; cesspit; georeferencing; GIS; sanitation*

1. INTRODUCTION

The result of the limited-extent pilot study of 2012 (Jonah *et al.*, 2015) to determine the spatial spread of raw sewage discharge over the built-up area of Minna was significant in its novelty because raw sewage discharge points are veritable mosquito breeding sites in the urban area. It is known that mosquitoes are active vector parasites that transmit malarial disease.

The term “sewage” describes raw sewage, sewage sludge, or septic tank waste. Raw sewage is mainly water containing excrement, industrial release, and debris such as sanitary towels, condoms, and plastic. Excrement is the major source of harmful microorganisms, including bacteria, viruses, and parasites. It is also water-carried waste, in solution or suspension, that is intended to be removed from a community. It is more than 99% water and is characterized by

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volume or rate of flow, physical condition, chemical constituents, and the bacteriological organisms that it contains. Sewage treatment reduces the water content and removes debris but does not kill or remove all the microorganisms (www.hss.delaware.gov).

The aim of this study is principally the employment of the tools of georeferencing and descriptive observations to identify locations within the built-up areal extent of Minna that are considered veritable mosquito breeding sites whilst further employing the route of the Geographic Information System (GIS) to create an interactive map of Minna encapsulating this endeavor such that this map becomes an environmental audit mechanism tool in the hands of public health inspectors and managers.

1.1. Classes of Sewage.

Classes of sewage include sanitary, commercial, industrial, agricultural, and surface runoff. The wastewater from residences and institutions, carrying body wastes, washing water, food preparation wastes, laundry wastes, and other waste products of normal living, are classed as domestic or sanitary sewage. Liquid-carried wastes from stores and service establishments serving the immediate community, termed commercial wastes, are included in the sanitary or domestic sewage category if their characteristics are similar to household flows. Wastes that result from an industrial process or the production or manufacture of goods are classed as industrial wastewater. Their flows and strengths are usually more varied, intense, and concentrated than those of sanitary sewage. Surface runoff, also known as storm flow or overland flow, is that portion of precipitation that runs rapidly over the ground surface to a defined channel. Precipitation absorbs gases and particulates from the atmosphere, dissolves and leaches materials from vegetation and soil, suspends matter from the land, washes spills and debris from urban streets and highways, and carries all these pollutants as wastes in its flow to a collection point (www.en.wikipedia.org).

1.2. What is a Sewage Spill?

Sewage spills occur when the wastewater being transported via underground pipes overflows through a manhole, cleanout, or broken pipe. Sewage spills cause health hazards, damage homes and businesses, and threaten the environment, local waterways, and beaches. Septic system failure can also result in exposure to sewage. Improper homeowner maintenance is the most common reason for septic system failure. If poorly maintained systems are not pumped out regularly, they have sludge (solid material) build up inside the septic tank. Sewage then flows into the absorption field, clogging it beyond repair. Heavy rains can saturate septic fields, causing systems to overflow and fail (www.hss.delaware.gov).

1.3. How can People be exposed to sewage?

People are exposed to sewage by hand-to-mouth contact during eating, drinking, and smoking or by wiping the face with contaminated hands or gloves. Exposure can also occur by skin contact, through cuts, scratches, or penetrating wounds, and from discarded hypodermic needles. Certain organisms can enter the body through the surfaces of the eyes, nose, and mouth, and they can be breathed in as dust, aerosol, or mist (www.hss.delaware.gov).

1.4. Hazards of Untreated Sewage.

Every year, hundreds of billions of gallons of untreated sewage flow into our rivers, lakes, and coastal waters. Unknowingly, many Americans and their loved ones risk serious illness when untreated sewage seeps into the water they use for recreation or drinking. The EPA (Environmental Protection Agency of the US) estimates that over 7 million people suffer from mild to moderate illnesses caused by untreated sewage every year. Another ½ million get seriously ill. However, the number of illnesses caused by raw sewage could be much higher than we think. Many people who get sick from untreated sewage are not aware of the cause of their illness and do not report it to their doctors or local health officials (www.hss.delaware.gov).

1.5. Pathogens.

Most illnesses that arise from contact with sewage are caused by pathogens, which are biological agents that cause disease or illness in a host. The most common pathogens in sewage are bacteria, parasites, and viruses. They cause a wide variety of acute illnesses, including diarrhea and infections. These illnesses can be violent and unpleasant but mostly pass after several days or weeks with no lasting effects. In some cases, however, pathogens can cause serious long-term illnesses or even death. Certain groups, such as children, the elderly, and those with a weakened immune system, are particularly vulnerable to

these long-term effects. When the parasite cryptosporidium contaminated the drinking water supply in Milwaukee in 1993, 403,000 people became ill, and 70-100 people died, the vast majority of whom had been HIV-positive (www.hss.delaware.gov).

Furthermore, according to Lamb (www.ehow.com) and Green (www.ehow.com), pathogens are at the heart of most of the conditions that result from raw sewage. Sewage pathogens often include parasites, viruses, and bacteria, which cause diarrhea and infections. Though these conditions can be violent, they often pass within a few days or weeks without lasting effects; however, death can occur. Raw sewage is particularly dangerous to people who have weak immune systems, such as children and the elderly.

1.6. Toxic Algal Blooms.

In addition to pathogens, the high nutrient levels in untreated sewage can cause illness when they create algal blooms. Algal blooms are rapid increases in the population of phytoplankton algae, or single-celled plants that serve as an important food source for other organisms. The nutrients in sewage act as fertilizers and cause the number of algae to swell. Some algae are toxic to humans, and they can come in contact with them by eating shellfish or swimming or boating in contaminated water. Symptoms from exposure include memory loss, vomiting, diarrhea, abdominal pain, liver failure, respiratory paralysis, and coma. If an affected person does not receive proper medical attention, some toxins can be fatal (www.AmericanRivers.org).

Sewage and wastewater contain bacteria, fungi, parasites, and viruses that can cause intestinal, lung, and other infections. Bacteria may cause diarrhea, fever, cramps, and sometimes vomiting, headache, weakness, or loss of appetite. Some bacteria and diseases carried by sewage and wastewater are E. coli, shigellosis, typhoid fever, salmonella, and cholera. Fungi such as Aspergillus and other fungi often grow in compost. These can lead to allergic symptoms (such as runny nose) and sometimes can lead to lung infection or make asthma worse. If you have other health problems, you may be more likely to get sick from exposure to Aspergillus. Parasites, including Cryptosporidium and Giardia lamblia, may cause diarrhea, stomach cramps, and even nausea or a slight fever. Most people have no symptoms of roundworm (Ascariasis).

Roundworms cause coughing, trouble breathing, and/or pain in your belly and blocked intestines. Viruses such as Hepatitis A cause liver disease. Symptoms of Hepatitis A are feeling tired, having pain in your belly, being nauseous, having jaundice (yellow skin), having diarrhea, or not being hungry. The Centers for Disease Control and Prevention (CDC) says sewage workers are not at more risk of Hepatitis A infection than other workers. If many people in your community have Hepatitis A, your risk may be higher than usual.

Because of the lack of waste management facilities in some parts of the world, sewage can be dumped in locations that are inadequate for the protection of natural resources, such as freshwater locations, and inadequate for the protection of individuals from diseases. As improperly treated sewage contains a number of chemicals and germs harmful to the human body, allowing such waste to be dumped in locations vital for providing basic human needs will lead to long-term problems with serious illnesses. The fact that poorer countries are also often countries with higher temperatures and levels of humidity (conditions in which such diseases thrive) added an extra level of danger.

1.7. Leptospirosis.

One of the diseases that come from the improper treatment of sewage is Leptospirosis (known via its scientific name, *Leptospira icterohaemorrhegiae*). The disease is spread by parasitic worms and transferred to humans via contaminated water and rats. The disease causes a number of symptoms to an individual who contracts it, such as high fevers, severe loss of appetite, vomiting and nausea, severe head and muscle aches. These symptoms last for a period of between four to seven days.

1.8. Hepatitis A.

Another serious disease caused by the mistreatment of sewage is Hepatitis A. The ingestion of contaminated water mainly causes this disease and is potentially fatal in large enough quantities. Hepatitis A causes symptoms such as fever, abdominal pain, dark-colored urine, and jaundice and will often infect an individual several weeks before they have knowledge of potentially suffering from it. The disease has an incubation time of three to four weeks, meaning an individual can contract Hepatitis A and not suffer any symptoms until at least a month later.

1.9. Parasites.

Parasites are also a common consequence of the improper treatment of sewage (some of these parasites are Giardia and Cryptosporidium). These parasites are found in raw sewage and contaminated water, and the symptoms could last for years (fever, diarrhea, and severe stomach cramps). A difference between the diseases and the parasites is the fact that a minority of individuals don't suffer any negative symptoms from the contraction of parasites.

1.10. Gastroenteritis.

American Rivers (www.AmericanRivers .org) stated that approximately 1.5 million people suffer from gastroenteritis at beaches along two counties in California every year. The condition, one of the most common causes of raw sewage, results in inflammation of the intestines along the gastrointestinal tract. The result is diarrhea, cramping abdominal pain, nausea, and vomiting. People often refer to these symptoms as the "stomach flu," though influenza includes head and body aches, as well as respiratory symptoms. Gastroenteritis can also be caused by shellfish and other food-borne illnesses. Other illnesses include cholera, dysentery, and infectious hepatitis.

1.11. Wildlife.

High raw sewage levels can affect the ecosystem by killing fish and other wildlife. Algal growth can increase rapidly in areas with high raw sewage levels. Algae consume oxygen and deplete its abundance of fish. Areas, where high raw sewage is detected are the result of sewage lines that are improperly maintained or sewage that hasn't been treated correctly. This can cause closures at beaches and other water recreation areas, sometimes leading to a drop in tourism.

According to the Encyclopaedia Britannica (2014), malaria is a serious relapsing infection in humans, characterized by periodic attacks of chills and fever, anemia, splenomegaly (enlargement of the spleen), and often fatal complications. It is caused by one-celled parasites of the genus *Plasmodium* that are transmitted to humans by the bite of *Anopheles* mosquitoes. Malaria can occur in temperate regions, but it is most common in the tropics and subtropics. In many parts of sub-Saharan Africa, entire populations are infected more or less constantly. Malaria is also common in Central America, the northern half of South America, and in South and Southeast Asia. The disease also occurs in countries bordering on the Mediterranean, in the Middle East, and in East Asia. In Europe, North America, and the developed countries of East Asia, malaria is still encountered in travelers arriving or returning from affected tropical zones.

Malaria in humans is caused by five related protozoan (single-celled) parasites: *Plasmodium falciparum*, *P. vivax*, *P. ovale*, *P. malariae*, and *P. knowlesi*. The most common worldwide is *P. vivax*. The deadliest is *P. falciparum*. In 2008, *P. knowlesi*, which was thought to infect primarily Old World monkeys and to occur only rarely in humans, was identified as a major cause of malaria in humans in Southeast Asia, accounting for as many as 70 percent of cases in some areas. *P. knowlesi* was found to be easily confused with *P. malariae* during microscopic examination, resulting in many cases being attributed to *P. malariae* when, in fact, they may have been caused by *P. knowlesi*.

Plasmodium parasites are spread by the bite of infected female *Anopheles* mosquitoes, which feed on human blood in order to nourish their own eggs. While taking its meal (usually between dusk and dawn), an infected mosquito injects immature forms of the parasite, called sporozoites, into the person's bloodstream. The blood carries the sporozoites to the liver, where they mature into forms known as schizonts. Over the next one to two weeks, each schizont multiplies into thousands of other forms known as merozoites. The merozoites break out of the liver and reenter the bloodstream, where they invade red blood cells, grow and divide further, and destroy the blood cells in the process. The interval between invasion of a blood cell and rupture of that cell by the next generation of merozoites is about 48 hours for *P. falciparum*, *P. vivax*, and *P. ovale*. In *P. malariae,* the cycle is 72 hours long. *P. knowlesi* has the shortest life cycle—24 hours—of the known human *Plasmodium* pathogens, and thus, parasites rupture daily from infected blood cells.

Most merozoites reproduce asexually—that is, by making identical copies of themselves rather than by mixing the genetic material of their parents. A few, however, develop into a sexual stage known as a gametocyte. These will mate only when they enter the gut of another mosquito that bites the infected person. Mating between gametocytes produces embryonic forms called ookinetes; these embed themselves in the mosquito's gut, where they mature after 9 to 14 days into oocysts, which in turn break open and release thousands of sporozoites that migrate to

the insect's salivary glands, ready to infect the next person in the cycle.

Typically, victims who are bitten by malaria-carrying mosquitoes experience no symptoms until 10 to 28 days after infection. The first clinical signs may be any combination of chills, fever, headache, muscle ache, nausea, vomiting, diarrhea, and abdominal cramps. Chills and fever occur in periodic attacks; these last 4 to 10 hours and consist first of a stage of shaking and chills, then a stage of fever and severe headache, and finally a stage of profuse sweating during which the temperature drops back to normal. Between attacks, the temperature may be normal or below normal. The classic attack cycles, recurring at intervals of 48 hours (in so-called tertian malaria) or 72 hours (quartan malaria), coincide with the synchronized release of each new generation of merozoites into the bloodstream. Often, however, a victim may be infected with different species of parasites at the same time or may have different generations of the same species being released out of synchrony—in which case the classic two- or three-day pattern may be replaced by more frequent rigors of chills, fever, and sweating. The parasites continue to multiply—unless the victim is treated with appropriate drugs or dies in the interim.

Besides attacks, persons with malaria commonly have anemia (owing to the destruction of red blood cells by the parasites), enlargement of the spleen (the organ responsible for ridding the body of degenerate red blood cells), and general weakness and debility. Infections due to *P. falciparum* are by far the most dangerous. Victims of this “malignant tertian” form of the disease may deteriorate rapidly from mild symptoms to coma and death unless they are diagnosed and treated promptly and properly. The greater virulence of *P. falciparum* is associated with its tendency to infect a large proportion of the red blood cells; patients infected with that species will exhibit ten times the number of parasites per cubic millimeter of blood than patients infected with the other three malaria species. In addition, red blood cells infected with *P. falciparum* have a special tendency to adhere to the walls of the tiniest blood vessels or capillaries. This results in obstruction of the blood flow in various organs, but the consequences are gravest when capillaries in the brain are affected, as they often are. It is this latter complication—known as cerebral malaria and manifested by confusion, convulsions, and coma—that frequently kills victims of *P. falciparum* malaria. Several strains of *P. falciparum* have developed that are resistant to some of the drugs used to treat or prevent malaria.

Infections of *P. vivax* and *P. ovale* differ from the other two types of malaria in that some of the sporozoites may remain dormant in the liver in a “hypnozoite” stage for months or even years before emerging to attack red blood cells and cause a relapse of the disease.

The Geographic Information System (GIS) provides an interactive platform by which maps that have been created of geospatial attributes can be queried in sort of user-friendly interfaces such that a “deep-mine” of acquired geospatial data can be readily processed and the result displayed in rapid relatable formats that constitutes the basis of a veritable audit mechanism. Jonah *et al.* (2011), Jonah and Jimoh (2013), Jonah and Ayofe (2014), Jonah and Saidu (2018), and Jonah and Sunday (2021) have employed this audit mechanism characteristic of the GIS in their works on urban built-up landmarks, site-specific topographic, natural-material economic-resource, raw sewage, and air pollution inquiries.

A GIS is a computer system for performing geographical analysis. GIS has four interactive components: an input subsystem for converting into digital form (digitizing) maps and other spatial data, a storage and retrieval subsystem, an analysis subsystem, and an output subsystem for producing maps, tables, and answers to geographic queries. GIS is frequently used by environmental and urban planners, marketing researchers, retail site analysts, water resource specialists, and other professionals whose work relies on maps. GIS evolved in part from the work of cartographers, who produce two types of maps: general-purpose maps, which contain many different themes, and thematic maps, which focus on a single theme such as soil, vegetation, zoning, population density, or roads. These thematic maps are the backbone of the GIS because they provide a method of storing large quantities of fairly specific thematic content that can later be compared.

2. METHOD

2.1 Study Area Segmentation and Pre-Survey.

At the outset, Minna township built-up areas, shown in Figure 1, were segmented into five sectors, namely Greater Bosso, Minna Central, Greater Maitumbi, Tunga, and Greater Chanchaga. Subsequently, the pre-survey stage, whence the survey party visited random segment

locations for site familiarisation and testing of the hand-held Geographic Information System unit especially, was initiated.

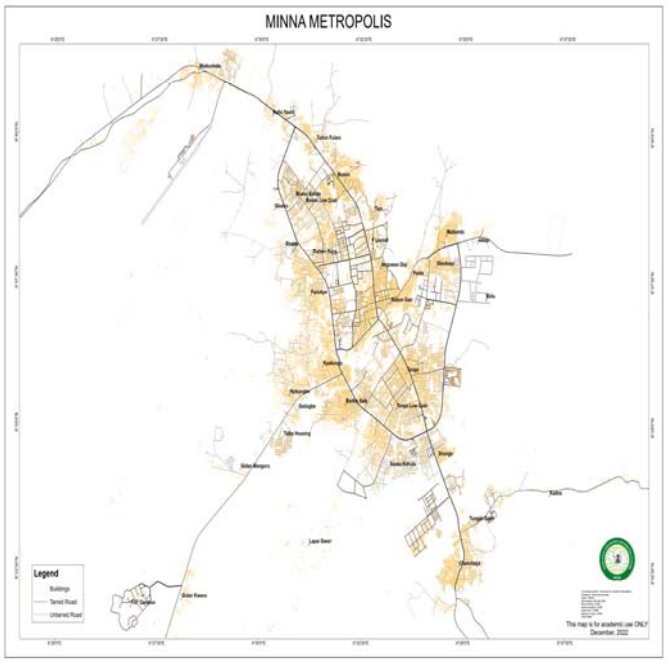

Figure 1. *Map of Minna township*

2.2. Principal Survey Procedures.

Upon the familiarisation trips to the broader survey area, the main exercise kicked in. Crew members investigate every acre of assigned sectors for locations where sewage water freely flows out of households into the neighborhood, forming slow-moving puddles. At such a location, geographic information coordinates are taken along with the date of survey, time of the survey, weather at the time of the survey, name of recorder or data specialist, and information about the defaulter householder (where this is volunteered). The survey party also takes photographs of the point of interest. This process is repeated for as many points as can be accessed by the data specialists. All this germane information is recorded on a purpose-specific datasheet.

3. RESULTS AND DISCUSSION

3.1 Analyses of Data

3.1.1 Importing Latitude and Longitude Information at Each Survey Point into ArcGIS®10.8.

From each data sheet corresponding to a distinct raw sewage pollution point, latitude and longitude (x-y) information was extracted and imported into the ArcGIS®10.8 software. Next, the World Geodetic System (WGS 1984) platform was chosen as the default coordinate system for the x-y information.

3.1.2 Acquisition of the Minna Township Built-up and Settlement Shapefiles.

The Minna township built-up and settlement shapefiles were duly acquired and imported into the ArcGIS®10.8 software. By merging the two distinct shapefiles, the required substrate of major and minor roads and settlements was activated, thus defining a collage of the Minna township map.

3.1.3 Creation of the Minna Raw Sewage Pollution Layer.

It is necessary to create polygons for locations with identified raw sewage pollution menace so as to separate these regions from other unpolluted zones. For the five sectors, distinct polygons were also created to segment the respective sub-study areas. This means that the road networks and settlements in these sectors are emphasized on the collaged Minna township map. Each georeferenced location is consequently highlighted on its true placement point in the respective sub-study areas. Figures 2 to 6 show the raw sewage pollution layers on the Minna GIS map for the different sectors of the town.

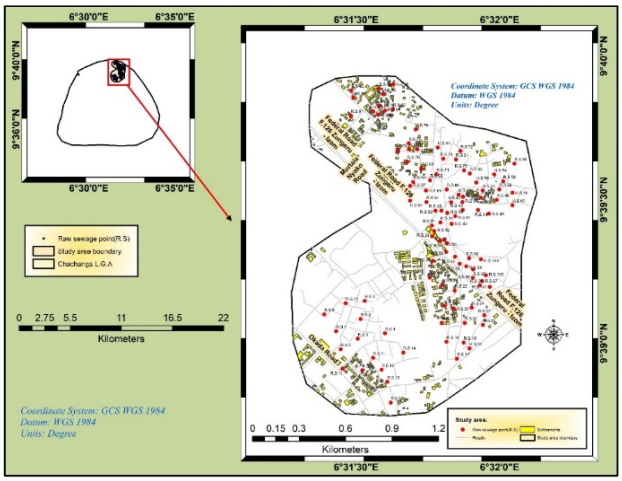

Figure 2. *The raw sewage pollution layer for Greater Bosso shows more sanitation default zones at the central to the north-northcentral portions*

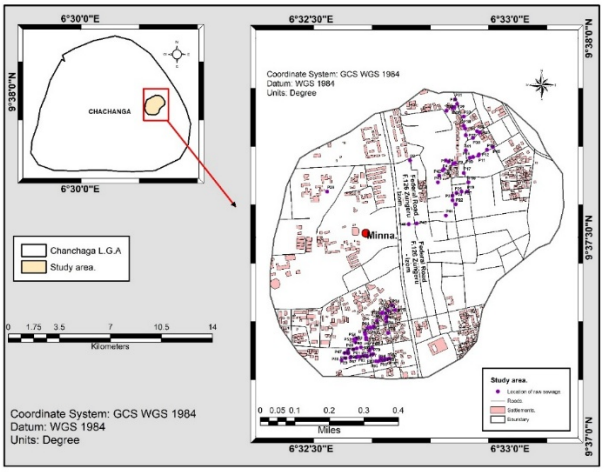

Figure 3. Composite raw sewage pollution layer for Minna Central showing zones of obvious mosquito breeding sites at the southwest and northeast

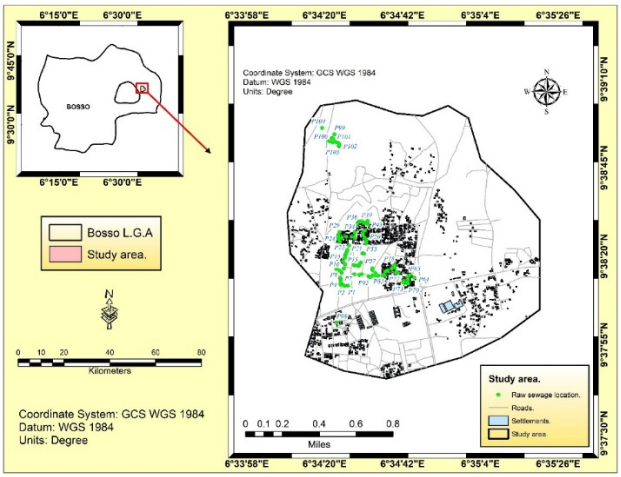

Figure 4. Composite raw sewage pollution layer for Greater Maitumbi showing preponderance of slum settlements at the central to the northwest portions

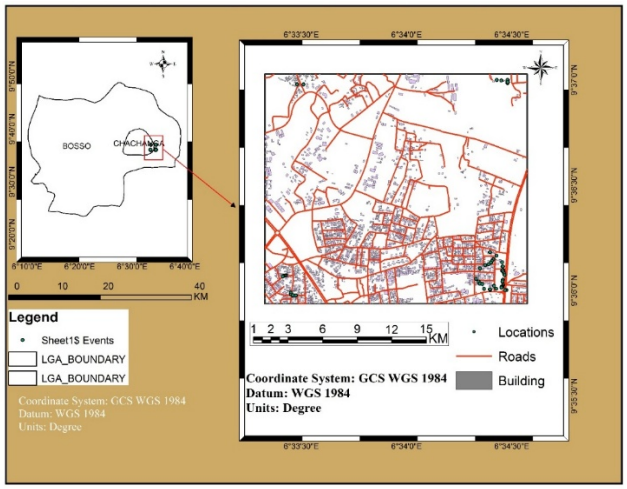

Figure 5. Composite raw sewage pollution layer for Tunga with no defined slum-settlement clusters or mosquito-breeding locations except at a tiny segment of the southeast portion of the neighborhood as well as at the extreme southwest

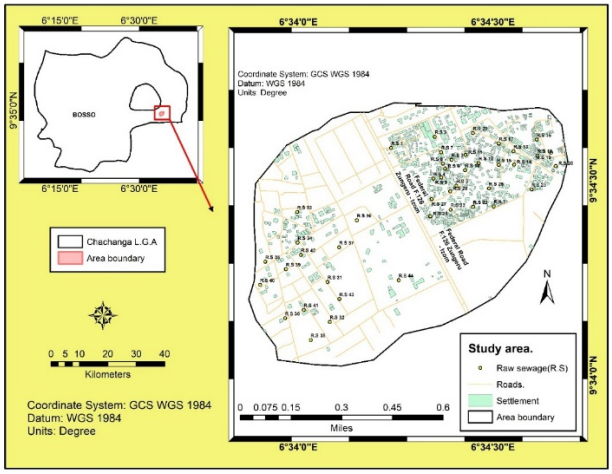

Figure 6. The composite raw sewage pollution layer for Greater Chanchaga indicates that poor housing settlements that favor mosquito-breeding locations are concentrated to the northeast and southwest of the federal highway bisecting this neighborhood

3.2 Discussion

The composite raw sewage pollution maps for the neighborhoods of Greater Bosso, Minna Central, Greater Maitumbi, Tunga, and Greater Chanchaga form the contiguous collaged map of Minna's built-up township. Representative dots at their true latitude-longitude positions on each sectored polygon area have been colored-coded to represent a raw sewage pollution point. However, the use of different color schemes for the different sectors was just a mere aesthetic excursion. Figure 2 indicates that more than 50% of the households visited are at default of sewage sanitation. The southern one-half of the Greater Bosso neighborhood, indicating fewer clusters, is the portion where very influential government functionaries and businessmen have built their dwellings in spite of cultural norms.

The information gleaned from Figure 3 indicates less than 25% raw sewage pollution regime for the Minna Central neighborhood.

The fact known to residents of Minna is that the proportion of green-clustered dots for the core Greater Maitumbi sub-study area of Figure 4 should be 95%-plus. The core built-up neighborhood is one large expanse of slum-infested portion of town. Alas, investigations for this study were limited to tiny portions of the northwest and the west-central neighborhoods of Greater Maitumbi, where the proportion of

households at the default of sewage sanitation was over 90%. Wide expanses of undeveloped bushlands ring off the core Greater Maitumbi sub-study area at the heart of Minna.

In the Tunga neighborhood, heavily built-up in the southern sector, as indicated in Figure 5, survey density does not correspond to housing density (this was due to survey resources constraints), but for the locations visited at the built-up zones of the northwest, northeast, southwest, and southeast, green-dot clusters overlap in regimes or patterns that will be nightmarish for town planners. The northern sector of the Tunga neighborhood is characterized by open spaces of undeveloped fields with wild vegetation growing there.

The densely built-up northeast zone characterizes the Greater Chanchaga neighborhood of Figure 6 and the comparatively spaced-out southwest zone, conveniently separated by the arterial F126 highway that traverses Minna town. Clusters of yellow dots in higher proportion are the norm for the northeast zone vis-à-vis the southwest zone.

4. CONCLUSIONS

Greater Bosso has its share of raw sewage pollution spots that form clusters in poor and low-income neighborhoods. Overall, economic status is a very important factor governing household sewage piping and proper collection in purpose-built cesspits. However, there are, regrettably, relatively affluent homes that still elect to pipe wastewater through orifices bored through the bottom of their brick fence. In Figure 2, the red clusters at the northeast are the slum settlement of Angwan Biri and its outlying neighborhood, whilst those traversing the F126 are the contiguous slum settlements of Hayin Gwari and Central Bosso built-up areas. The scattered red dots in the southeast zone correspond to the relatively well-planned Okada Road neighborhood. Stagnant pools of wastewater that correlate with the red dots in Figure 2 are the media that encourage mosquitoes to breed perennially in this neighborhood. It is no surprise that endemic malarial infestations are commonplace in the Angwan Biri, Hayin Gwari, and Central Bosso built-up areas. The Bosso Campus of the Federal University of Technology, Minna, is actually located in the Central Bosso sector.

The contiguous low-income slum settlements of Limawa and Makera are recognized in Figure 3 by the clusters of purple dots at the south end of the sector, whilst the clusters at the northeast are the densely-populated, unplanned Angwan Sarki-Angwan Daji sectors. There cannot be much surprise here because the clusters observed here correspond to frontier settlements of Minna township from over 80 years ago. It is within the Minna Central neighborhood that the Government Reservation Area (GRA) neighborhood is located at the northwest and where retired army generals' (including two former heads of state) homes fuse with government offices and the Central Bank's offices plus other commercial banks' operation offices at the east-central portion. The northwest and southeast portions of the Minna Central neighborhood are the "cleanest" habitable built-up areas because of the absence of sewage sludge that encourages mosquitoes and other vermin to breed. This situation sharply contrasts those of the Limawa, Makera, and Angwan Sarki-Angwan Daji sectors.

The predominance of clusters of green dots in Figure 4 for Greater Maitumbi indicates obvious slum settlements. Were available resources to permit a full-scale house-to-house survey, there is no doubt Figure 4 will be one green-dot clustered map.

Obviously, the slum-dwelling conclusion associated with dot clusters can be made for the northwest, northeast, southwest, and southeast portions of Figure 5. These relatively small segments forming a veritable disconnected "ring" over the wider Tunga neighborhood will lead to the obvious subjective conclusion that Inner Tunga suffers raw sewage sanitation default. Nonetheless, a purpose-specific study must be conducted in this regard. The Tunga sector is one of two "old town" neighborhoods (the other being Minna Central) of Minna from over 80 years ago, and not having a built-up segment designated for GRA, it is a veritable sewage-sludge-cum-mosquito-breeding built-up neighborhood.

Yellow-dot spread corresponds to residential densities in the two zones of interest in the Greater Chanchaga sector of Figure 6, and this pattern appears to be the norm. Clustered, poorly-spaced homesteads are the default of raw sewage sanitation, and thus, these homesteads provide a convenient breeding ground for mosquitoes, thereby engendering endemic malarial infestation.

5. DECLARATIONS

5.1 Study Limitations

From the outset, the projected expense to be incurred by a study of this nature necessitated its execution in a format of a suite of collaborators covering different assigned portions of Minna town. A good enough coverage for academic purposes can be achieved if resources are pooled in this format. If external sources of funding and collaboration had been secured for this study, then a time-independent investigation observation would have also been adopted.

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5.3 Funding Source

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5.4 Competing Interests

The authors declare that there exists no conflict of interest whatsoever arising from the preparation of this manuscript for publication with any other competing interests, whether they be of the authors' or of second parties and third parties thereof. The data employed in the enunciation of the textual material herein are original, having been duly acquired by the authors as part of the annual undergraduate schedule of project supervision here at the Federal University of Technology, Minna, Nigeria. This body of data field, duly archived for validation and reference purposes, are available for integrity checks anytime.

5.5 Open Source

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SOUTHERN JOURNAL OF SCIENCES

ESTABLISHED IN 1993

Note

WITH STRONG PRESENCE AT THE SECOND SOUTHERN SCIENCE CONFERENCE: A HISTORY OF EXCELLENCE IN EDUCATION AND RESEARCH

DE BONI, Luis Alcides Brandini[1*]

[1] Araucária - Scientific Association. Brazil.

** Corresponding author*
e-mail: root@acaria.org

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ABSTRACT

Background: The Second Southern Science Conference (SSCON 2024) represents a significant milestone in international scientific collaboration, bringing together researchers from twelve nations across multiple continents. The conference, held in Mendoza, Argentina, and co-hosted by the University of Vassouras in Brazil, marked both the 64th anniversary of Universidad de Mendoza and the 20th anniversary of Periódico Tchê Química, demonstrating the growing importance of cross-border academic partnerships. **Aim**: This study aimed to document and analyze the outcomes and impact of the Second Southern Science Conference, focusing on participation metrics, collaborative patterns, and institutional contributions while highlighting the significance of the hybrid format in facilitating global scientific dialogue. **Methods**: The analysis involved quantitative assessment of conference participation metrics, including the number of approved papers, author distributions, and institutional representation. The study examined participation patterns across countries and institutions, analyzing collaboration trends through statistical data visualization and comparative analysis of submission rates. **Results**: The conference achieved significant participation metrics with 66 approved papers and 247 contributing authors, averaging 4 authors per paper. The Universidad Nacional de Córdoba emerged as the leading institution, showcasing its 4 centuries legacy of academic excellence. The analysis revealed strong representation from Latin American institutions, with Brazil and Argentina leading in submissions. Most papers involved 2-5 collaborators, indicating effective research collaboration patterns. Over 500 people participated in the event through both in-person and virtual attendance options. **Discussion**: The hybrid format successfully facilitated broader international participation and knowledge exchange, which is particularly beneficial for addressing contemporary global challenges. The strong showing from Latin American institutions highlights the region's growing influence in international scientific discourse. The conference's interdisciplinary nature fostered new collaborative initiatives and research partnerships. **Conclusions**: The conference demonstrated the effectiveness of hybrid international scientific events in fostering global collaboration and knowledge exchange. Areas for improvement were identified, including extended submission timelines and establishment of a permanent management committee. The success of this edition supports the planning of future iterations, with the next edition scheduled to be held in Vassouras, Rio de Janeiro.

Keywords: *Scientific conference, international collaboration, hybrid events, academic research, Latin American science*.

1. INTRODUCTION

The Second Southern Science Conference (SSCON 2024) was held in Mendoza, Argentina, from November 7th to 9th, 2024, with co-hosting in Brazil by the University of Vassouras. This hybrid event brought together researchers from twelve nations across multiple continents. The conference marked both the 64th anniversary of Universidad de Mendoza and the 20th anniversary of Periódico Tchê Química, a publication dedicated to promoting scientific and technological advancements.

DOI: 10.48141/2764-5959.03.v32.n38.2024_CONFERENCE_pgs_21_30.pdf

Figure 1: Participating Countries in the SSCON 2024 - Argentina, Brazil, Georgia, India, Iraq, Ireland, Mexico, Nigeria, Portugal, Russia, Spain, United States, and France.

2. Conference Committees

The Second Southern Science Conference (SSCON 2024) was led by a distinguished group of researchers and professionals from multiple countries, bringing together an exceptional team of academic leaders to organize and guide this international scientific event.

International Organizing Committee

A diverse and accomplished group of academics and researchers led the conference organization:

1. **Conference Chairs**:
    - Dr. Cristián Andrés Quintero (Argentina, Universidad de Mendoza/Universidad Juan Agustín Maza)
    - Dr. Cristiane de Souza Siqueira Pereira (Brazil, University of Vassouras)
2. **Co-Chairs and Key Organizers**:
    - Dr. Walter José Peláez (Argentina, INFIQC-CONICET-FCQ-UNC)
    - Dr. Ketevan Kupatadze (Georgia, ISU)
    - M. Sc. Shaima R. Banoon (Iraq, University of Misan)
    - Dr. Luis Alcides Brandini De Boni (Brazil, A.S.A. General Secretary and Event Treasurer)
3. **Additional Key Organizers**:
    - Dr. Paulo Roberto Barros Gomes (Brazil)
    - Dr. Olubunmi Atolani (Nigeria)
    - Dr. Joan Josep Solaz-Portolés (Spain)
    - Dra. Yolanda Echegoyen-Sanz (Spain)

Local Organizing Staff

Mendoza Host City

- Dr. Noelia Ceballos
- Dr. Patricia Camargo
- Lic. Federico Velazco Montagna
- Dr. Luis Alcides Brandini De Boni
- Paula Cambuli Bianchi
- Agostina Perlbach
- Agustina Quiroga
- Bioq. Andrés González
- Micaela Cabrini
- Abril Videla
- Paloma Rosas

Vassouras Host City

- Dr. Cristiane de Souza Siqueira Pereira
- Dr. Paloma Martins Mendonçais
- M.Sc. Leonardo Feijó Silvestre Mattos
- Larissa Funayama Morra
- Rafael Cardoso
- Sergio Gurito de Carvalho
- Ana Beatriz de Andrade Pereira
- M.Sc. Renata Costa Albuquerque

Scientific Committee

The scientific committee comprised over 60 distinguished researchers from various countries, representing institutions such as:

- University of Kerbala, Iraq
- I. M. Sechenov First Moscow State Medical University, Russia
- Federal Rural University of Rio de Janeiro, Brazil
- University of Vassouras, Brazil
- Nuclear and Energy Research Institute, Brazil
- National University of Córdoba, Argentina
- University of Valencia, Spain
- Ilia State University, Georgia
- And many more international institutions

The conference brought together experts from diverse fields, including environmental sciences, medical research, chemical engineering, biotechnology, and science education, truly embodying the spirit of international academic collaboration.

3. Main Themes and Speakers

The conference covered a comprehensive range of topics, including:

- Food Production and Security
- Energy Production and Sustainability
- Environmental Sciences and Resource Management
- Drug Production and Development
- Production Without Waste
- One Health Approach
- Science Education

Distinguished speakers at this significant international event included, among other eminent researchers and scholars:

- Dr. Mayná Coutinho (Brazil) - Environmental Engineering and Sustainability
- Dr. Miguel Walter Fornes (Argentina) - Reproductive Health Research
- Dr. Bhavna Ambudkar (India) - Electronics and Telecommunications
- Dr. Juliana Gracieli Rezende (Brazil) - Water Resource Management
- Dr. Élcio Jeronimo de Oliveira (Brazil) - Engineering and Space Technology
- Dr. Nancy Fabiana Ferreyra (Argentina) - Nanomaterials and Biosensors
- Dr. Peter Andrew McCullough (USA) - Medical Sciences

The complete list of speakers is available in the book Proceedings of the II Southern Science Conference - Book A

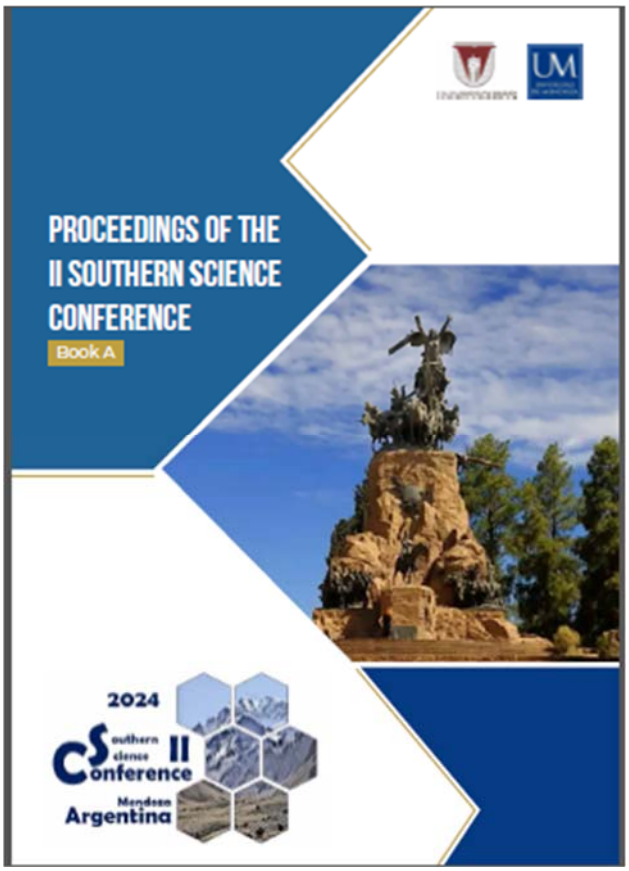

Figure 2: Cover page of the Proceedings of the II Southern Science Conference - Book A

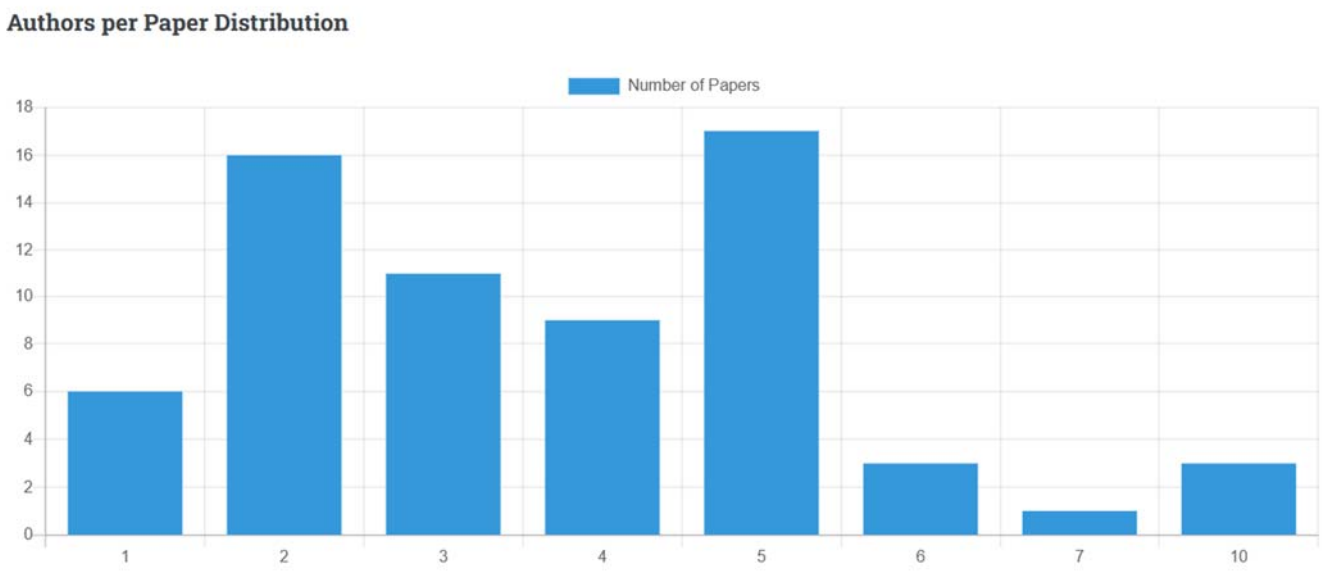

Figure 3: Distribution of Authors per Paper

Figure 4: Cerro de la Gloria monument located in Mendoza, Argentina.

The event at Universidad de Mendoza provided an excellent opportunity for professionals from diverse fields to meet and exchange experiences. The combination of in-person and virtual attendance options created a dynamic environment for knowledge sharing and networking. The historical setting of Mendoza, coupled with the university's modern facilities, provided an ideal backdrop for meaningful scientific discussions and collaboration building. Participants particularly valued the interdisciplinary nature of the interactions, which led to several new collaborative initiatives being proposed during the conference.

4. Results and Participation Analysis

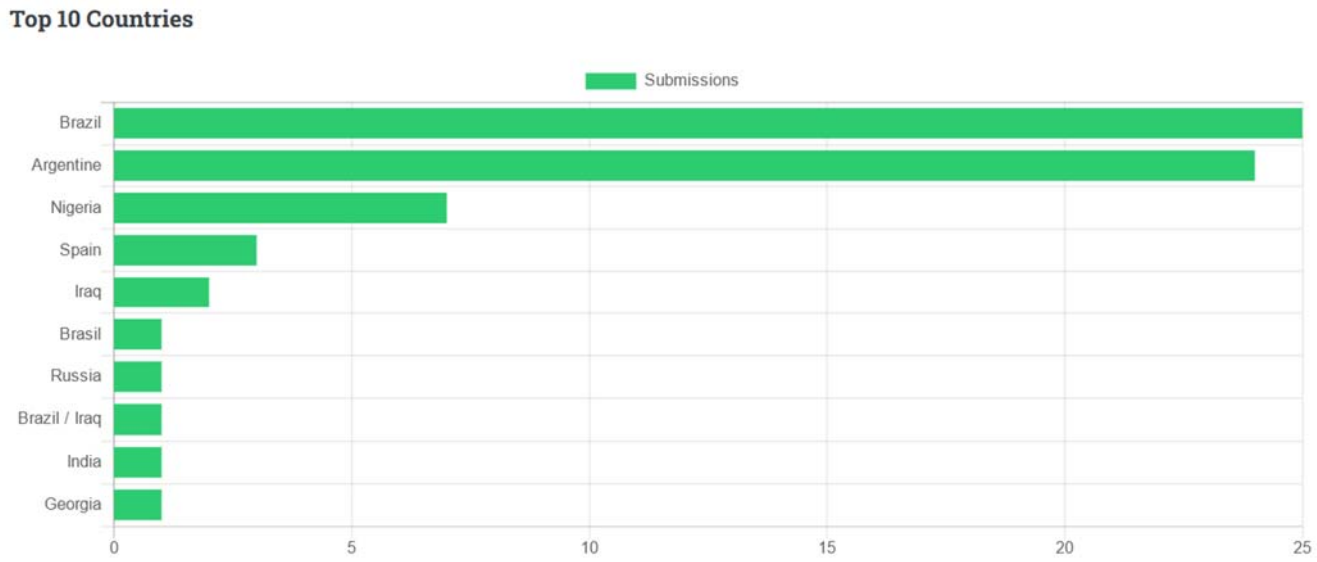

Figure 5: Top 10 Countries by Number of Approved papers

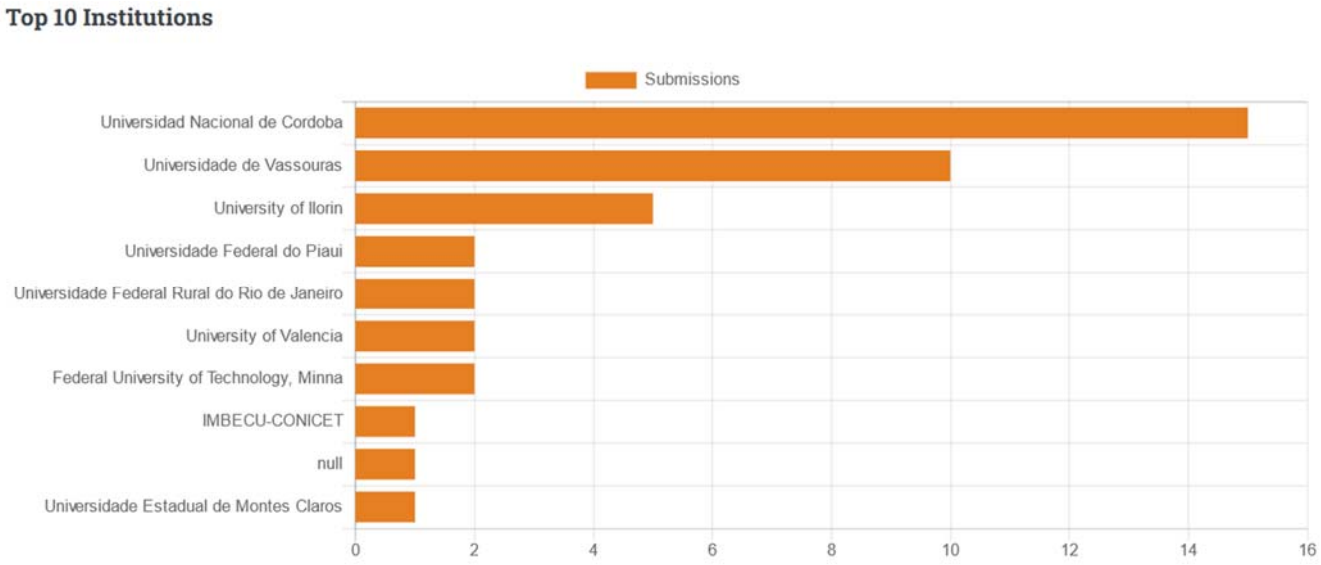

Figure 6: Top 10 Institutions by Number of Submissions

A notable highlight was the participation of the Universidad Nacional de Córdoba (UNC), which showcased its more than 400-year tradition in education and research. As Argentina's oldest university and one of the first established in the Americas, UNC emerged as the leading institution with the highest number of accepted papers, demonstrating its longstanding commitment to academic excellence.

Figure 7: Universidad Nacional de Córdoba (UNC).
Source: Charliemoon ar. (2012, September 6). Compañia de Jesús vista desde el patio del Rectorado de la Universidad Nacional de Córdoba [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Compañia_de_Jesús_vista_desde_el_patio_del_Rectorado_de_la_Universidad_Nacional_de_Córdoba.jpg

The conference achieved significant participation metrics:

- 66 approved papers
- 247 total contributing authors
- Average of 3.7 authors per paper
- Most papers involved 2-5 collaborators
- Strong representation from Latin American institutions
- Over 500 people were involved in the event

5. Conference Program Details

Venue Details

- **Main Location:** Universidad de Mendoza
- **Address:** Boulogne Sur Mer 683, CP 5500, Mendoza, Argentina
- **Main Conference Room:** Facultad de Ciencias Médicas-Aula Magna "Dr. René Favaloro"

Conference Format
The event was conducted in hybrid mode with both in-person and virtual sessions:

Virtual Access

- Room A: (Virtual)
- Room B: (Virtual)
- Physical venue: Aula Magna Dr. René Favaloro

Program Overview

The conference spanned three days (November 7-9, 2024) featuring:

Day 1 (November 7th)

- Opening Ceremony (09:30-10:00)
- Technical Sessions:
  - Intracellular transport to environmental science
  - Chemical Engineering Lab Tour in Vassouras Univesity (in-person only)
  - Institutional Journals Summit
  - International Relations meetings
- Parallel Sessions (Rooms A & B):
  - Bioengineering and materials science
  - Medical research and biotechnology
  - Environmental sustainability
  - Chemical processes and development

Day 2 (November 8th)

- Environmental and water resource management
- Medical and biological research presentations
- Scientific writing and publishing workshop
- Extended programs:
  - Biotechnology
  - Health Sciences
  - Regional development and sustainability

Day 3 (November 9th)

- Academic entrepreneurship session
- Medical research presentations
- Closing ceremony and future announcements
- Networking sessions

Figure 8: Cultivating new ties of friendship between Brazil and Argentina.

The conference not only featured the expertise of seasoned researchers, but also demonstrated a strong focus on the future of science. As evidenced by the Figure 8, the organizing team included both experienced academics and enthusiastic young assistants, such as Luisa and Vera, who were actively involved in the conference.

The presence of these energetic young participants, who seemed to balance their excitement for learning and playing, underscores the conference's commitment to fostering the growth and development of the next generation of scientists. By engaging children and students in the proceedings, the organizers ensured that the event cultivated an inclusive and collaborative atmosphere, one that will inspire the future leaders of the scientific community. The intergenerational teamwork showcased in this image exemplifies the conference's holistic approach to advancing scientific progress.

Program Statistics

- Format: Multiple simultaneous tracks
- Rooms: 3 concurrent virtual rooms (A, B, and C)
- Languages: EN, PT, ES
- Speakers: Over 30 expert presenters
- Sessions: 30-minute average duration
- Networking: Extended breaks between sessions

6. Conference Impact and Future Directions

The conference successfully combined in-person and virtual attendance options, enabling broader international participation and knowledge exchange. This hybrid format proved effective in facilitating global scientific collaboration while addressing critical contemporary challenges.

Areas identified for improvement include:

- Extending the timeline between submission deadlines and event start
- Establishing a permanent event management committee
- Planning the next edition to be held in Vassouras, Rio de Janeiro

The event demonstrated the growing importance of international scientific collaboration in addressing global challenges while highlighting the significant contributions of Latin American institutions to various fields of research.

7. Contact Information

For additional details of the conference:

- E-mail: information@sscon.org
- Website: www.sscon.org

8. DECLARATIONS

8.1. Study Limitations

The note is limited to its content.

8.2. Acknowledgements

The author is highly grateful for the opportunity to participate in the conference and to the organizing institutions for their dedication and hard work.

8.3. Funding source

The author funded this note.

8.4. Competing Interests

The author participated in the conference and was extremely well-received in Argentina. Therefore, this amazing impression may have limited his judgment.

8.6. AI Usage Declaration

This manuscript was developed with the assistance of artificial intelligence tools. Specifically, Claude AI (Anthropic) was used to help organize and structure the content. All information and data presented are accurate and were verified by the author, with the AI serving only as a writing and organization aid. The final content, analysis, and conclusions were reviewed and validated by the author to ensure the accuracy and integrity of the scientific reporting.

8.9. Image Consent Statement

I hereby declare that consent for the use of children's images, in Figure 8, has been obtained from their legal guardians, in compliance with the Brazilian Children and Adolescent Act. The guardians have been duly informed about the use, purpose, and distribution of the images, and have expressed their agreement through formal signed authorization.

Name of project/research coordinators: Dr. Luis A. B. De Boni; Dr. Noelia Ceballos.

SOUTHERN JOURNAL OF SCIENCES

ESTABLISHED IN 1993

Interview

ENTREPRENEURSHIP, INNOVATION, AND COMPETENCY-BASED EDUCATION - INTERVIEW WITH PROF. PAULO CÂMARA. ENGLISH VERSION

Dr. Paulo Wilton Câmara[1]
Universidade de Vassourasl. Brazil.

Luis Alcides Brandini De Boni [2*]
Araucária Scientific Association. Brazil

** Corresponding author*
e-mail: labdeboni@gmail.com

Recebido em 25 de Agosto de 2024 – A versão 1.0 da tradução foi concluída em Dezembro de 2024.

SCAN ME

NOTE: Transcript and translation version 1.0.

Dear friends, the interview transcription was done by machine and later reviewed. We are aware that there are imperfections. If you would like to collaborate with improvements, please contact us at southbchem@gmail.com.

https://www.youtube.com/watch?v=ZXxPJzzgzZA

ABSTRACT

Background: The interview was conducted with Professor Paulo Wilton da Luz Câmara, who serves as an associate professor at the University of Vassouras, general coordinator of postgraduate lato sensu programs, and deputy coordinator of the Master's in Environmental Sciences. The Professor has extensive academic and corporate experience. **Objectives**: The main objectives were to understand the importance of corporate experience in the role of a professor and researcher, discuss the evolution of public entrepreneurship policies in Brazil, understand the role of incubators, explore research on renewable energies in the defense sector, and learn about planned innovations for postgraduate programs. **Methods**: The interview was conducted in a semi-structured format with open-ended questions. The audio was transcribed for subsequent analysis and content structuring. **Results**: Corporate experience significantly influences academic performance. There has been relative improvement in public entrepreneurship policies, but the involved bodies lack specific knowledge. Incubators are necessary tools to foster entrepreneurship and innovation. The main challenges in renewable energy research for defense are awareness and organizational policy. Planned innovations for postgraduate programs include connecting education levels, shared management, and an open committee. **Discussion**: The Professor highlights the importance of practical corporate experience in enriching academic performance, noting advances in entrepreneurship policies while emphasizing the need for more specific knowledge. Incubators are seen as essential to fostering entrepreneurship and innovation. In the field of renewable energy applied to defense, challenges are related to awareness and organizational policy. **Conclusion**: The interview underscores the relevance of practical corporate experience in enriching academic performance and the need to improve entrepreneurship policies. Incubators are fundamental to fostering entrepreneurship and innovation. Research on renewable energies in defense faces challenges of awareness and organizational policy. Planned innovations for postgraduate programs aim for greater integration and participation.

Keywords: *Entrepreneurship, Education, Business Administration, Innovation, Technology.*

DOI: 10.48141/2764-5959.04.v32.n38.2024_CAMARA_pgs_31_36.pdf

This interview is part of the interinstitutional scientific dissemination partnership project of the SSCON conference.

Image: SSCON 2024 logo.

Luís: Today, we have the honor of welcoming Professor Paulo Wilton da Luz Câmara for a Q&A session. Professor, first, I would like to thank you for your availability to meet with us and also make a small disclosure about our interview. Our interview will be distributed under a Creative Commons license, and it is public. The transcription of our interview in Portuguese will be published by Periódico Tchê Química and in English by the Southern Journal of Sciences. We will also share our interview with a partner television station. Professor, initially, I would like to ask you to introduce yourself and give a brief history of your career.

Dr. Paulo Wilton da Luz Câmara.

Dr. Paulo C.: First of all, I want to thank you for your attention. It's an honor to be talking with you. Given the objectives of our conversation, we'll get to a larger point. So, here it is: my name is Paulo Wilton Câmara. I'm an associate professor at the University of Vassouras. I'm the general coordinator of lato sensu graduate programs and vice-coordinator of the Master's program in environmental sciences, for which I'm also part of the faculty. My background is in administration. My Master's degree is in administration, focusing on strategic planning and business. My doctorate is in political science, and my post-doctorate is in the defense industrial base. This name comes from the program that was carried out at ESG. I have about 35 years of experience in teaching and also in the corporate world, where I worked at various companies such as Coca-Cola, Pepsi-Cola, Philip Morris, IBM, and others.

Luís: Professor, regarding your experience in the private sector - IBM, Pepsi, Coca-Cola, Philip Morris - how does this corporate experience influence your role as a professor and researcher?

Dr. Paulo C.: I don't believe we can teach with confidence and proper direction if we don't have business practice, especially depending on the type of subject, discipline, or area. This is my view, and no one can change it. What I've learned to this day in the corporate environment, in the companies where I worked, obviously starting not in executive positions or functions, but eventually reaching them, I use and continue to use. I worked in sales, operations, and planning. I only wasn't involved in finance and production. I used the rest, including marketing. I usually tell my students, when referring to examples: "Look, excuse me for using my own examples, but it's because I know mine down to the smallest details and can answer any question about any of them. Third-party examples are just what's written, what we've heard." I do not doubt that my time in corporate life has helped and continues to help me greatly. Currently, I'm practically focused on teaching and academia.

Luís: Perfect, Professor. Moving on to our second question: in your doctorate, you addressed the question, "Why doesn't Brazil have an entrepreneurship policy?" Several years after completing your thesis, how do you evaluate the evolution of public entrepreneurship policies in Brazil?

Dr. Paulo C.: I've noticed that there has been a relative improvement, naturally, due to time and greater effort from the agencies involved. I highlight SEBRAE itself, which, in my understanding, is the most effective agency for

institutional reasons. It works, and SEBRAE has been working. I fought a lot during the time I provided ad hoc services for them. I didn't work at SEBRAE. I worked for SEBRAE, doing specific work according to their needs. So, I think this has been improving over time, although it's been a long time. We could be much more advanced in this if it weren't for some setbacks that we continue to suffer along the way.

The main problem I see is the lack of more specific knowledge from the agencies. That is, practical knowledge regarding general actions developed for medium and small-sized companies. Each group has specific needs, and within these needs, there are different moments. Not all companies, regardless of their group, need money, for example. Money is good for everyone, but sometimes the problem at that moment for that company isn't a matter of credit. Often, the problem is support, legal support, and specific knowledge. Actions are offered as if everything were the same thing. This understanding, I still think, complicates the direction and elaboration of public policies a bit.

Luís: Perfect, Professor. I'll move on to our next question. You coordinated business incubators at UNISUAM and Severino Sombra University, now University of Vassouras. What is the importance of incubators in fostering entrepreneurship and innovation?

Dr. Paulo C.: Regarding incubators, I might be biased because I love this business, but I think they are necessary tools that help a lot as long as they are well-directed and organized. Our concern is to bring what we discuss in the classroom to the market. Incubators, again, as long as they are well-organized and directed, are adequate tools to foster, direct, and help identify these good ideas that we bring from the classroom to transform into business. That's the primary objective of any incubator: transforming ideas into business. I have no doubt about the importance of these tools in teaching and business propagation.

Luís: Regarding incubators, Professor, what are your best memories? Any success case that you remember?

Dr. Paulo C.: This reminds me because I saw a duplicate of this in São Paulo sometime after we had already developed it at college, at University. It refers to an alarm. In Rio de Janeiro, we have a serious security problem, like anywhere in Brazil, but here things are more complicated. So, there was a group of students who built an alarm inside buses to identify to those outside the bus that it was being robbed. I found that very interesting. Although it's not something of great splendor, it was a very cool thing, with very good practical effect. The kids thought about it, identified the problem, researched, and the thing worked out.

Luís: Perfect. Allow me to move on to our next question, Professor. In recent years, you have dedicated yourself to research on renewable energy applications in the Defense sector. What are the main challenges and opportunities in this area?

Dr. Paulo C.: The main focus is on awareness and the need for better use of physical spaces for applying related technologies, mainly through solar and wind energy. Those that can be used within the circular economy have now become a subject in my bioeconomics course. When we talk about recycling, biomass, where we use plants, organic waste, and others, we see military institutions with large physical spaces that could be used for developing these technologies.

The main problem lies in awareness and organizational policy. We see, for example, unit commanders who spend two years in the units and often don't have time to develop something. Sometimes, we can visualize actions in this direction that run into budgetary issues or other limitations. In the end, it's a binomial: policy and awareness.

Luís: Perfect, Professor. As General Coordinator of lato sensu graduate programs at the University of Vassouras, what innovations do you intend to implement in the courses under your management?

Dr. Paulo C.: Lately, I received one more gift, which was the free courses that were incorporated into the graduate coordination. I left the coordination of the administration course at our Maricá campus and was brought to Vassouras to take over graduate coordination. The first task was to restructure in all aspects: physical, organizational, personnel, human resources, and training of the people themselves. A lot of time was spent on this, and obviously, we haven't reached the end, but we're on the right path.

Within this path, I've always valued continuing education. One thing I'm working on more diligently is the connection between undergraduate, lato sensu graduate programs,

and Master's, starting with free courses. The general connection includes free courses, and undergraduate, graduate, master's, and doctorate programs. Master's and doctorate are a bit more complicated to achieve because they involve many other issues and aren't under my direct responsibility.

Within the area of free courses and graduate courses, we have total autonomy. We've been working in this direction of connection, showing what we have in lato sensu graduate programs and free courses. We do this through constant conversations and meetings with supervisors, coordinators, professors, and even students. We show that, even in the best course at the best institution, students will never leave with all the knowledge and skills needed. We need to complement this undergraduate development through the offer of these free courses and graduate programs.

Regarding environmental sciences, we're already well on this path. We're creating free courses and adding subjects focused on the matter. I have courses in Circular Economy, Bioeconomics, and Sustainability. We seek to bring all these things together to create a path in this direction.

We have the University's alumni meeting, which aims to bring these graduates into our work. We have research applications and development in some disciplines. For example, I transformed the TCC (Course Conclusion Work) into PFC (Course Final Project). This leads to a product presentation honoring innovation. We've ended the traditional TCC in some courses. We seek to capture these better potentials so that this becomes business in the end.

I work a lot with shared management in the sense of involving all employees, even in major business decisions. We have some specific agreements and permanently seek to put an open collegiate to work, where everyone speaks up, and the collegiate really matters.

We're now launching, scheduled for August 30, distance learning graduate programs.

Luís: Professor, I have two questions for you. How long have you been in Vassouras?

Dr. Paulo C.: Two years.

Luís: And regarding future planning for the institution's development, how many years ahead have you planned for?

Dr. Paulo C.: For two years as well. Of course, the second year undergoes adjustments. In fact, the first one does, too. Any plan must be flexible; otherwise, it's not planning. I usually tell students that planning is flexible. Any plan has to be flexible; otherwise, it will not move forward. So, I made this plan for 2024, and it's going well. We've been making efforts, and it's going relatively well. For next year, 2025, I have a draft. It's not a detailed plan, and it's an outline that I feed according to what happens in 2024 so that by the end of 2024, I'll have the 2025 planning ready.

Luís: Perfect. All right then, Professor. Continuing, in 2020, you published the book "Competency-Based Teaching: A Matter of Resilience". Could you explain the concept of competency-based teaching and how it can be applied in administration courses?

Dr. Paulo C.: This work is a continuation of another work where we talked about "Are we delivering what we sell?". This first one emerged from an analysis and conversation about educational institutions saying what they want, selling education services, and to what extent this is true or not.

"Competency-Based Teaching" is a suggestion for a teaching model that replaces disciplines with modules. The curricular structure doesn't follow disciplines and periods but rather modules. This is because I understand there's a big difference between teaching for competency and competency-based teaching.

In this work, based on the National Curricular Guidelines for Administration and Field Research, we reached the conclusion of 13 necessary competencies for the administrator, distributed in nine modules. We created a framework where, on one side, the listed competencies are listed, and on the other side, the necessary knowledge is required to acquire that competency.

The application of this goes into practical experience where the value of course load practically doesn't exist. The value is the acquisition of competency. If that competency is acquired in 3 months, that's fine. If it's acquired in 6 or 7 months, that's fine. It depends on the characteristics and needs for acquiring these competencies.

This idea arose because technology, politics, and society are changing rapidly, and administration courses aren't always adequately adapted to this. It's difficult to have two or three curricular matrices running at the same time. In this suggested model, there is an enormous ease in maintaining this update relative to market needs.

Luís: Professor, moving on to our next question, your doctoral thesis used the Advocacy Coalition Framework as a theoretical framework. Could you briefly explain this model and how it can be useful for analyzing public policies?

Dr. Paulo C.: The Advocacy Coalition Framework is a reference model by Sabatier from 1999. It emphasizes the role of beliefs and values in the process of formulating, changing, and updating public policies identifying the groups involved.

The model begins by identifying the policy triggers based on problems and the policymakers, whether governmental, public, or private actors. The problem is identified, and these groups, as well as the beliefs and values that these groups attribute to that subject, are studied.

What we notice is that there isn't a global alignment regarding industrial policy, which involves entrepreneurship, innovation, production, in short, everything that involves the market. All of this exists, but it's very scattered. We try to understand why it works this way, and it's exactly because, for some groups, a subject isn't interesting, but it is for others. Then, another group enters in the middle and says the idea is theirs. Groups end up fighting over ideas.

At the end of this story, our biggest problem from the moment policies are implemented is the lack of evaluation. Evaluation of time, effective results, and budget. It's like a control process.

This doctoral work went in this direction. It helped me quite a bit to better understand how these things happen, as within the area of innovation and entrepreneurship, we also talk about public policies. Now, at least, I have an idea.

Luís: Perfect, Professor. Let's move on to our next question. You have extensive experience as an instructor and consultant for SEBRAE in Rio de Janeiro. What are the main challenges currently faced by Brazilian Micro and Small Enterprises?

Dr. Paulo C.: The current problems are basically the same old problems. The characters change, but the problems remain. The actors change. It's like what my grandmother used to say: "Change the bread, and the flies are still there," or vice versa.

First, I have already commented on this. I wasn't a SEBRAE employee, and I didn't work there. I worked for SEBRAE in an ad hoc situation, where I analyzed business plans and provided some instruction and consulting for some companies.

Regarding the challenges, the main ones is knowledge and the respective learning. There is a lack of knowledge of the target audience, which is the direct beneficiaries. I think that's the biggest problem. Then, we depend on people, the actors who shape these policies, and these knowledge directions. We depend on their specific knowledge.

That's why, when you asked about the corporate experience, it brought me exactly to this subject. That is, living, going through, and feeling the problem firsthand is different from you hearing about it, and listening to it. It's more or less like the theory of the paper engineer who has the diploma but has never built a building or been on the road. I usually say there are many theorists in company building. It's a journey that is priceless.

Luís: Professor, we're reaching our last question. Looking to the future, what trends and innovations do you believe will have the greatest impact on teaching and research in administration in the coming years?

Dr. Paulo C.: I have no doubt that it's technology development. And I connect this with the competencies business. What's new today? How do I bring this into my curriculum, into my grid, and into my content program?

To work with a curricular matrix, you can alter it from within the discipline. You can modify the content. I've always given professors the freedom to do this.

In truth, I think the entry of these new technological tools, especially those currently being pushed by artificial intelligence, is getting really serious. The biggest changes happening in knowledge in general - we're talking about

administration, but this is general - are related to agility, better control, and better management that these tools are providing.

I currently have an employee who learned BI (Business Intelligence). She's training and capacity building for other employees. Then, the employees create wonderful things. That's it: it's management and tools driven by technology.

Without any doubt, Artificial Intelligence has a great weight. The bases of the anchors won't change. If you talk about planning, for example, the good old SWOT analysis continues. The bases remain the same, but the way of doing things and the tools used to develop these bases are different. They're new, they're sensational, and more agile. Agility is one of the main points.

Luís: That's incredible, Professor. We've reached the end of our interview today. On behalf of the journals where we're going to publish, I would like to thank you for your availability to receive us. Also, on behalf of all conference colleagues, we hope to see each other in November, right? Have some wine.

Dr. Paulo C.: Very good. It will be very good. I'm the one who thanks you for the opportunity to talk about subjects that are really in my head, that even confuse me. Thank God they confused me; it would have been worse if I had certainty about each one. It was an honor to talk. I'm available if something hasn't been fully explained. Feel free.

Luís: Thank you very much, Professor. Have a good late afternoon.

Dr. Paulo C.: Thank you very much. Have a good weekend.

DECLARAÇÕES

1. Limitations: The interview is limited to its content.

2. Source of funding: The host funded this interview.

3. Conflicts of interest: The host has worked for the journal for many years, and this may have influenced the interview.

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Review paper

REVISÃO E ESTUDO DE COMPLEXOS METÁLICOS COM POTENCIAL ANTIFÚNGICO CONTRA CEPAS DE *Candida albicans*

SILVA, Sarah Soares Da [1] e SANTOS, Edjane Rocha Dos [1*].

[1] Universidade Federal de Mato Grosso, Instituto de Ciências Naturais Humanas e Sociais.

** Corresponding author*
e-mail: edjane.santos@ufmt.br

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ABSTRACT

Background: Candidiasis, caused mainly by *Candida albicans* yeast, is a pathology that affects a significant amount of people in the world, mainly women, thus being a public health issue. In addition, clinical practice has found it difficult to treat candidiasis for two reasons: the multidrug resistance associated with the exacerbated use of available drugs and the high number of side effects caused by current antifungal drugs. In this scenario, this work is a literature review on the antifungal activity of metal complexes against C. *albicans* since they are extensively studied for their varied applications in health sciences, as an object of study in the area of inorganic chemistry, in the subareas of bioinorganic chemistry and pharmaceutical chemistry. **Aim:** The present work consists of a literature review in electronic databases on the potential antifungal action against Candida albicans presented by metal complexes. **Methods:** Data was collected using the Capes, PubMed, Cochrane Reviews and Virtual Health Library (BVS) databases. **Results**: The results obtained through bibliographic surveys show the importance of studies of metal complexes against the strain of C. albicans, which have promising inhibitory activities and in some cases, with Minimum Inhibitory Concentration (MIC) values lower than 20µg/mL **Discussion:** The results obtained through bibliographic surveys show the importance of studies of metal complexes against the strain of C. albicans, which have promising inhibitory activities, and in some cases, with Minimum Inhibitory Concentration (MIC) values lower than 20µg/mL. **Conclusion:** Highlighting the activity performed by ruthenium complexes and Schiff bases when coordinated to metallic ions arouses great interest in a future study of a complex of this metal with a Schiff base in its coordination site.

Keywords: *Candida albicans;* Antifungals; Metal complexes; Ruthenium; Schiff bases.

1. INTRODUÇÃO

A levedura do gênero *Candida* é um micro-organismo comum a microbiota humana, sendo que 50 a 70% de indivíduos saudáveis apresentam esse fungo em mucosas do corpo, tais quais a vaginal e a gastrointestinal (Veira da Rocha, Nunes, Rocha Neves, Azevedo, & Albuquerque, 2021). O gênero *Candida* é dividido em diversas espécies, sendo as que mais se destacam por seus níveis de virulência são: *Candida albicans, Candida glabrata, Candida krusei, Candida tropicalis* e o complexo *Candida parapsilosis,* dentre estas deve-se destacar a atividade patogênica desempenhada pela *C. albicans,* que em alguns casos evolui como um patógeno extremamente nocivo para a homeostase do corpo humano (Salomão, 2017).

Candida albicans é considerada um agente etiológico de risco, dado que, é responsável pela disseminação de infecções superficiais e até mesmo risco de morte em pacientes imunocomprometidos (De Barros, et al., 2020). A incidência dos casos de candidíase – denominação dada a patologia infecciosa causada pela *Candida* – aponta a espécie como a terceira maior causa das septicemias no mundo, uma vez que, no ano de 2021 preponderou uma taxa de 65,3% dos casos de infecções (Silva Vieira, Rodrigues Pires, Furtado, Motta, & Araújo Firmo, 2021), e no Brasil os casos das infecções por *C. albicans* é de 34,3%, sendo o gênero feminino o principal alvo de infecção de repetição por essa espécie pelo desenvolvimento da candidíase vulvovaginal (Silva Vieira, Rodrigues Pires, Furtado, Motta, & Araújo Firmo, 2021).

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Além dessa, é possível salientar a presença de outras formas de manifestações clínicas da candidíase, que consistem em infecções das mucosas (acomete os tecidos do trato digestório e genital), cutâneas (áreas da pele como virilhas, axilas e dobras da pele), sistêmicas (atinge diversos órgãos) e alérgicas (lesões cutâneas vesiculosas e lesões eczematozas) (Barbedo & Sgarbi, 2010), os fatores de virulência dessa espécie englobam a expressão de adesinas e invasinas, tigmotropismo, secreção de enzimas hidrolíticas, bomba de efluxo, morfologia das células e formação de biofilmes (Polke, 2015), também destaca-se como coeficiente relevante para a taxa exponencial de casos de candidíase a emergente tolerância e resistência medicamentosa desenvolvida pelo fungo, e também, a recorrência e veemência de infecções atreladas a essa espécie (Whaley, et al., 2017). Assim, surge a necessidade de desenvolvimento de novas opções que possam ser utilizadas como estratégia terapêutica para tal patogenia.

Segundo o Formulário Terapêutico Nacional (FTN) (Brasil, 2010), a classe dos antifúngicos engloba os medicamentos responsáveis pelo tratamento e profilaxia das infecções fúngicas, os medicamentos mais utilizados são os azólicos ou azóis tais como o cetoconazol, o fluconazol, o itraconazol, o miconazol, entre outros. Ademais, o FTN reforça que essa classe medicamentosa confere aos fungos uma resistência cada vez maior como reflexo do crescimento da população imunocomprometida, tendo em vista o uso cada vez mais frequente de profilaxia e tratamento empírico com antifúngicos (Brasil, 2010). Então devido a essa resistência e aumento dos casos, novos estudos sobre antifúngicos vem sendo realizados a fim de encontrar um medicamento que tenha alta eficiência. Dentre os estudos encontram-se os complexos metálicos como possíveis antifúngicos.

Os complexos metálicos são amplamente estudados por suas características únicas que configuram a esse grupo uma ampla gama de aplicações em diversas áreas. Nesse sentido, o uso desses compostos visando explorar sua atividade antifúngica apresenta crescimento exponencial, uma vez que, os microrganismos, tais quais as leveduras do gênero *Candida,* apresentam uma notável resistência às vias de tratamento corriqueiramente utilizadas na prática clínica (Pavic, et al., 2019).

Estudos mostram que os complexos metálicos apresentam atividade antifúngica com notável eficácia no que tange ao tratamento da candidíase por *C. albicans*, ou seja, as cepas de *C. albicans* apresentam suscetibilidade a este tipo de composto inorgânico quando em comparação à antifúngicos já disponíveis para abordagem farmacológica da candidíase por *C. albicans,* como exemplo os azólicos – como o fluconazol- que são via comum de tratamento que conferem resistência microbiana ao longo do tempo (Malik, et al., 2020). A explicação para o sucesso dos complexos metálicos se dá por diversos fatores, dentre eles, destacam-se o menor exercício de pressão seletiva – que são as condições que favorecem o desenvolvimento de um micro-organismo – no desenvolvimento de resistência do patógeno, além de considerável toxicidade contra o patógeno e baixos efeitos no hospedeiro (Pavic, et al., 2019). No espectro de infecções pelos fungos do gênero *Candida spp.* a espécie de maior gravidade como questão de saúde pública mundial, é a *C. albicans* (Carvalho, Eleutério, Travassos, Santana, & Miranda, 2021), apesar da dificuldade em estimar a incidência de candidíase invasiva, essa levedura permanece como a principal responsável por grande parte dos casos de candidíase (Quindós, Marcos-Arias, San-Milán, Mateo, & Eraso, 2018).

Anterior à classificação de patógeno a espécie coexiste no corpo humano, e a transição da *C. albicans* de comensal para patógeno depende de alterações na homeostase do organismo que promovem a adaptação da levedura, provocando infecção e desenvolvimento da doença (Niemiec, Kapitan, Polke, & Jacobsen, 2020). A patogenicidade se dá pela transição morfológica, que ocorre também em outras espécies de *Candida*, por meio da expressão de adesinas e invasinas e na formação de biofilmes (Dadar, et al., 2018).

C. albicans possui dois mecanismos para invadir as células hospedeiras: endocitose induzida e penetração ativa (Mayor, Wilson, & Hube, 2013). As duas formas de invasão são estimuladas pela alteração na temperatura corpórea - temperaturas acima de 36,5ºC, bem como pela mudança no pH sanguíneo e tissular, facilitando a proliferação da levedura, e desenvolvimento da doença (Figura 1).

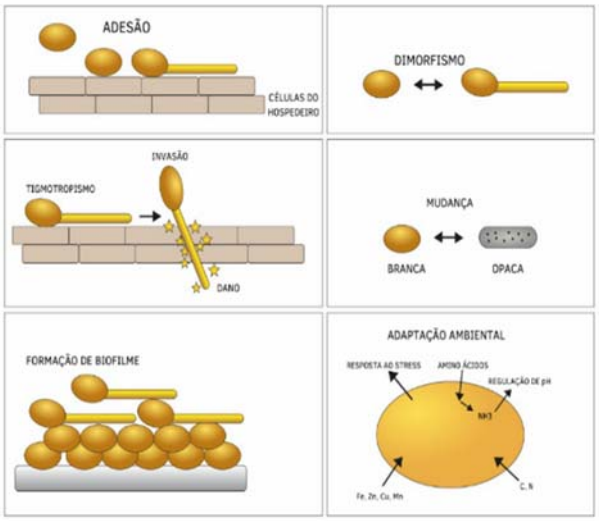


Figura 1- Visão geral dos mecanismos de patogenia da C.albicans, com a formação de biofilme. *Fonte: adaptado de Virulence, 2013, 4:120*

A formação de biofilmes é importante para o processo proliferativo da espécie, são formados por uma rede complexa de Substâncias Poliméricas Extracelulares (SPE) - ou do inglês Extracelular Polymeric Substances (EPS) (Pereira, Fontenelle, Brito, & Morais, 2020). Os biofilmes são formados durante o processo de adesão da levedura (Cernakova, et al., 2019). A formação de biofilme é regulada por fatores genéticos, concentração de oxigênio, pH, temperatura e fatores ambientais, essas características fornecem a levedura resistência a uma extensa gama de substâncias comumente utilizadas como antifúngicos (Gow, Van De Veerdonk, Brown, & Netea, 2012).

A habilidade de formar biofilmes representa um dos mais importantes fatores de virulência do patógeno, outro fator, é a resistência e desenvolvimento em altas temperaturas, que faz com que a *C. albicans* seja uma das poucas espécies capazes de sobreviver a 37ºC e até em temperaturas induzidas por febre (Pereira, Fontenelle, Brito, & Morais, 2020) (Cernakova, et al., 2019) (Pierantoni, et al., 2021).

Os agentes antifúngicos são pertencentes a uma classe medicamentosa responsável pela profilaxia e tratamento de infecção fúngicas (Brasil, 2010), os três principais tipos utilizados como estratégia medicamentosa nas infecções por *Candida albicans*, são eles, os polienos, os azólicos e as equinocandinas, cujos mecanismos de ação agem de diferentes formas na homeostase do fungo, impedindo sua instalação ou sua proliferação (Houst, Spizek, & Havlicek, 2020), esses fármacos são utilizados de forma tópica ou sistêmica (Tabela 1) (Ivamov, Ciric, & Stojkovic, 2022). Os fatores que diferenciam os medicamentos de cada classe são seus respectivos mecanismos de ação.

Tabela 1- Classes de antifúngicos de primeira escolha no manejo da patologia causada pela C. albicans

Antifúngicos	
Polienos	Anfotericina B, Natamicina e Nistatina
Azóis	Imidazóis (cetoconazol e miconazol), Triazóis (fluconazol, itraconazol, voriconazol)
Equinocandinas	Anidulafungina, Caspofungina e Micafungina

As equinocandinas (Figura 2) são hexapeptídios cíclicos não-ribossomais com uma cadeia lipofílica lateral, que age com efeitos inibitórios na enzima 1,3-β-D-glucano sintase (Figura 3) que é necessária para manutenção da parede celular do fungo (Huttel, 2020). O uso dessa classe é recomendado principalmente quando se há suspeita de candidíase invasiva (Tsekoura, et al., 2019), por sua ação seletiva em células mamíferas que, quando comparado à outras drogas, diminui os efeitos colaterais (Patil & Majumdar, 2017).

No entanto, nessa classe medicamentosa, bem como em outras classes de antifúngico, ocorre o efeito antifúngico paradoxal (Steinbach, Lamoth, & Juvvadi, 2015), que diz que ao se elevar o uso de antifúngicos à sua dose crítica, *C. albicans* tende paradoxalmente aumentar sua colonização. Além disso, deve-se levar em consideração o alto custo de produção dos fármacos dessa classe, em detrimento da taxa de mortalidade que quando comparado aos azóis são semelhantes (Spellberg, 2019). O mecanismo de resistência do fungo aos fármacos dessa classe está intimamente relacionado com a mutação do gene de síntese do glucano (FKS), pela substituição dos aminoácidos em *hot spot* de FKS1 (Perlin, 2011), esse gene codifica a enzima 1,3-β-glucano sintase (Figura 3), essas

mutações dão início ao aumento na CIM do fármaco, que ocasionam o estresse pela exposição prolongada e repetitiva do mesmo, e assim ocasionando posterior falha no tratamento com essa classe medicamentosa (Pristov & Ghannoum, 2019).

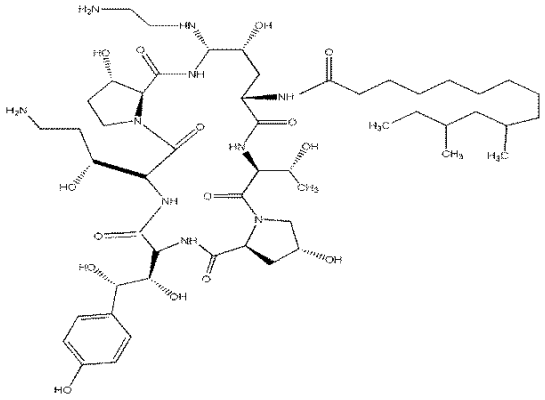


Figura 2- Estrutura molecular da Caspofungina, um exemplo de equinocandina.
Fonte: Imagem autoral

Os azóis ou azólicos agem por meio da inibição da enzima 14α-esterol-desmetilase, prevenindo assim a síntese do ergosterol que altera a funcionalidade e a estrutura da parede celular do fungo (Nocua-Báez, Jerez, Tarazona-Guaranga, Robles, & Cortés, 2020). Os azóis são fármacos de primeira escolha no tratamento e profilaxia de infecções fúngicas, os quais apresentam maior efetividade que a anfotericina B (Osa, et al., 2020), porém, seu uso prolongado está particularmente associado com hepatotoxicidade e efeitos relacionados a transtornos hormonais (Benitez & Carver, 2019), e também a crescente resistência gerada pelo uso dos fármacos dessa classe no tratamento da candidíase de repetição.

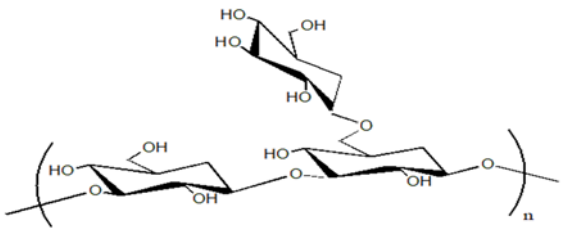


Figura 3 - Estrutura molecular da enzima 1,3-β-D-glucano.
Fonte: Imagem autoral

Apesar da fundamental ação antifúngica desempenhada pelos agentes dessa classe, principalmente do fluconazol (Figura 4), na terapêutica medicamentosa de pacientes com infecções mucocutâneas, cutâneas e sistêmicas (Kaneko Matsuno, et al., 2021) - onde esses agem também como pós-antifúngicos prolongados- seu uso por longos períodos pode acarretar resistência fúngica, além de um elevado número de efeitos colaterais (Campoy & Adrio, 2017).

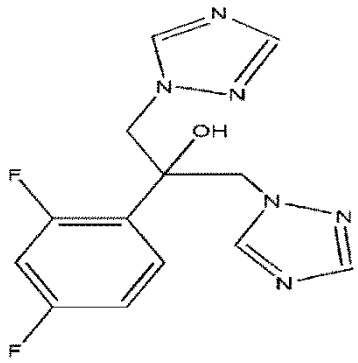


Figura 4 - Estrutura molecular do Fluconazol.
Fonte: Imagem autoral

A resistência está principalmente relacionada aos azóis - Imidazois e triazóis - que são as vias mais comuns de tratamento utilizadas na prática clínica e, por consequência, aumentam de forma exponencial os níveis de virulência da *Cândida spp.,* e diretamente da *C. albicans* (Bohner, Papp, & Gacser, 2022).

O mecanismo de resistência do fungo a essa classe medicamentosa é associado a formação de biofilme, a maior expressão da bomba de efluxo dos medicamentos, e a modificação na estrutura dos alvos (Rocha, Nunes, Neves, Ximenes, & Albuquerque, 2022). A formação de biofilmes representa um importante mecanismo de resistência, estando presente também em outras classes de antifúngicos, estes com estrutura bem consolidada possuem uma matriz extracelular forte com as EPS constituída de carboidratos, fósforo, hexosamina, proteínas e ácido urônico que promovem ligações entre as células (Koo, et al., 2017). Já a expressão da bomba de efluxo é responsável por diminuir a concentração do agente antifúngico na célula do fungo, que resulta na resistência da espécie (Perlin, Rautemaa-Richardson, & Alaustrey-Izquierdo, 2017), enquanto a modificação na estrutura dos sítios alvo, como na enzima 14α-esterol-desmetilase, faz com que os ázois não exerçam a atividade esperada (Marichal, et al., 1999).

Essa classe de antifúngicos inclui a anfotericina B desoxicolato (AMBd) e a lipossomal (AMBl) (Figura 5), o mecanismo de

ação inclui a ligação ao ergosterol na membrana do fungo, promovendo alteração na permeabilidade celular e acarretando a inibição do fungo (Gonzalez, Rodriguez, Agudelo, Zuluaga, & Vesga, 2016).

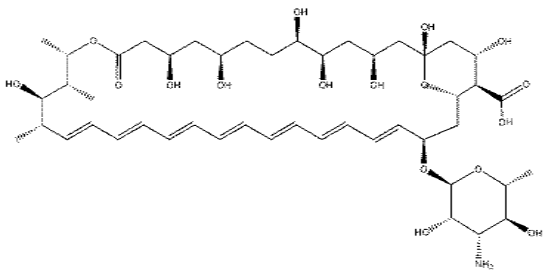


Figura 5- Estrutura molecular da anfotericina B, um exemplo de polieno.
Fonte: Imagem autoral

Porém, uma gama relevante de efeitos colaterais está associada ao uso continuado dessa classe, tais quais febre, tontura e tremores, e em alguns casos nefrotoxicidade também foi relatada (Buerden, Hausammann, Ceschi, Kupferschmidt, & Weiler, 2021).

A resistência do fungo aos polienos está associada a mutações nos genes responsáveis pela síntese do ergosterol (ERG), ERG2, ERG3, ERG6 e ERG11, que diminui a expressão dos sítios alvo de ação dessa classe (Passad, Shah, & Rawal, 2016), assim, a menor presença de ergosterol tende a conferir resistência do fungo aos medicamentos dessa classe, além disso, também pode-se relacionar a maior resistência pelo uso prévio de inibidores de ergosterol, como é o caso dos azóis (Dick, Merz, & Saral, 1980).

Portanto, devido à resistência e efeitos colaterais conferidos aos medicamentos citados, vem-se estudando e buscando novos compostos que sejam tão quanto eficientes contra a *C. albicans*, e dentre esses compostos os complexos metálicos vem se mostrando altamente efetivos no que tange à multirresistência comumente atrelada aos antifúngicos existentes no mercado, bem como a pequena ou quase nula quantidade de efeitos colaterais conferidos a esses compostos.

Complexos metálicos ou compostos de coordenação são um conjunto formado pela espécie central, que é um íon metálico, e seus ligantes, que podem ser íons, moléculas ou compostos orgânicos (Coelho, 2015). Portanto, um complexo é uma combinação de ácido de Lewis- átomo ou íon central, e uma base de Lewis-ligantes, sendo um receptor e o outro doador de elétrons, respectivamente (Shiriver & Atkins, 2008).

Os complexos metálicos fazem parte de um conjunto de compostos conhecidos como compostos de adição, esses são divididos em dois grupos: os sais duplos, que perdem suas características quando em solução, e os complexos metálicos, que preservam sua identidade quando diluídos. A teoria de ligação que melhor explica e representa atualmente as ligações nos complexos é a teoria de Werner, que propõe que a natureza desses compostos possui dois tipos de valência, tratando-se da valência primária- que é não direcional, ou seja, o complexo existe na forma de íon positivo, essa valência representa o número de ligações no íon complexo e deve ser compensada por um número igual de cargas provenientes de íons negativos- e da valência secundária- que é direcional, assim o número de valências secundárias é igual ao número de átomos ligantes no metal, que determina assim o número de coordenação (Lee, 1999).

Esse tipo de composto vem apresentando alto potencial biológico, tendo eficiência em diversas atividades como antioxidantes, anti-inflamatórios, ação contra doença de Alzheimer, além da potencial atividade antifúngica desempenhada por esses compostos, que é objeto de estudo para essa revisão.

O uso de complexos metálicos como agentes terapêuticos tem ganhado crescente atenção, esse potencial farmacológico se deve a fatores como o controle de suas propriedades cinéticas e termodinâmicas, por meio da adequação dos estados de oxidação, dos tipos e números de biomoléculas ligantes e da geometria de coordenação desses compostos (Benite, Machado, & Barreiro, 2007). O estudo desses compostos para fins farmacológicos se tornou de interesse relevante a partir da descoberta da cisplatina que possui propriedades anticancerígenas (Matada & Jathi, 2019).

Metais de transição do quarto período da tabela periódica são preferíveis na análise de atividades biológicas por serem mais baratos e por possuírem natureza menos tóxica e mais biocompatível, tais como Cu, Co, Mn, Ni e Zn (Santos, et al., 2022). Ademais, alguns complexos mostram importante interação com proteínas β-peptídicas que estão relacionadas à doença de Alzheimer, esses incluem complexos

de V, Mn, Re, Fe, Ru, Co, Rh, Ir, Pt e Cu (Gomes, Bataglioli, & Storr, 2020).

Ainda, complexos do íon rutênio vem sendo estudados de forma veemente, pois esse é um elemento do mesmo grupo do ferro, e assim, é visto na literatura que complexos de Ru(II) estão associados a potenciais biológicos tais quais o potencial anticancerígena, como por exemplo o *cis*-[RuII(Hind)$_2$(bpy)$_2$](PF$_6$)$_2$ (Figura 6) que age como ácido de Browsted-Lowry com pH próximo ao fisiológico, tendo assim, baixa toxicidade e acarretando apoptose das células tumorais (Sales, et al., 2020). Outrossim, complexos do mesmo elemento apresentaram atividades antioxidantes e anti-inflamatórias (Sasahara, et al., 2020).

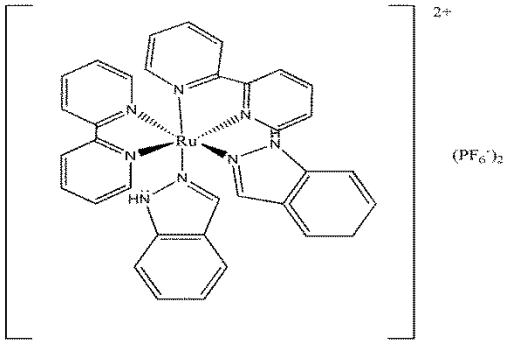


Figura 6 -Estrutura do complexo cis-[Ru(Hind)$_2$(bpy)$_2$](PF$_6$)$_2$

Fonte: Imagem autoral

2. MÉTODOS

O presente trabalho consiste em uma revisão de literatura, nas bases eletrônicas de dados - plataforma de periódicos da CAPES, Cochrane Reviews, PubMed e Biblioteca Virtual em Saúde (BVS), sobre a potencial ação antifúngica contra a *Candida albicans* apresentada pelos complexos metálicos, o levantamento bibliográfico foi conduzido no período de dezembro de 2021 a junho de 2022.

Na presente revisão decidiu-se fazer um estudo através de levantamento bibliográfico acerca de possibilidades viáveis de tratamento para a candidíase, posto que, a *C. albicans* é um importante agente etiológico no gênero *Candida*, sendo a espécie que mais causa infecções de repetição e representando a maior taxa de virulência dentre pacientes imunossuprimidos (De Barros, et al., 2020).

2.1. Métodos

A aquisição de conhecimentos referentes à área da química de coordenação (conceitos, métodos e aplicações), noções referentes a complexos metálicos (síntese, caracterização e análises) e noções relativas a compostos biológicos chamados bases de Schiff e aos fungos do gênero *Candida* da espécie *C. albicans* e por se tratar de uma revisão de literatura, optou-se por utilizar bases de dados disponíveis na internet para consulta de artigos publicados nos últimos cinco anos em revistas científicas, que tratassem do tema abordado. Sendo essas bases o site de periódicos da CAPES, Cochrane Reviews, PubMed. As bases de dados utilizadas apresentam extensa gama de literatura disponível sobre os mais variados assuntos no que tange a química de complexação, visto isso, se torna mister a seleção meticulosa das referências a serem utilizadas para elaboração da pesquisa bibliográfica de forma confiável e que respeite os critérios da metodologia científica, para isso foram utilizadas para pesquisa as seguintes palavras-chave: *candida, Candida albicans, Candida infeccions, candidemia, antifungals, metal complexes, antifungal properties metal complexes* e *Candida albicans and metal complexes.* A seleção dos artigos consistiu em três etapas que foram, pesquisa “bruta”, análise dos critérios a serem respeitados pelo artigo pesquisado e leitura seguida de fichamento do artigo.

Na primeira etapa foram utilizadas as palavras-chave em cada uma das bases de dados, sendo que nessas foram constatados uma média de 200 a 300 artigos publicados por palavras-chave pesquisadas.

A segunda etapa, foram selecionados os artigos que respeitassem o intervalo de publicação de cinco anos, de 2017 a 2022, além do conteúdo do artigo ser condizente com o tema da pesquisa e a relevância da publicação. Cabe destacar que, as referências utilizadas que não estão no intervalo de cinco anos de publicação foram selecionadas tendo em vista a confiabilidade da revista em que foi publicado bem como a quantidade de referenciais que continham esses artigos citados, além de livros veementemente utilizados no ensino de química inorgânica, nessa etapa foram selecionados 139 artigos.

Na terceira etapa, que consistiu em leitura e fichamento dos artigos, apenas foram citados e utilizados como referência os artigos que apresentaram metodologia confiável, domínio do

assunto abordado e relação conivente com o tema do trabalho que se apresenta, assim, foram utilizadas 93 referências, que incluem artigos publicados em revistas bem como livros acadêmicos.

Foram utilizados alguns programas que permitiram o esclarecimento e conhecimento de algumas informações que seriam obtidas na prática, dentre eles, usou-se o programa *ChemDraw*, o qual é um editor de moléculas e através desse foram obtidos e a representação visual das moléculas empregadas na pesquisa. Além desse, utilizou-se também o software de design gráfico *Corel Draw*© e o *adobe Illustrator*© para edição e adaptação das imagens, esses últimos foram adquiridos com recursos financeiros próprios.

Foram utilizados alguns programas que permitiram o esclarecimento e conhecimento de algumas informações que seriam obtidas na prática, dentre eles, o programa ChemDraw, o qual possibilitou a obtenção e ilustração das moléculas dos complexos.

3. RESULTADOS E DISCUSSÃO

3.1. Resultados

Os estudos realizados através do levantamento bibliográfico (Tabela 2), evidenciam o potencial dos complexos metálicos como uma nova estratégia terapêutica, uma vez que se considera o baixo nível de toxicidade e espera-se também que esses compostos acarretem o menor desenvolvimento de resistência fúngica.

Tabela 2. R*esultados da pesquisa bibliográfica dos termos de pesquisa por base de dados*

Term	Database	Results	Exclusions
candida	CAPES	20	14
	Cochrane Reviews	32	28
	PubMed	22	17
Candida albicans	CAPES	27	18
	Cochrane Reviews	5	0
	PubMed	3	0
Candida infeccions	CAPES	15	8
	Cochrane Reviews	6	4
	PubMed	9	6
Candidemia	CAPES	28	24
	Cochrane Reviews	12	8
	PubMed	19	11
Antifungals	CAPES	41	32
	Cochrane Reviews	36	24
	PubMed	27	25
metal complexes	CAPES	18	15
	Cochrane Reviews	9	8
	PubMed	17	13
antifungal properties metal complexes	CAPES	4	2
	Cochrane Reviews	3	3
	PubMed	5	1
Candida albicans and metal complexes	CAPES	5	0
	Cochrane Reviews	7	4
	PubMed	9	6

Foi avaliado o potencial antifúngico dos complexos de Cu (II) com ligantes 2-thiouracil e 6-methyl-2-thiouracil (Figura 7), os quais apresentaram valores de CIM em média de 31 a 125µg/mL contra *Candida spp.* e agentes microbianos de outros gêneros, enquanto os fármacos Anfotericina B e fluconazol apresentam

CIM de 0,25µg/mL e 0,5µg/mL, respectivamente, contudo o complexo de Cu(II) ainda se mostra uma opção de maior viabilidade, pois, os fármacos citados estão extensivamente associados com a resistência fúngica e com candidíase invasiva (Dantas, et al., 2018).

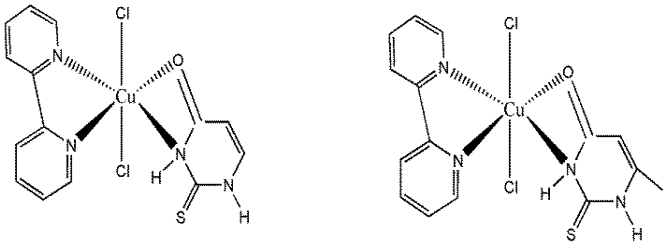


Figura 7-[Cu(Bipy)Cl_2(thiouracil)] e [Cu(Bipy)Cl_2(6-methylthiouracil)], respectivamente
Fonte: Imagem autoral

Os complexos de Ferro (III) e Zinco (II) foram comparados em um estudo com um fármaco de uso comum no tratamento de candidíase, que evidenciou suas diversas ações microbiológicas, porém destacou-se sua ação antifúngica com Zona de Inibição (ZI) de até 24 mm, para o complexo de Fe(III), enquanto o antifúngico de controle, nistatina, tem ZI igual a 19 mm (Naureen, et al., 2021).

Outrossim, os autores MOHAPATRA, SARANGI, AZAM, *et al.* (Mohapatra, et al., 2019) reportam complexos do tipo [ML_2].nH_2O (onde L = 2-(α-metil salicilideno-2'-imino) aminobenzotiazol (HMAB), 2-(α-fenilsalicilideno-2'-imino) aminobenzotiazol (HPAB), 2-(o-Vanillideno-2'-imino) aminobenzotiazol (HVAB) e M= Co(II), Ni(II), Cu(II) e Zn(II)). Para os complexos com HMAB ligado aos íons metálicos citados acima, os valores de CIM foram iguais a 18,2 µg/mL; 16,3 µg/mL; 17,4 µg/mL; 14,2 µg/mL para Co(II), Ni(II), Cu(II) e Zn(II) respectivamente, e quando esses íons estão ligados a HPAB, os valores de CIM para os íons de Co(II), Ni(II), Cu(II) e Zn(II) são de 22,1 µg/mL, 17,3 µg/mL, 20,1 µg/mL, 18,3 µg/mL, respectivamente, e com os mesmos íons para HVAB, 23,3 µg/mL, 20,2 µg/mL, 19,2 µg/mL, 18,3 µg/mL, enquanto o CIM da referência, gentamicina, foi de 2,7µg/mL. Observe que os complexos que apresentaram melhores valores de CIM foram os complexos com o ligante HMAB, e dentre esses com o íon de Zn (II) com CIM de 14,2 µg/mL, dessa forma, esse composto apresentou significante atividade antifúngica.

Os autores NAUREEN *et al.* (Naureen, et al., 2021) e MOHAPATRA *et al.* (Mohapatra, et al., 2019) apontam em seus estudos que bases de Schiff- iminas que possuem em sua estrutura molecular um grupo funcional que contém uma dupla ligação entre o carbono e o nitrogênio (C=O)-O-carboximetilquitosana coordenada aos íons de zinco, cobre e níquel alcançaram altos padrões antifúngicos, em concentrações de 200µg/mL com inibição de 87,5%, que acarretaram a inibição do crescimento dos fungos e a diminuição da fitotoxicidade de algumas espécies (Naureen, et al., 2021) (Mohapatra, et al., 2019) (Liu, et al., 2018).

A atividade antifúngica desempenhada pelos complexos citados tem relação aparente com a interação com proteínas que desempenham papel estrutural na parede celular dos fungos, além do metabolismo de lipídios e o transporte de elétrons (Naureen, et al., 2021) (Mohapatra, et al., 2019).

Esses complexos têm sido veementemente estudados para serem posteriormente utilizados como novos agentes terapêuticos no tratamento da multirresistência adquirida pelos fungos no decorrer de tratamentos prolongados (Dar, et al., 2019).

Os complexos metálicos possuem um potencial antifúngico extremamente promissor. Especificamente contra as cepas de *C. albicans* esses compostos apresentam atividade antifúngica com diversas vantagens quando em comparação aos antifúngicos disponíveis no mercado (Matiadis, Tsironis, & Stefanou, 2019).

Um exemplo disso são os complexos de manganês, cobalto, cobre, zinco e cádmio, os quais demonstraram baixa toxicidade em células mamíferas (Matiadis, Tsironis, & Stefanou, 2019), com atividade farmacológica desempenhada pelos complexos de cobre, que apresentam CIM de aproximadamente 20µg/mL, enquanto o fármaco utilizado como referência, nistatina, apresenta CIM de 14µg/mL (Vijayan, Princess, Raja, & Joseph, 2021), já os complexos de cobalto(II) quando ligados a derivados de compostos pirazólicos e dinitrobenzoatos apresentam uma alta inibição da *C. albicans* com CIM igual a 125µg/mL quando em comparação com o Itraconazol, que apesar de ter sido determinada uma CIM igual a 1µg/mL seus efeitos colaterais e desenvolvimento de resistência fúngica tornam o complexo mais que o fármaco interessante para uso clínico. Além disso, o complexo apresenta inibição significativa dos fatores de virulência que acarretam a candidíase, então os resultados de estudos com

esses complexos os exibem como alternativas farmacológicas promissoras (Fonseca, Leal-Pinto, Roa-Cordeiro, & al., 2019).

Os complexos de cobalto (II) quando coordenados com ligantes glutarato e bipiridil - bpy, bpe e bpymh (bpy = 4,4′-bipiridil, bpe = 1,2-bis(4-piridil)etileno, bpymh = N,N′-bis(piridil-4-ilmetileno)- também apresentam atividade antifúngica contra cepas de *C. albicans*, induzindo a inativação celular (Kim, Miltra, & Veerana, 2019). Para os complexos de manganês(II), utilizando como fármaco de referência a nistatina (CIM= 12mg/mL), o valor de CIM foi igual a 25 mg/mL frente as cepas de *C. albicans,* portanto, o complexo apresenta valores promissores de inibição do patógeno (Skthivel, et al., 2021).

Complexos de íon de prata I, ligados a carbenos N-heterocíclicos (NHC) são citados por apresentar CIM igual a 125µg/mL, ao passo que a atividade desempenhada por antifúngicos como a anfotericina-B apresenta valor de CIM igual a 62µg/mL, contudo, esse fármaco, comumente utilizado em ambiente hospitalar confere alta taxa de resistência fúngica (Dileepan, Ganeshkumar, & Ranjith, 2021).

Diversos estudos têm demonstrado o potencial atrelado às bases de Schiff (Figura 8), no que tange as suas atividades biológicas e mostram que elas possuem uma extensa gama de aplicações farmacológicas, como atividades antimicrobianas, antioxidantes, antifúngicas (Abdel-Aziz, Shawky, & Khalil, 2018), anticancerígenas, anti-inflamatórias, antielmínticas, analgésicas (Mukhtar, et al., 2021), antimalárico, antitérmico e antiviral (Ghanghas, Choudary, Kumar, & Poonia, 2021).

Suas diversas aplicações se dão pelas propriedades estruturais, de doação de elétrons e dos grupos funcionais que estão presentes na composição desses ligantes (Zayed, Zayed, Hindy, & Mohamed, 2018), não obstante, o elevado interesse nesses compostos como ligantes também está relacionado a suas propriedades quelantes e sua enorme estabilidade (Sakthivel, et al., 2021). A fórmula geral das bases de schiff (Figura 8) é dada por RR'C=NR" (R" ≠ H) (Golbedhagi, Tabanez, Esmaeili, & Fausto, 2020).

As bases de Schiff tem baixa atividade antifúngica quando livres, ao serem ligadas a um metal a atividade de inibição fúngica do complexo apresenta valores promissores, o que demonstra que a complexação acarreta maior atividade biológica desses compostos (El-Sonbati, et al., 2019). Estudos preliminares evidenciaram complexos de Cu, Ni e Zn coordenados por bases de Schiff com proeminentes atividades antifúngicas (Malekshah, Shakeri, Khaleghian, & Salehi, 2020). É relatado também que complexos de cobalto (II) com ligantes triazólicos (Figura 9) das bases de Schiff, apresentou atividade antifúngica cerca de 5 a 10% maior que a do ligante livre. Esses complexos apresentaram CIM igual a 2,5mg/mL contra cepas de *C. albicans* (Lin, Betts, Keller, Cariou, & Gilles, 2021).

Os Complexos de lantanídeos Gd, Sm e Nd coordenados as bases de Schiff tem valores de zonas de inibição (ZI) para amostras de cepas de *C. albicans* iguais a 20,03mm; 17,97mm; 18,78mm e 20,03mm, respectivamente, enquanto, no mesmo estudo, o ligante livre obteve 20,10mm de ZI (Abdel-Aziz, Abduh, Mohhamed, & Al-Gabri, 2022), indicando que a coordenação ao íon metálico aumenta a sua atividade biológica

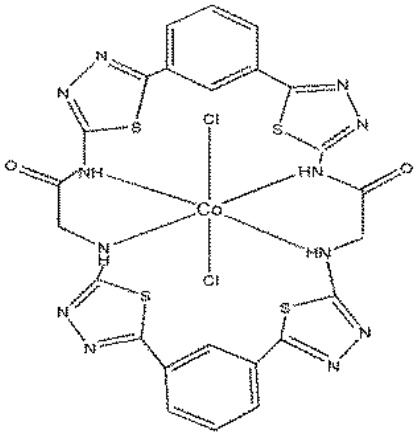


Figura 9- Complexo de Co(II) contendo ligante tidiazol que foi avaliado com atividade antifúngica contra C. albicans
Fonte: Imagem autoral

Não obstante, os complexos de íon rutênio têm demonstrado enorme potencial contra diversas patologias, dentre elas, atividade antifúngica contra cepas de *C. albicans,* nesse sentido cabe um estudo de literatura aprofundado acerca dos resultados até o momento obtidos, utilizando esses complexos.

Os complexos de rutênio são extensamente utilizados em estudos de avaliação de atividade biológica para diversas patologias. Diversos autores vêm sintetizando e

caracterizando complexos de rutênio coordenados a diferentes ligantes a fim de observar sua atividade antifúngica (Amirtaghanesan, Vadivel, Dhamodran, & Chandraboss, 2022).

Em casos como em complexos de Ru (III) ligados a bases de Schiff quitosanas (Figura 10), esses obtiveram resultados promissores contra cepas das espécies *Aspergillus flavus, Aspergillus niger, Penicillium chrysogenum, Fusarium oxysporum* e *Trichoderma veride*.

Os complexos $[Ru(CVSB)(H_2O)_2]Cl_2$ (a), $[Ru(CSSB)(H_2O)_2]Cl_2$ (b), $[Ru(COSB)(H_2O)_2]Cl_2$ (c), apresentaram zona de inibição (ZI) de 14 mm, 12mm e 11mm de diâmetro, respectivamente, para as cepas *A. flavus*, enquanto que para *A. nigger*, todos os complexos apresentaram diâmetro de ZI igual 12mm, já para as cepas *P. chryogenum* bem como para *F. oxyspurum* os valores foram iguais a 11mm, 10mm e 11mm, respectivamente, e para *T. veride* o estudo apontou que os complexos (a), (b) e (c), respectivamente, apresentaram valores de 12mm, 10mm e 12mm, enquanto para a anfotericina B o resultado de ZI foi de 22mm, 26mm, 20mm, 22mm, 26mm respectivamente para as cepas descritas acima, observe que os valores de ZI para os complexos são menores que o fármaco, porém, essa diferença é compensada quando compara-se os efeitos colaterais e grande probabilidade de incitar multirresistência fúngica que é atrelado aos medicamentos (Amirtaghanesan, Vadivel, Dhamodran, & Chandraboss, 2022), posto isso, o uso dos complexos como pré-fármacos se torna cada vez mais promissor.

Verificou-se também que a terapia fotodinâmica tem sido profusamente utilizada para a análise da atividade antifúngica desses compostos. O complexo *cis*-$[Ru(phen)_2(pPDI)]^{2+}$ foi avaliado frente as cepas de *C. albicans* em uma concentração de 12,5μM, na presença de luz esse complexo acarretou uma diminuição considerável de 50% da concentração original do patógeno (Maia, et al., 2018). Em uma análise de CIM com estudo de terapia fotodinâmica o complexo $[Ru(phen)_2(pPDIp)(PF_6)_2]$ (Figura 11) apresentou inibição em CIM igual a 50μg/mL (Tiburcio, et al., 2022).

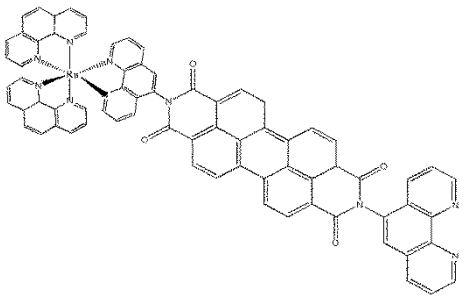


Figura 11- Complexo $[Ru(phen)_2(pPDIp)(PF_6)_2]$
Fonte: Imagem autoral

Em comparação com o fluconazol, o azólico mais comumente utilizado no tratamento de infecções fúngicas, o complexo $[Ru(CO)_3(L_2)_2]$, onde L_2= $C_{17}H_{18}NO$, apresentou valor da CIM em cepas de *C. albicans igual a* 1,56μg/mL (Ramadan, Elsheemy, Hassan, & Abdel-Aziz, 2018), e os complexos $[Ru(\eta_6\text{-p-cimeno})(L1)Cl_2]$, onde L1= N-((4 methoxyphenyl) carbamothioyl) benzamida, e $[Ru(\eta_6\text{-p-cymene})(L2)Cl_2]$ (Figura 12), onde L_2=metil 4-(3-benzoylthioureido)benzoato, apresentaram valores da CIM em aproximadamente 62,5μg/mL (Obradovic, et al., 2020).

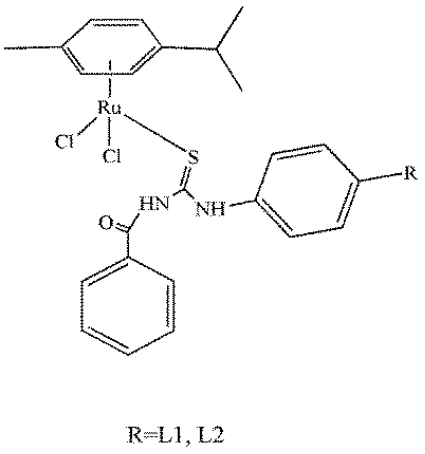
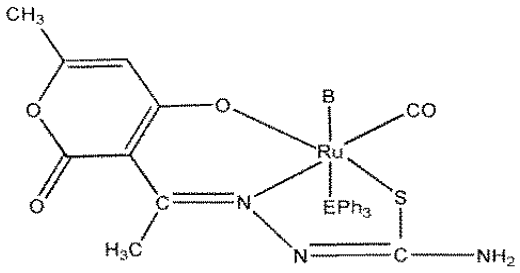


Figura 12-Complexo $[Ru(\eta_6\text{-p-cimeno})(L1)Cl_2]$
Fonte: Imagem autoral

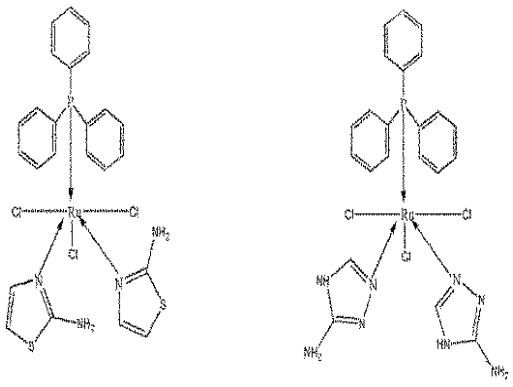
Outros complexos, tais quais, complexos carbonil de Ru(II) contendo ácido dehidroacético, $[Ru(d\text{-hatsc})(CO)(B)(EPh_3)]$, onde E= P, B = PPh_3, py (pyridine traduzido como piridina), pip(phosphatidylinositol phosphate traduzido como fosfatidilinositol fosfato) ou mor (Methanol Oxidation Reaction traduzido como reação de oxidação de metanol) e E=As, B=$AsPh_3$ (trifenilfosfina) (Figura 13), apresentaram potencial atividade inibitória contra a *C. albicans* cujo resultado foi de 15μg/mL enquanto o ligante livre não inibiu a cepa, o que reforça a atividade promissora esperada por esses compostos (Kannan, Sivagamasudri, Ramesh, & Liu, 2008).



E=P, B=PPh_3,py, pip, mor
E=As, B=$AsPh_3$

Figura 13-Complexo [Ru(d-hatsc)(CO)(B)(EPh_3)]
Fonte: Imagem autoral

As zonas de inibição de complexos terpiridínicos de Ru(II), ([$Ru(Pph_3)(Atz)_2Cl_3$] e [$Ru(Pph_3)(Ath)_2Cl_3$], onde Ath= 2-aminothiazol e Atz= 2-aminotriazol (Figura 14), também foram estudadas, e apresentaram valores de 17mm e 18mm, respectivamente, para cepas de *C. albicans,* que são valores satisfatórios (Naik, et al., 2020).



(a) *(b)*

Figura 14- (a) [$Ru(Pph_3)(Atz)_2Cl_3$] e (b) [$Ru(Pph_3)(Ath)_2Cl_3$]
Fonte: Imagem autoral

Nesse sentido, pode-se observar que os complexos de rutênio coordenados por diferentes ligantes desempenham relevante atividade antifúngica. Deve-se dar destaque aos ligantes tais quais as bases de Schiff que desenvolvem atividades antifúngicas promissoras quando ligadas a diferentes metais.

A partir da realização do levantamento bibliográfico durante a revisão de literatura foi possível observar que os resultados para os complexos metálicos, quando medidas suas Zonas de Inibição, bem como suas CIMs, tinham em alguns casos valores menores que os fármacos já existentes, os compostos obtiveram valores significativos levando em consideração suas baixas taxas de efeitos colaterais e de surgimento de resistência fúngica.

Na tabela 2 estão dispostos valores de ZI e CIM relatados na literatura (Dantas, et al., 2018), (Mohapatra, et al., 2019), (Dileepan, Ganeshkumar, & Ranjith, 2021), os quais foram selecionados os complexos metálicos de Cu, Co, Ag e Ru com maiores potenciais antifúngicos contra cepas de C. albicans. Observou-se, através desse levantamento bibliográfico, que os complexos que se destacaram no exercício de ação antifúngica foram os complexos sintetizados a partir dos metais Cu (Dantas, et al., 2018), Co (Mohapatra, et al., 2019), Ag (Dileepan, Ganeshkumar, & Ranjith, 2021) e Ru (Tabela 3) e seus respectivos íons. Dentre os ligantes que foram utilizados pelas pesquisas referenciadas se pode destacar a atividade das Bases de Schiff, apesar de quando livres não obterem atividade significativa, quando coordenadas ao íon metálico demonstram potencial atividade antifúngica (El-Sonbati, et al., 2019).

Tabela 3- Valores de Zona de inibição (ZI) e Concentrações Inibitórias Mínimas (CIM) dos complexos metálicos de Cu, Co, Ag e Ru

Complexos	Zona de inibição(mm)	CIM
Cu		20µg/mL
Co		125µg/mL
Ag		125µg/mL
Ru	17-18mm	1,56-62,5µg/mL
Fluconazol		0,50µg/mL

Os complexos de Cu, Co, Mn, Ag e Ru foram comparados com os medicamentos, nas publicações consultadas, nistatina, itraconazol, anfotericina B e fluconazol (Tabela 4) (Matiadis, Tsironis, & Stefanou, 2019), apesar de suas CIM serem consideravelmente maiores que as apresentadas pelos medicamentos todos os autores destacam que os complexos são mais vantajosos uma vez que, a presença de multiressistencia e efeitos colaterais veementes é

persistente com o uso dos medicamentos. Os complexos de Cu, Mn, e Ru obtiveram resultados promissores, já os complexos de Co e Ag analisados pelos ensaios estudados apresentaram resultados de CIM com valor consideravelmente maior que o medicamento cuja comparação foi feita.

Tabela 4- Dados de Concentrações Inibitórias Mínimas(CIM) dos complexos com potencial antifúngico e fármacos, de primeira ou segunda escolha, utilizados no tratamento de candidíase que foram citados nas publicações consultadas

Complexos	CIM (µg/mL)	Fármaco	CIM (µg/mL)
Cu	20	**Nistatina**	14
Co	125	**Itraconazol**	1
Mn	25	**Nistatina**	12
Ag	125	**Anfotericina B**	62
Ru	1,56	**Fluconazol**	0,50

Verifica-se na literatura que os complexos de Ru ligados a bases de Schiff apresentaram resultados satisfatórios e promissores na inibição das cepas de *C. albicans,* com CIM de 62,5µg/mL a 1,56µg/mL (Maia, et al., 2018) (Tiburcio, et al., 2022) (Obradovic, et al., 2020) (Kannan, Sivagamasudri, Ramesh, & Liu, 2008)(Tabela 5).

Tabela 5- Dados obtidos de Concentrações Inibitórias Mínimas pelas referencias consultadas dos complexos metálicos com íon rutênio

REFERÊNCIA	CIM (µg/mL)
(Maia, et al., 2018)	50
(Tiburcio, et al., 2022)	62,5
(Obradovic, et al., 2020)	1,56
(Kannan, Sivagamasudri, Ramesh, & Liu, 2008)	15

Dessa forma, fica explicita a importância do estudo de revisão bibliográfica sobre a potencial atividade antifúngica dos complexos metálicos contra *C. albicans*, fazendo com que esses sejam objetos de estudo que podem apresentar relevância no tratamento das patologias que estão associadas as cepas de *C. albicans.*

3.2. Discussãos

A recorrência de casos de candidíase vulvovaginal afeta aproximadamente 138 milhões de mulheres anualmente no mundo (Lírio, et al., 2022), sendo, assim um enorme problema de saúde pública que se apresenta como um tabu na sociedade, carecendo de tratamentos efetivos. Além disso, a mortalidade atrelada a infecção sistêmica por essa espécie do fungo é de cerca de 40% (Bienvenu, 2020), maior taxa de quando comparada a outras espécies do gênero.

C. albicans tem apresentado um exponencial aumento na multirresistência aos antifúngicos atualmente existentes no mercado, que são utilizados de forma indiscriminada por não haverem disponíveis outras opções de terapia medicamentosa para o tratamento da infecção causada pelo fungo dessa espécie, o que acarreta em um ciclo persistente de uso irracional dessa classe e consequente aumento da CIM necessária para a inibição do patógeno, além do mais, esses medicamentos apresentam efeitos colaterais que se tornam cada vez mais comuns por conta do uso exacerbado desses medicamentos (Enjalbert, et al., 2006).

Posto isso, como os complexos metálicos são altamente ativos em diversas enfermidades, inclusive utilizados na quimioterapia de câncer, como o caso da cisplatina, e outros, como o complexo com íon rutênio que se encontram em fase clínica de testes (Alessio, 2017), estes também apresentam atividade antifúngica contra cepas de *C. albicans* se tornando um objeto de estudo científico de enorme potencial, por suas características únicas e podem representar um enorme avanço no tratamento das patologias associadas a essa espécie.

4. CONCLUSÕES

A partir dos resultados estudados e verificados através do levantamento bibliográfico é possível evidenciar que a atividade antifúngica contra cepas de *C. albicans* desempenhada

pelos complexos metálicos é promissora.

Evidencia-se o potencial da presente revisão que pode servir de base para consulta por grupos de pesquisa do ramo, podendo assim desenvolver novos complexos metálicos com finalidade de obter atividade antifúngica contra as cepas desse fungo, o que contribui de forma positiva para a resolução do problema de saúde pública atrelada a *C. albicans,* além do avanço na área de pesquisa no ramo da química bioinorgânica e da química farmacêutica.

5. DECLARAÇÕES

5.1. Limitações do estudo

Nenhuma limitação foi encontrada no decorrer da pesquisa.

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5.3. Fonte de financiamento

Todos os softwares e recursos de pesquisa utilizados na presente revisão foram financiados com recursos próprios dos autores.

5.4. Intereses concorrentes

Os autores declaram que o presente trabalho não possui quaisquer conflito de interesse.

5.5. Acesso aberto

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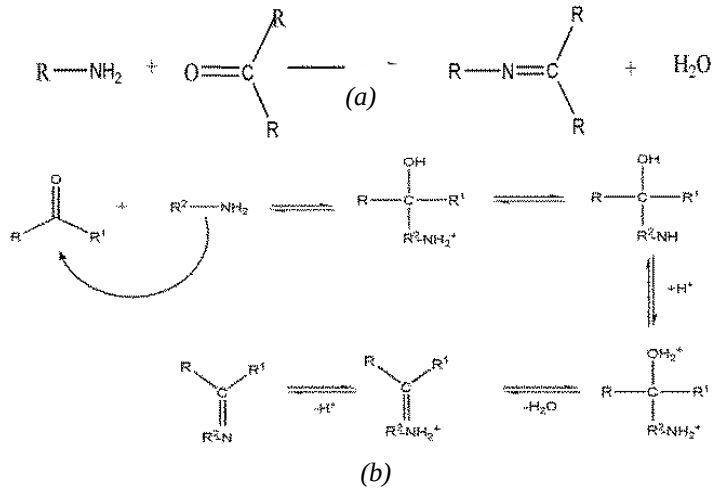

Figura 8- (a) Estrutura geral das bases de Schiff e (b)síntese de uma base de Schiff pela condensação de uma carbonila.
Fonte: Imagem autoral

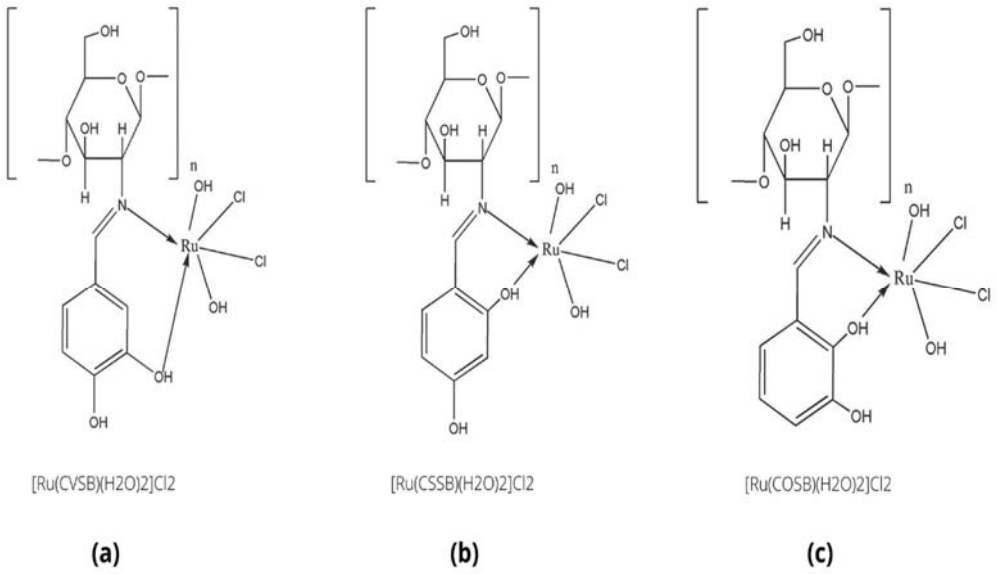

Figura 10-Complexo de Ru(III) ligados a bases de Schiff
Fonte: Imagem autoral

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D-DIMER A RISK FACTOR ASSOCIATED WITH C-REACTIVE PROTEIN FOR PREDICTING THE SEVERITY OF INFECTION BY COVID-19

SARHAN, Dhamya Kadhim[1]; SHARBA, Intisar Razzaq[2*]; MOHAMMED, Zainab Basim[3]

[1,2] University Kufa, Faculty Science, Department Biology. Iraq.

[3] Ibn Sina University of Medical and Pharmaceutical Sciences. Iraq.

** Corresponding author*
e-mail: intisar.sharba@uokufa.edu.iq

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ABSTRACT

Background: COVID-19, caused by SARS-CoV-2, has unresolved mortality risk factors and clinical course, highlighting the need for further research. **Aims**: The study aimed to asses D-dimer and C-Reactive Protein (CRP) as the risk factors for severity covid-19 and who are less capable of surviving. **Methods**: A retrospective study conduct of COVID-19 in adult inpatients aged >20 at Al-sadder and Alamal Hospital in Iraq. Demographics, clinical trials, treatments, and viral RNA samples were analyzed. The study involved 100 patients, with 67 discharged and 33 hospitalized died. The majority of the participants 45% were aged < 40, but 55% were aged >40 years. **Results**: A significant and 57% were male 37(55.2%) Survivor vs. 20 (60.6%) non-survivor, p=0.024), more than 43% were female (30(44.8%) Survivor vs. 13(39.4%) non-survivor, p=0.010. Patients had underlying comorbidities (66%), survivor 37(55%), and non-survivor 29(87%). The most prominent comorbidity in non-survivors more than survivors was diabetic mellitus 85%, asthma 58%, stroke 48%, renal failure 42%, heart strake 33%, and hypertension 18%. The study found significant differences in WBC, lymphocyte count, D-dimer, Ferritin, CRP, and LDH levels in non-survivors compared to survivor patients, with a positive correlation between D- dimer and these parameters. The ROC analysis curve showed CRP with a high AUC of 80.2%, 87.9% sensitivity, and 37.3% specificity, while D-dimer and LDH had AUCs of 0.74.9 and 70%, respectively. **Discussion**: The study found that older age, higher d-dimer, ferritin, CRP, and LDH are associated with disease severity and higher mortality risk in adult COVID-19 patients. **Conclusions**: These biomarkers could aid in early detection of disease progression signs and better patient management

Keywords: *COVID-19, D-dimer, CRP, and LDH*

1. INTRODUCTION

The novel ß-coronavirus Sudden Respiratory Distress Syndrome (SARDS) was established as the cause (ARDS) Coronavirus-2 is a virus that causes Coronavirus Disease in the Year 2019 (COVID-19) (SARS-CoV-2). It was classified as a public health emergency by the World Health Organization (WHO)of worldwide concern in the first month of 2020 (Guo *et al.,* 2020; Zhou *et al.,* 2020).

COVID-19 is categorized into three severity levels. If flu-like symptoms emerge early on, they frequently occur. Viral pneumonia is the result of a viral infection. Patients could be admitted to the hospital for a prolonged stay or placed on a ventilator. Inflammation of the lungs and coagulopathy are two diseases that can occur together. The active phase reaction begins with a combination of physiological and metabolic changes that occur shortly after tissue injury (Sharba & ALsaleh, 2024). Of an inflammatory process. Inflammatory indicators C-reactive protein (CRP), ferritin, IL-6, and IL-1 are all high, and d-dimer has also been related to ARDS, which has poor clinical results. Finally, The third stage of the disease is fibrosis. (Polak *et al.,* 2020). The intracellular reserve ferritin has been intensively researched as an indicator of iron metabolism. (Lino *et al.,* 2021). Ferritin is an acute protein that

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increases in response to a range of inflammatory conditions. Cancer, iron excess, and liver or renal illness are just a few examples. Even if there is a temporary presence of COVID-19, this can be performed by monitoring ferritin levels. Ferritin levels in hospitalized patients have been found to be significantly higher in several investigations. However, there isn't usually a specific marker for hemophagocytic lymphohistiocytosis. (Melo *et al.,* 2021).

D-dimer is a fibrin breakdown product produced by plasma fibrinolytic enzyme, and it's a common thrombotic biomarker (Aljuboory & Sharba, 2024). It's considered typical to have a D-dimer level of less than 0.5 g/mL, and levels increase as people get older and during pregnancy. As the incidence of community-acquired pneumonia increases, so does the severity of the disease, so does the amount of D-dimer. In COVID-19 patients, D-dimer has been recognized as a possible prognostic predictor. The entrance day D-dimer has been shown in multiple studies to predict sickness severity. (Zhou *et al.*, 2020). In this early case series, the assessment of risk factors for severe disease and mortality is not well understood.

The study aimed to look into laboratory biomarkers in COVID-19 individuals to see whether there are any that can distinguish between people who are more likely to develop severe disease and those who aren't, as well as those who are less capable of surviving or are at a high or low risk of dying. Identifying laboratory signs that can distinguish between these patients would also increase clinical situational awareness.

2. MATERIALS AND METHODS

2.1. Materials

All adult inpatients included in the two-center cohort study (≥20 years old) COVID-19 has been confirmed in the lab from Al-sadder and Alamal Hospital in Al-Najaf, Iraq, who had been died or had discharged before and during the time of the study from 1st December 2021 to 31st January 2022. Demographics, Data from clinical trials, treatments, and laboratories, as well as serial samples for detecting viral RNA, were obtained from the hospital database, and survivors as well as non-survivors were compared. The criteria for exclusion are also important. Patients with anemia, thalassemia, and pregnant women who have already been diagnosed, liver disease and cancer were not included in the study.

2.2. Methods

A retrospective cross-sectional study was conducted on all verified all COVID-19 patients have been diagnosed with polymerase chain were included in the polymerase chain reaction (PCR). Severe disease was diagnosed in 100 patients who met any of the following criteria. Dyspnea has a respiratory rate of less than 30 breaths/minute in the resting state, and finger oxygen saturation is 93%. PaO2/FiO2 300 mm Hg. Respiratory failure requiring medical ventilation. The demographic characteristics, as well as comorbidities such as chronic obstructive pulmonary disease (COPD) and asthma, diabetes mellitus, renal failure, hypertension, heart attack, heart failure, stroke, clinical and laboratory findings including white blood cell count (WBC), lymphocyte, D-dimer, Ferritin, C-reactive protein (CRP), and lactic dehydrogenase (LDH), The tests were carried out in the hospital's Clinical Pathology Laboratory and the results were acquired from the hospital's database. Two groups of patients were defined as the subject's survivor and the survivor. All information was entered into a standardized data sheet.

2.3. Statistical Analysis

The Kolmogorov-Smirnov test was used to analyse the distribution of the variables. Qualitative data was provided as median (interquartile range (IQR) 25 percent-75 percent) values. While quantitative data was provided as a mean and standard deviation, qualitative data was presented as a percentage, along with numbers and percentages. The Chi-square test was used to analyze the demographic characteristics. An independent t-test was used to compare the laboratory findings. A receiver operating curve (ROC) was used to determine a cut-off value for potential illness severity predictions, as well as the predictors' sensitivity and specificity. A Pearson correlation test was used to compare the studied parameters. SPSS version 28 is a statistical package for the social sciences (IBM Corp., Armonk, NY, USA) that was used to analyze all of the data. The significance level was set at $p<0.05$ (Sullivan, 2017).

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Characteristics of Covid-19 patients

The current study enrolled 100 patients with COVID-19. The characteristics of baseline patients are shown in Table (1). Survivors of COVID-19 were 67%, and 33% were non-survivors. The age range of all the patients was from 22 to 75 years (median (IQR) 43 (32–63.75) years, The average age of non-survivor patients was substantially higher than the average age of

survivors (51.48±15 vs. 44.46±17.74, p=0.042). Patients were divided into groups according to age involved (45%) were aged groups < 40, and (55%) were aged groups >40 years. A significant and 57% were male (37(55.2%) Survivor vs. 20 (60.6%) non-survivor, p=0.024), more than 43% were female (30(44.8%) Survivor vs. 13(39.4%) non-survivor, p=0.010).

Patients had underlying comorbidities (66%), survivor 37(55%), and non-survivor 29(87%). The most prominent comorbidity in non-survivors more than survivors was diabetic mellitus (85% vs. 18%), asthma (58% vs.10%), stroke (48% vs.10%), renal failure (42% vs. 6%), followed by heart strake (33% vs. 10%), and hypertension (18% vs.15%).

3.1.2. Major laboratory parameters and markers were tracked in all patients with COVID-19 in survivors and non-survivors.

3.1.2.1. Hematological parameters

Mean of Hb level 12.79±1.38 in all patients, the results showed no significant differences between survivor and non-survivor of covid-19 patients (12.89±1.49 vs. 12.58±1.13, p=0.294). The median WBC value was (8.7) mg/dl (IQR: 6.1–15.63mg/dl). The mean WBC in non-survivor patients was markedly higher than in survivors(15.49±4.68 vs. 7.74±4.04, p=0.0001), 2(6.1) % of non-survivors had WBC less than <4 mg/dl, but 87.9% with WBC more than >10 mg/dl as compared with survivor patients (17(25.4%), and 14(20.9%) respectively. The baseline lymphocyte count median (IQR) value 57.6 (52.8–61.1) was significantly decreased in survivors than non-survivors (p=0.003).

3.1.2.2. D-dimer, Ferritin, CRP, and LDH.

The average value of D-dimer was (2.35) µg/ml with (IQR: (1.2–4.72) µg/ml, highly significant in non-survivor when compared with the survivor (3.86±2.12 vs. 2.62±2.1, p=0.007). The normal of ferritin (20.0–300.0 lg/mL), also elevated with COVID-19 patients' median value was (775) µg/ml, (IQR: 720.3–866.4) µg/ml. Ferritin levels were significantly elevated in non-survivors mean value was (831.4±146.03) µg/ml, as compared with survivors (766.74±91.21) µg/ml, (p=0.008).

The highest value of CRP was achieved with COVID-19 (4.55) mg/dl, (IQR:1.5–5.3 mg/dl) and CRP (normal value: <0.5 mg/dl). There was a significant increase in the mean value of (5.58±1.43) mg/dl in non-survivors compared to (3.14±2.39) mg/dl in survivors (p=0.0001). Moreover, the median serum LDH level was (341.5) IU/L (IQR: 291.3–427 IU/L). Highly significant in non-survivor when compared with survivor mean value of (403.06±99.06 vs. 332.37±94.06, p=0.0001).

3.1.3. Correlation analysis between laboratory parameters

The association of Inflammatory biomarkers and D-dimer as ferritin, CRP, and LDH, in addition to WBC and lymphocytes, were shown in Table (2) and Figure (2). The results noticed a significant positive correlation between D. dimer and ferritin (r=0.355, p<0.001) weak correlation, but highly correlation with CRP (r=0.646, p<0.001), LDH (r= 0.457, p<0.001), WBC (r=0.437, p<0.001), and weak correlation with lymphocyte (r=0.374, p<0.001). A significant weak correlation between ferritin and CRP (r=0.244, p=0.015), and WBC (r=0.315, p=0.001), but no significance with lymphocyte (r=0.159, p=0.114), also a positive correlation with LDH (r=0.667, p=<0.001). CRP was high significant positive correlation with LDH (r=0.457, p<0.001), WBC (r=0.444, p=0.001), and lymphocyte (r=0.436, p=0.114).

3.1.4. The Area Under the Curve (AUC)

ROC curve analysis showed CRP as a marker of COVID-19 severity in survivors compared with survivors with a cut-off value of 4.45 mg/dl, with 87.9% sensitivity and 37.3% specificity, and high significant AUC= 0.802 (95% CI: 0.717-0.886). In comparison, the AUC for the D-dimer value as a marker of COVID-19 severity was 0.749 (95% CI: 0.652-0.846). And a cut-off for D. dimer of 2.40 µg/ml, with 81.8% sensitivity and 32.8% specificity. The AUC of LDH was 0.70 (95% CI: 0.587-0.813), a cut-off was 353.50 (IU/L) with 72.7% sensitivity and 37.3% specificity. But the ferritin showed the lowest AUC, 0.684 (95% CI: 0.555-0.813), a cut-off was 809.50 (µg/ml) with 69.7% sensitivity and 37.1% specificity. Table (3) and (Figure 3).

3.2. Discussions

3.2.1. Characteristics of the covid-19 patients

The retrospective study determined several risk factors for death in adults in Iraq who were hospitalized with COVID-19. The current study assessed 100 covid-19 positive patients, out of which 67 were survivors and 33 were non-survivor patients. In particular, in older age, d-dimer levels greater than 1 µg/mL were associated with a higher risk of non-survivor hospital death. Additionally, elevated levels of blood ferritin, CRP, LDH, leukocytosis, and lymphocytopenia were more commonly seen in association with disease severity in diagnostic covid-19. Both viral survivors and non-survivors have sustained in throat samples. In SARS and MERS, older age has already been recognized as a substantial independent predictor of mortality. (Hong *et al.,* 2018). Increased age was linked to death in patients with COVID-19, according to the current study. The age-related impairments in T-cell and B-cell activity, as well as the overproduction of type 2 cytokines, could result in a lack of viral replication control and more extended proinflammatory responses, potentially leading to poor outcomes. (Opal *et al.,* 2005).

Diabetes, hypertension, heart attack, asthma, stroke, and renal disease were all found to be comorbid in this study and may play important roles in disease severity and death. An increase in comorbidities with

increasing age could explain the greater death rate in the senior population. (Bozkurt *et al.,* 2021). The prevalence of diabetes mellitus among Covid-19 patients varies according to reports. Research by Li *et al.* (2020) found that diabetes was two times more common in severe cases than in moderate cases and that 9.7% of patients with patients had diabetes. The results of the current study were in agreement with (Li et al. 2020). We found that 85% of non-survivors had diabetes. The immune system is thought to be affected by blood glucose levels, making it more susceptible to SARS-CoV-2 infection and other infectious diseases. (Emami *et al.,* 2020).

When comparing non-survivor covid-19 to survivor covid-19, the current study found a greater rate of asthma, stroke, and heart attack. In severe COVID-19 patients, heart failure and coronary artery disease (CAD) were more common than in moderate COVID-19 individuals, as well as those who are closely linked to the occurrence of diabetes and hypertension. Previous research has shown that cardiovascular disorders worsen the severity of COVID-19, as well as mortality among patients with COVID-19 (Orioli *et al.,* 2020, Bozkurt *et al.,* 2021).

3.2.2. Laboratory Finding:

3.2.2.1. White blood cell and lymphocyte

Between the survivor and non-survivor groups, laboratory and biochemical parameters were found to be significantly different. WBC, lymphocytes, d-dimer, ferritin, CRP, and LDH levels were found to be pathologically increased. The status and degree of multi-organ failure are reflected in sepsis and septic shock. (Singer *et al.,* 2016). Although bacterial infections are the most common cause of sepsis, sepsis can also be caused by viral illnesses. This could also explain why a low lymphocyte count is linked to a poor prognosis and a higher complication rate (Zhang *et al.,* 2020). A rapid increase in neutrophil count may also result in lymphocyte apoptosis. Additionally, lymphocytes have ACE receptors, which may be responsible for the virus's direct cytotoxic action (Xu *et al.*, 2020). In this research, we discovered that more than 87.9% of non-survivor patients had WBC more than 10.0 cells/L. Although bacterial infections are the most common cause of sepsis, sepsis can also be caused by viral infections (Zhou *et al*., 2019).

3.2.3. Serum D. dimer level

The non-survivor group had much higher D dimer values, which was consistent with the findings of other studies that examined D dimer levels (Nizami *et al.,* 2021, Rahman *et al.,* 2021). D-dimer value >2000 mg/L upon hospital admission was a predictor of mortality in COVID-19 patients, according to Zhang et al (2020). When comparing non-surviving COVID-19 patients to survivors, a recent study discovered that higher fibrin-relevant (D-dimer and fibrin degradation product) levels were significantly associated with non-surviving COVID-19 patients, In severe SARS-CoV-2 infected patients with increased d-dimer or sepsis-induced disseminated intravascular coagulation, low molecular heparin was also used. Increased d-dimer values in hospital admissions may be a good predictor of COVID-19 severe and fatal cases (Tang *et al.,* 2020). A similar study found that the d-dimer can distinguish between patients with and without significant COVID-19 forms, although it lacked mortality data(Henry *et al.,* 2020). This could be owing to a hypercoagulable state brought on by cytokine storm and viremia, which leads to fibrin polymerization, thrombus formation (Sharba & ALsaleh, 2024), and, ultimately, a negative consequence (Spiezia *et al.,* 2020). In addition, there was a significant positive connection between D-dimer and CRP (r=0.646; p=0.001) in this study. Siemens et al. (2009) found comparable findings in patients with pulmonary embolisms. In COVID-19 patients, there was also a strong positive connection between D-dimer and CRP. The weak influence connection between D-dimer and serum ferritin (r=0.355; p0.001), on the other hand, was shown to be significant. These data imply that during the immunological response to COVID-19, hyperinflammation stimulates coagulation pathways (Jose and Manuel, 2020).

3.2.4. Serum Ferritin level

The non-survivors of COVID-19 had significantly higher serum ferritin levels. Non-survivors had higher ferritin levels than survivors, according to a previous study (Taneri et al., 2020). Furthermore, ferritin levels were observed to rise in correlation with the severity of the condition (Li *et al.,* 2020). The hospital death rate was higher in patients with serum ferritin levels >300 ng/mL than in patients with serum ferritin levels 300 ng/mL, according to Zhou et al (2020). Ferritin level 809.5 was also shown to predict non-survivors with a sensitivity of 69.7.9% and specificity of 37.1.2% (AUC = 0.684). When all of these observations were combined and analyzed, Hyperferritinemia was found to be an independent risk factor in COVID-19 patients, as well as a predictor of illness severity. There are two possible explanations for ferritin's relevance. According to a recent study, the clinical course of severe COVID-19 patients is similar to that of macrophage-activating syndrome patients, which is characterized by elevated ferritin levels and the presence of a cytokine storm. In patients with COVID-19, the H-chain of ferritin-activating macrophages is responsible for increased inflammatory cytokine output (Shoenfeld *et al.,* 2020). Another possibility is that an increase in ferritin helps the immune system respond to invading bacteria by supporting iron metabolism, including viral infections. For viral replication, host cells must have improved cellular metabolism and optimum iron levels. As a result, restricting iron bioavailability is critical for interfering with virus replication. Despite the underlying etiology, Patients with COVID-19 had higher blood ferritin levels. It would be beneficial to see if serum ferritin can be utilized as a biomarker for the severity of inflammation in COVID-19 patients (Wessling-Resnick, 2018). Nonetheless, ferritin is thought to be a good predictor of bad outcomes.

3.2.5. Serum CRP and LDH level

CRP is a well-known inflammatory biomarker that is observed to be increased in the majority of people with COVID-19. In comparison to non-severe instances, more severe cases showed a more obvious increase in CRP levels (81.5% vs 56.4%, respectively) (Guan *et al.,* 2019). Higher CRP levels have also been connected to the development of acute respiratory distress syndrome, increased troponin-T levels, and myocardial damage in patients with severe COVID-19 (Wu *et al.,* 2020, Shi *et al.,* 2020). This can be interpreted as an indication of severe inflammation. CRP serum levels that are elevated are linked to an increased risk of death. Non-survivors have been shown to have a gradual increase in CRP during their hospital stay (Zhou *et al.,* 2019). We discovered that non-survivors of COVID-19 had higher CRP levels than survivors. Moreover, the analysis of AUC showed a higher CRP of (AUC= 0.802 (95% CI: 0.717-0.886).

4. CONCLUSIONS

The study concluded that older age, higher d-dimer, ferritin, CRP, and LDH were associated with disease severity, and adult patients with COVID-19 have a higher risk of dying. D-dimer and CRP were among the best predictors of disease progression. In addition, These biomarkers could be utilized to separate patients who need intensive care at the time of admission, allowing for risk stratification and, hence, better patient management. This will also aid in the reduction of patient mortality by allowing for the early detection of disease progression signs.

5. DECLARATIONS

5.1. Study Limitations

Due to the pandemic that swept the world and the warning and prevention of the risk of **COVID-19** infection, the most important restrictions were the difficulty of obtaining and recording information from the infected patients directly.Therefore, the laboratory and statistical database kept for the infected in the health centers from which the samples were collected was adopted.

5.2. Acknowledgements

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5.3. Funding source

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5.4. Competing Interests

The authors declare that they have no conflicts of interest regarding the publication of this article.

5.5. Open Access

6. HUMAN AND ANIMAL-RELATED STUDIES

6.1. Ethical Approval

After approval was obtained from Kufa University and the Health Intuition Ethics Committee (November 2021).

6.2. Informed Consent

All COVID-19 patients who had been confirmed by polymerase chain reaction (PCR) tests were included in a retrospective cross-sectional research. One hundred patients who satisfied any of the criteria for infection were diagnosed with severe illness. Hospitalized patients have been permitted to give verbal permission due to the significant risk of infection transmission.

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Table 1. *Demographics and Clinical characteristics in Survivor and non- Survivor of COVID-19 patients.*

Parameters	Total patients of Covid- 19 n= 100	Survivor n=67(67%)	Non- Survivor n=33(33%)	p-value
	Median (IQR)	Mean ± SD	Mean ± SD	
Age (year)	43 (32–63.75)	44.46±17.74	51.48±15	0.042
< 40 n(%)	45 (45%)	37 (55.2%)	8 (24.2%)	0.0001*
> 40 n(%)	55 (55%)	30 (44.8%)	25 (75.8%)	0.500
Male n(%)	57 (57.0%)	37 (55.2%)	20 (60.6%)	0.024 *
Female n(%)	43 (43.0%)	30 (44.8%)	13 (39.4%)	0.010 *
Hb (g/dl)	12.8 (11.8–13.7)	12.89±1.49	12.58±1.13	0.294
WBC (X10/mm3)	8.7 (6.1–15.63)	7.74±4.04	15.49±4.68	0.0001 *
< 4 n(%)	19 (19.0%)	17 (25.4%)	2 (6.1%)	0.0001 *
> 4-10 n(%)	38 (38.0%)	36 (53.7%)	2 (6.1%)	
> 10 n(%)	43 (43.0%)	14 (20.9%)	29 (87.9%)	
Lymphocyte	57.6 (52.8–61.1)	55.56±6.13	59.13±3.5	0.003 *
D. dimer (µg/ml)	2.35 (1.2–4.72)	2.62±2.1	3.86±2.12	0.007 *
Ferritin (µg/ml)	775 (720–866.4)	766.74±91.21	831.4±146.03	0.008 *
CRP (mg/dl)	4.55 (1.5–5.3)	3.14±2.39	5.58±1.43	0.0001 *
LDH (IU/L)	341.5 (291–427)	332.37±94.06	403.06±99.06	<0.001 *

*Significant differences at p-value <0.05. IQR, interquartile range; COVID-19, coronavirus disease 2019; Hb, hemoglobin blood; WBC, white blood cells CRP, C-reactive protein; LDH, lactate dehydrogenase.

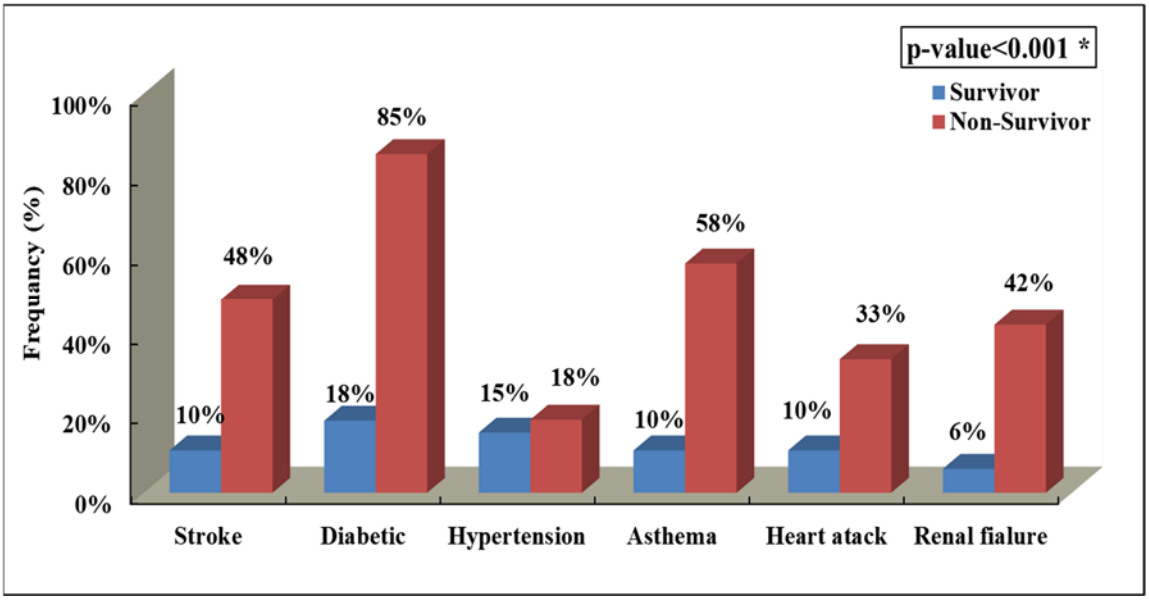

Figure 1*: Prevalence of comorbidities frequency in survivor and non-survivor of covid -19 patients*

Table 2: *Correlation of D-dimer, CRP, and Ferritin levels in COVID-19 patients*

Parameters		D. dimer (µg/ml)	Ferritin (µg/ml)	CRP (mg/dl)	LDH (IU/L)	WBC (X10 mm3)
Ferritin	**R**	0.355**	--			
	P-value	<0.001				
CRP	**R**	0.646**	0.244*	--		
	P-value	<0.001	0.015			
LDH	**R**	0.457**	0.667**	0.457**	--	
	P-value	<0.001	<0.001	<0.001		
WBC	**R**	0.437**	0.315**	0.444**	0.360**	--
	P-value	<0.001	0.001	<0.001	<0.001	
Lymphocyte	**R**	0.374**	0.159	0.436**	0.250*	0.400**
	P-value	<0.001	0.114	<0.001	0.012	<0.001

No. of covid 19= 100 patients; WBC, white blood cells CRP, C-reactive protein; LDH, lactate dehydrogenase. * Correlation is significant at p-value < 0.05; **. at p-value < 0.01.

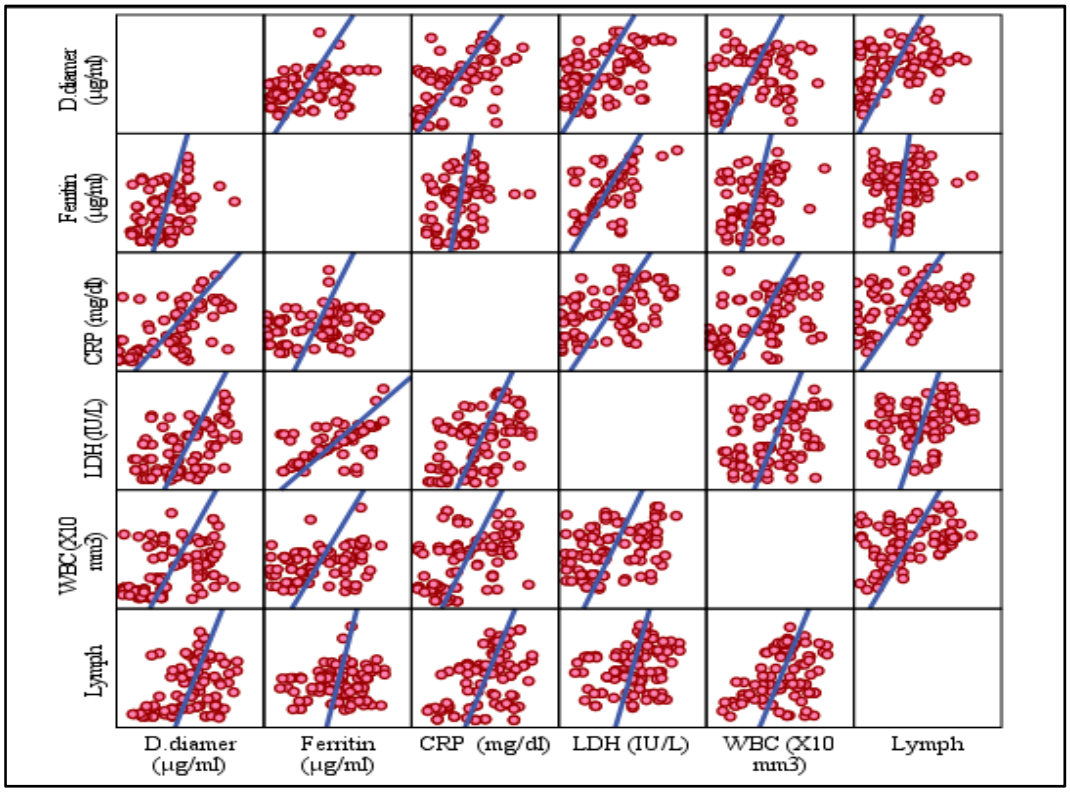

Figure 2: *Multiple scatter plots showed correlations of D. dimer, ferritin, CRP, LDH, WBC, and lymphocytes in patients with COVID-19. WBC stands for white blood cells; CRP is for C-reactive protein; LDH stands for lactate dehydrogenase*

Table 3: *The Area under the curve for study parameters to predict the marker effectiveness for COVID-19 between survivor and non-survivor*

Parameters	AUC	Std. Error	p-value	95% CI	Cut-off	Sensitivity-1 - Specificity
CRP (mg/dl)	0.802	0.043	0.0001	0.717-0.886	4.450	0.879-0.373
D. dimer (µg/ml)	0.749	0.050	0.0001	0.652-0.846	2.40	0.818-0.328
LDH (IU/L)	0.700	0.058	0.001	0.587-0.813	353.50	0.727-0.373
Ferritin (µg/ml)	0.684	0.066	0.003	0.555-0.813	809.50	0.697-0.371

AUC, Area Under the Curve; CI, Confidence Interval. CRP, C-reactive protein; LDH, lactate dehydrogenase.

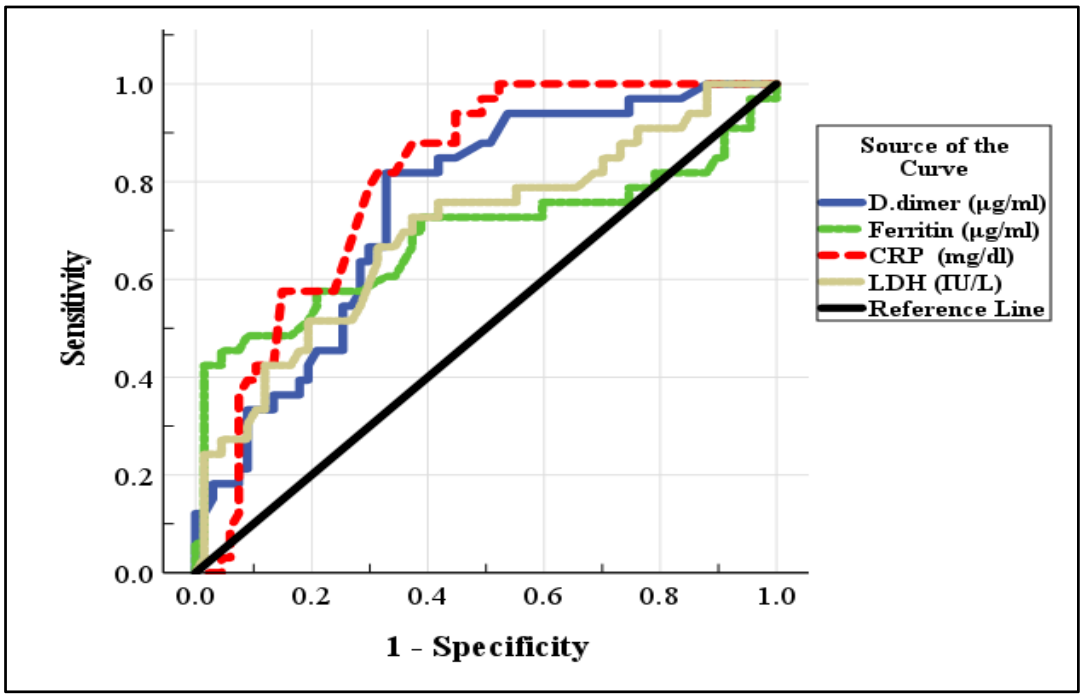

Figure 3. *ROC curve for the D-dimer, Ferritin, CRP, and LDH to predict COVID-19 severity ROC, receiver operating characteristic; CRP, C-reactive protein; COVID-19, coronavirus disease 2019*.

SOUTHERN JOURNAL OF SCIENCES

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Interview

FROM ACADEMIA TO INDUSTRY: A JOURNEY OF INNOVATION IN CHEMICAL ENGINEERING - INTERVIEW WITH PROFESSOR FERNANDO LUIZ PELLEGRINI PESSOA. ENGLISH VERSION

Dr. Fernando Luiz Pellegrini Pessoa
Professor Titular SENAI CIMATEC. Brazil.

Luis Alcides Brandini De Boni*
Araucária Scientific Association. Brazil

** Corresponding author*
e-mail: labdeboni@gmail.com

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SCAN ME

NOTE: Transcript and translation version 1.0.

Dear friends, the interview transcription was done by machine and later reviewed. We are aware that there are imperfections. If you would like to collaborate with improvements, please contact us at southbchem@gmail.com.

https://youtu.be/4Htl-8W8Crw?si=R81XKOu5VqG3nMJO

ABSTRACT

Background: The interview with Professor Dr. Fernando Luiz Pellegrini Pessoa covers his extensive career and contributions to chemical engineering, focusing on innovations and sustainability. **Objectives**: To explore Professor Pellegrini's experiences in various areas of chemical engineering, including teaching methods, research in supercritical extraction, biodiesel production, and process intensification. **Methods**: Semi-structured interview addressing topics such as academic and industrial career, teaching methods, ongoing research, and future perspectives for the chemical industry. **Results**: Professor Pellegrini highlighted the importance of practical application of theoretical knowledge, the development of the Water Source Diagram method, advances in supercritical extraction and biodiesel production, and the need for process intensification in the industry. **Discussion**: The interview revealed the importance of integration between academia and industry, the need for teaching methods that facilitate learning, and the challenges in implementing sustainable and efficient technologies in the chemical industry. **Conclusion**: Professor Pellegrini emphasizes the importance of process intensification and sustainability in the evolution of the chemical industry. He highlights the need for greater collaboration between academia and industry to address future challenges and implement innovative solutions.

Keywords: *Chemical Engineering, Process Intensification, Supercritical Fluids, Water Source Diagram, Industrial Sustainability.*

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Interviewer: Today, we have the honor of talking with Professor Dr. Fernando Luiz Pellegrini Pessoa. Professor, could you give us a brief presentation of your career?

Dr. Fernando Luiz Pellegrini Pessoa.

Prof. Pellegrini: I consider my career as starting 17 years ago, teaching at a college entrance exam prep course. Actually, I used to set up the courses and call first-year students. I was in my second year of scientific studies at that time, so I would call eighth-grade students to earn some money. That's when I really fell in love with academia.

I took the college entrance exam - in my time it was called vestibular - and got into Chemical Engineering at UFBA (Federal University of Bahia). I studied Chemical Engineering, took the Petrobras course, but asked to leave to avoid being tied to a job at the company. I went to do my master's at COPPE/UFRJ. After completing the credits, I joined UFBA in a large FINEP project with UFBA and, at the time, COPENE (now Braskem) for simulator development.

I stayed at UFBA for three and a half years teaching, developing research, and even became coordinator of this project for 2 years. After this period, I asked to leave this research part. I hadn't finished my master's because you get involved in many activities.

In 1986, I started a consulting and software development company. This company got two projects, but a colleague preferred to go to Rio, so we closed the company and I joined the Petrochemical Complex, where I worked for 5 and a half to 6 years. It was at what is now Braskem Vinyls, it was Camaçari Petrochemical Company, producing polyvinyl chloride (PVC). I worked a lot in the vinyl monochloride optimization area. We managed to save 2 million dollars per year by optimizing the entire process.

I did my doctorate in thermodynamics. I worked with the Danish team, the inventors of UNIFAC, Rasmussen and Fredenslund (UNIquac Functional-group Activity Coefficients). I spent 1 and a half years in Denmark. I returned to the company, resigned because I wanted to enter academic life.

I applied for three different positions: UFRJ (Federal University of Rio de Janeiro) in process engineering, UFF (Fluminense Federal University) in biotechnology, and at Rural Rio de Janeiro (UFRRJ) in transport phenomena. The UFRJ competition happened first, I passed and worked there for 28, 29 years. I left as a full professor.

Over this time, I have participated in various projects. Today I have around 160 students who have completed their master's and doctoral degrees under my supervision. This is a milestone that I consider important, as the main objective is to educate people. I hope to reach 200. Just over 40 to go. If I continue at this pace, it will take another 10-15 years. My goal is to stop at 85 years old, and then just focus on writing books.

At UFRJ, I have many articles published in journals and conferences. I don't even count conference papers anymore, there are over 600 works. In journals, there must be around 200. I'm not sure exactly, my students keep track of that. I have a student who manages this control for me, receiving a small scholarship that I pay for personally.

Then I retired. A rule came out here in Brazil where the sum of your working time, INSS (Social Security) time, with your age above 90 years, a rule that came out right at the beginning. Since I started signing my work papers early, I added it up and decided it was time for a change. I went on to apply for visiting professor positions. I was approved at both UFBA and the Federal University of Pernambuco.

Since my family is all from Salvador, Bahia, I ended up returning to Salvador. During one of these visits, I was already approved at UFBA (Federal University of Bahia), and had chosen to stay at the Federal University of Bahia, which is my homeland. Then CIMATEC came along. Someone invited me to talk with CIMATEC's board. I was enchanted by their ideas, which were quite different from the Federal University. At CIMATEC, besides doing basic research, the main objective is to direct results straight to industry. It's much more applied research, it doesn't stay on the shelf, you have to apply it. SENAI CIMATEC is made for industries.

I've been a full professor here for 7 years. We have doctoral and master's programs. Two years ago, we managed to raise our doctoral program to grade 6. It was 5, so now it's a program of excellence. We have good students and the good thing is that everything we do must be applied. What we say is that it has to reach technological maturity, or TRL (Technology Readiness Level), around 8-9. That's the objective.

Technology Readiness Level: Originally developed by NASA and is now widely used in various fields.

The scale goes from 1 to 9, where:

TRL 1: Basic principles observed and reported
TRL 2: Technology concept formulated
TRL 3: Experimental proof of concept
TRL 4: Technology validation in laboratory environment
TRL 5: Technology validation in relevant environment
TRL 6: Demonstration in relevant environment
TRL 7: Prototype demonstration in operational environment
TRL 8: Complete system qualified
TRL 9: Actual system proven in operational environment

In context, when "TRL 8-9" is mentioned, it means the goal is to reach a level where the technology is practically ready for commercial use or real implementation, with the system already tested, qualified and proven in an operational environment.

***Interviewer*:** Professor, before we begin our interview properly, I need to make some announcements:

1. Our interview will be made available under a Creative Commons license;
2. The Portuguese transcription will be published by Thcê Química Journal, and the English version in the Southern Journal of Sciences. We will also make our video available to a local television station;
3. The estimated duration of our interview is approximately 45 minutes;
4. I am not a professional reporter.

Professor, starting our questions: You have had quite a diverse career, encompassing both academic work and industry experience. How has this combination of experiences shaped your approach to engineering education and research?

Prof. Pellegrini: That made things much easier, because I have certain preferred subjects or lines of work: thermodynamics and process engineering or process systems engineering. I have this large number of students who have defended their theses because when I teach, I present cases from my industry experience. I say: "I applied thermodynamics to this. Just by using phase equilibrium, I studied and achieved savings of X thousand reais." In systems and process engineering, I show how I optimized certain processes.

I show practical cases where I applied all the theory. That's why students like to choose me as their advisor. They have that idea: "Now that I'm going to study all this theory, where will I apply it?" This helped me a lot, including focusing on industrial problems. Whenever I take material to study or review, or an article, I think: "How will I apply this industrially? How will I apply this in practice?"

This makes it easier to structure a class. I review my classes every semester. People even joke: "Professor, you've been teaching for 40 years, why do you need to review?" I answer: "I review because there are new things, new subjects." There are thermodynamic studies that I can apply, for example, to healthcare. Sometimes I give examples applying it to cataract eye drops. I keep updating myself on the practical applications of these areas.

This changes both the way of thinking and

advising. All the theses and dissertations I supervise always have a chapter on practical application. When it's basic research, we indicate: "Look, this here can lead to that." When it's applied research, I show a real industrial case.

***Interviewer*:** As a professor at SENAI CIMATEC (National Industrial Learning Service - Integrated Manufacturing and Technology Center), what innovative teaching methods have you implemented to prepare students for evolving challenges in chemical engineering?

Prof. Pellegrini: Actually, I haven't studied any of these innovative methods that have appeared. I've been doing it more or less the same way since I started. I really liked working from a specific project, a theme. For example, in the thermodynamics class at UFRJ, which has four courses in the School of Chemistry - Food Engineering, Bioprocess Engineering, Industrial Chemistry, and Chemical Engineering - I would divide the class into these four areas and start by offering a project to the groups. In healthcare, thermodynamics applied to bioprocess engineering, protein purification. The entire course was discussed based on these projects.

Today I really enjoy teaching online. For some subjects, especially when it's a lecture, it works well. For some classes, I always like to have a part that's deduction, and then I prefer the classroom and the board. I'm still old school, I like to put my derivatives and integrals on the board.

I tell students: "Every course we teach, whether master's or doctorate, has an informative part and a formative part." The formative part is fundamental. I push students to study, but I always say on the first day of class: "My concern is to give a good class and be available for you to discuss with me, but the concern to study is yours."

I give my example: my Chemical Engineering course didn't have Mass Transfer. When I went to do my master's and doctorate, as I leaned towards thermodynamics and process engineering, I only had the basic course. Today I have several Mass Transfer books because I always need to study when a project in this area comes up.

I recommend my students to study Paulo Freire, because his idea about literacy can be applied in the classroom, bringing the classroom environment and adapting the class to that environment for them to learn more. And also Augusto Boal, with the Theatre of the Oppressed, who made the audience part of the play.

***Interviewer*:** Professor, you were recognized as a level 1A researcher by CNPq. What advice would you give to young researchers who aspire to reach this level of excellence?

Note: CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico) is Brazil's National Council for Scientific and Technological Development, and level 1A is the highest classification for researchers in Brazil's research productivity fellowship system.

Prof. Pellegrini: This is a question I could answer in either a beautiful or pragmatic way. The pragmatic way is to follow the rules. CNPq just released new rules this week. There won't be researcher 1A anymore, it will be researcher A, B, and C. The rules are very clear and well-defined. Each committee adapts their ideas. Being pragmatic means following that because you want to get the grant. It's about having so many publications in high impact factor journals.

I have a former student, now an excellent researcher recognized worldwide, who was pragmatic. He followed all the rules and achieved what no one had. But I never did that. I simply said: "It's a consequence." I'm very utopian indeed, I really like to dream. I said: "I'm going to publish, I'm going to do what is my obligation, which was paid for by the government."

Since I received government grants during my master's, doctorate, and post-doctorate, I have to give back to society. I didn't care much about the pragmatic aspect. I really enjoy teaching classes and giving lectures. My main function is to educate students. And my research helps me prepare my classes, because without it I can't have knowledge, be at the state of the art to be able to give a good class.

***Interviewer*:** Your work in supercritical fluid extraction has been extensive. Could you highlight a breakthrough moment in this research that particularly excited you?

Note: This is a technical question specifically about supercritical fluid extraction, which is an important separation technique in chemical engineering where substances are extracted using supercritical fluids (substances above their critical temperature and pressure).

Imagem: Laboratório para extração com fluido supercrítico.
Fonte da imagem: gerada por IA em runwayml.com.

Prof. Pellegrini: The moment was my first doctoral supervision, of who is now Professor Silvio Vieira de Melo. It was right after I joined UFRJ. When I left Salvador definitively, I was working in petrochemicals. When I arrived in Rio, there was none of that. Today there's pre-salt, but there wasn't at that time.

Since I passed the process engineering competition, after extensive research, I realized I needed to apply it to natural products. I surveyed what was available in the Rio region that I could add value to. At the time, Professor Maria Ângela Meireles from UNICAMP was who first started working with supercritical extraction in Brazil. She had the experimental part, being from food engineering. I told Silvio: "Let's work on the process engineering part focused on supercritical extraction."

Supercritical extraction is used today to purify, extract various pharmaceuticals, various biomolecules in pure form. For pharmaceuticals, you need to have 99.9999% purity, and supercritical fluid can provide that purity. Then came the oil deasphaltation part, using supercritical propane along with CO_2.

With pre-salt, where you get up to 80% CO_2 in the fields, all supercritical at 700 bar pressure and 100-120°C temperature, a corrosion problem emerged. The supercritical fluid, especially CO_2, when it reaches this condition, the dielectric constant, which is practically zero at ambient conditions, goes to 78, close to that of water. If water at this level can dissociate salts, CO_2 can too, causing corrosion.

Today I continue working with supercritical fluid. At CIMATEC, I support the food group in this area. We have a small equipment, but we can see the extraction curve and do scaling. It has a future mainly because CO_2 is a green solvent. In the future, CO_2 capture for use as a supercritical fluid will be important.

In the Amazon, for example, there are places where 3 to 4 liters of diesel are spent for people in the community to use 1 liter of diesel. If you make a well-structured biorefinery, looking at the environment, you can extract high value-added products from the Amazon rainforest and produce biofuel with the residue, adding value to that population without harming the environment..

***Interviewer*:** The Water Sources Diagram method that you developed seems crucial for water management. How do you see this tool evolving to address future water scarcity challenges?

Note: The "Diagrama de Fontes de Água" (Water Sources Diagram) is a systematic method for water and wastewater minimization in industrial processes, particularly important for sustainable water management in industries.

Imagem: Representação de uma biorrefinaria.
Fonte da imagem: gerada por IA em ideogram.ai.

Prof. Pellegrini: It was an interesting method, based on water Pinch theory. When we tried to apply it to multicontaminants, it didn't work. I talked with Professor Zempieri from UNICAMP, who did his doctorate with Linnhoff's group at UMIST. He confirmed that it really didn't work.

The method emerged when I had a student I was advising. A paper came out from Professor Henrique Matos from Instituto Superior Técnico giving an idea. My student started: "If I do it this way, it works." At the time, I was on medical leave, and I started developing the method.

We began applying it in various industries: paper, petrochemical, among others. Regarding water scarcity, industry consumes a large amount of potable water. The energy transition in Brazil has to go through an increase in energy efficiency of the Brazilian technological park. We need to optimize what we have, as the cost will be much lower with this optimization.

When we talk about water, energy is involved. When we optimize, we already contribute to decarbonization. We are trying to develop a computer program for the Water Sources Diagram. We already have two master's dissertations that developed versions in Excel VBA and C++, but we want something professional.

***Interviewer*:** How do you see the chemical industry evolving in the next decade to meet sustainability goals?

Note: This question addresses the future direction of the chemical industry in relation to environmental sustainability and climate change mitigation targets.

Prof. Pellegrini: First, industry has to believe in process intensification. The method I like is the one developed in Denmark, at the University of Lyngby. It analyzes the entire process flowchart, breaks it down into equipment, looks at the function of each one and the phenomena involved.

The goal of intensification today is to minimize environmental impact, reduce plant size while maintaining the same nominal capacity - reducing CAPEX (Capital Expenditure) and OPEX (Operational Expenditure) - and improve social impact. At CIMATEC, we're working with social metrics, because each region has its own characteristics.

One problem is that even within academia, many colleagues don't believe in intensification or don't know about it. If the academic community itself doesn't believe in it, how will this knowledge be passed on to industry? It's a relatively small community.

I had an interesting experience in a roundtable with a foreign oil company director. When I presented about thermodynamics, she said that "enthalpy and entropy were useless." I explained that these concepts are fundamental even in management. When I asked if she would apply academic knowledge in her home country without the requirement of special participation, she was honest: "I wouldn't apply it."

At SENAI CIMATEC, we have a different approach. When a project comes up, it goes through a team specialized in negotiation. Before, at the university, I used to charge very low fees. Once I charged R$ 37,000 for an energy integration project that an English company later revealed they had charged R$ 460,000 for.

***Interviewer*:** On behalf of the Second Southern Scientific Conference, I would like to express our sincere gratitude for your participation and for sharing your valuable knowledge and experiences with us. Your contribution is extremely important for the advancement of

Science and Technology in our region and in our country.

Prof. Pellegrini: Thank you. It was very good. I talked about many things that I haven't talked about in a long time. People even joke that I'm a hermit, that I just stay studying, but I do other things, I like cinema. It was a pleasure to participate.

***Interviewer*:** Thank you, Professor. Have a good day.

Prof. Pellegrini: Good day to you too.

Help with definitions:

***CAPEX** (Capital Expenditure):*

Refers to expenses that a company makes to acquire, improve, or maintain long-term physical assets, such as properties, equipment, or infrastructure.

Main characteristics:
· These are investments that generally bring benefits over time.
· Include purchases of machinery, factory construction, land acquisition, among others.
· Typically, these expenses are recorded on the balance sheet as assets and are depreciated or amortized over time.

Example:

Purchasing new machinery for a factory or constructing a new office.

***OPEX** (Operational Expenditure):*

Refers to costs related to a company's daily operations, such as salaries, rent, and utility bills.

Main characteristics:
· These are recurring expenses necessary to keep operations running.
· Include expenses such as maintenance, raw materials, energy, software licenses (SaaS), and marketing costs.
· Typically, these expenses are recorded in the income statement and directly impact profit in the period they occur.

Example:

Payment of electricity bills or maintenance of existing equipment.

DECLARAÇÕES

1. Limitações: A entrevista limita-se ao seu conteúdo.

2. Fonte de financiamento: O anfitrião financiou esta entrevista.

3. Conflitos de interesses: O anfitrião trabalha para a revista há muitos anos e isso pode ter influenciado a entrevista.

5. AI Usage Declaration: This manuscript was transcribed and translated with the assistance of artificial intelligence tools. Specifically, Claude AI (Anthropic), ChatGPT (OpenAI), Perplexity AI, and Google Colab were used to help organize and structure the content. All information and data presented are accurate and were verified by the editors, with the AI serving only as a writing and organization aid. The final content, analysis, and conclusions were reviewed and validated by the author to ensure the accuracy and integrity of the scientific reporting.

SOUTHERN JOURNAL OF SCIENCES

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Note

SECOND SOUTHERN SCIENCE CONFERENCE - INTERNATIONAL SCIENTIFIC CONFERENCE – 2024

Prof. Dr. Walter José Peláez[1,2,3,*]

[1]Universidad Nacional de Córdoba. Facultad de Ciencias Químicas. Departamento de Fisicoquímica, X5000HUA, Córdoba, Argentina.

[2]Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Instituto de Investigaciones en Fisicoquímica de Córdoba (INFIQC), X5000HUA, Córdoba, Argentina.

[3]Co-chair of the Second Southern Science Conference.

** Corresponding author*
e-mail: walter.pelaez@unc.edu.ar

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ABSTRACT

Background: Scientific conferences play a vital role in knowledge exchange and collaboration across disciplines. Building on the success of its 2022 inaugural event, the Second Southern Science Conference (SSCON 2024) aimed to expand international scientific collaboration while addressing contemporary challenges in sustainability and research methodology. **Aims**: To evaluate the effectiveness of a hybrid conference format in facilitating global scientific collaboration and to showcase cutting-edge research across multiple disciplines, with particular emphasis on sustainability and technological innovation in Latin America. **Methods**: The conference implemented a hybrid format combining in-person and virtual attendance. Over three days, 38 lectures were presented by renowned researchers, covering key topics including materials science, environmental sustainability, chemical processes, and regional development. Participation metrics and collaboration patterns were analyzed to assess the conference's impact. **Results**: The conference achieved significant participation with 242 contributing authors from 13 countries across four continents. Notable research presentations included advances in laser surface modification techniques, geotechnology applications in biofuel production, sustainable silica synthesis from biomass, and green valorization of tropical seeds. The conference produced 66 approved papers, with most involving 2-5 collaborators. **Discussion**: The hybrid format proved effective in removing geographical barriers and promoting global engagement. The strong representation from Latin American institutions highlighted the region's growing influence in international scientific discourse. Key research presentations demonstrated innovative approaches to sustainability challenges, particularly in waste utilization and environmental technology. **Conclusion**: SSCON 2024 successfully evolved from its predecessor, demonstrating the effectiveness of hybrid conferencing in fostering international scientific collaboration. The conference established itself as a vital platform for knowledge exchange, particularly in sustainability and technological innovation, while identifying areas for future improvement such as extended submission timelines and permanent management structures.

Keywords: *Conference, Evolution, Hybrid format, Collaboration, Cutting-edge research and technology, Sustainability.*

1. INTRODUCTION

In my previous editorial (Peláez, 2022), I addressed the readers of the Southern Science Journal and committed myself to put all my efforts to make both the Southern Science Conference and the Southern Science Conference grow and evolve. Today, looking back on what has happened, I can say that the effort has paid off, but that I need to keep working and focusing my energy to continue moving towards a more globalized and interrelated world. To the best of my knowledge, evolutionary changes in living beings occur due to mutations that produce the appearance of individuals who are better

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adapted to their environment (Darwin, 1859). These also happen in scientific journals and events, where the most adapted ones remain in time and are recognized by their peers. In our case, the Second Southern Science Conference evolved and grew greatly in 2024 in comparison with the first edition in 2022 (Southern Brazilian Journal of Chemistry, 2022; Second Southern Science Conference, 2024a) , incorporating new institutions and collaborators from different parts of the world, strengthening the network that only scientific knowledge and its dissemination can achieve.

The hybrid format of the SSCON 2024, significantly influenced participation rates in several ways, one of the most important ways was broadening the local and international participation in comparison with the first edition (Southern Brazilian Journal of Chemistry, 2022; Second Southern Science Conference, 2024a). In this occasion, the hybrid program allowed both in-person and virtual attendance to engage in the conference. This was crucial for the promotion of global scientific collaboration and knowledge exchange, as it removes geographical barriers that might have limited attendance in a traditional format. In this event, more than 240 authors from different countries and 4 continents shared their knowledge and research, Figure 1.

Figure 1. SSCON 2024 Participating Countries: Argentina, Brazil, Georgia, India, Iraq, Ireland, Mexico, Nigeria, Portugal, Russia, Spain, United States, and France

2. Selected lectures given by renowned researchers

During the three days of the conference, 38 lectures were given by renowned researchers on different topics proposed by the Scientific committee (Second Southern Science Conference, 2024b). All of them turned out to be of a high level, but I have selected a few representative speeches to perform some comments, belonging all of them to the following key topics: Materials science, Environmental sustainability, Chemical processes and development and Regional Development and Sustainability.

In the lecture titled **Materials surface modification by pulsed laser techniques**, **Prof. Dr. Maximiliano Rossa** (Rossa, n.d.) commented that his research primarily focuses on the fields of Physical Chemistry and Laser Chemistry, with a particular emphasis on Molecular Reaction Dynamics, Laser Techniques in Material Processing and Surface Modification. His research involves studying various gas-phase physical and chemical processes, especially those involving metal-containing species and clusters, as well as s-heptazine derivatives. This research aims to understand the fundamental mechanisms of molecular interactions and reactions in different environments. In his conference, Prof. demonstrates how specific laser techniques can modify the surface characteristics of polymer films. For instance, the Surface Bio-Inspired (SBI) technique can increase surface roughness or create micro-foams and craters on polymer surfaces. Additionally, the Direct Laser Interference Patterning (DLIP) technique is noted for its ability to produce precise periodic patterns on polymer films, which can enhance properties like fluorescence and wettability. Overall, Dr. Rossa's research integrates advanced laser techniques with molecular dynamics to innovate in the processing and application of polymeric materials, showcasing the potential for significant advancements in material science.

The use of geotechnologies in monitoring new raw materials for biofuel production was

lecture performed by **Prof. Dr. Anna Claudia dos Santos** (Santos, n.d.) . Prof. Santos commented that the purpose of her Study is based on the Role of Geotechnologies for addressing challenges in biofuel production, highlighting the use of satellite imagery and spatial analysis as essential tools and emphasizes the importance of compliance with environmental policies, such as Brazil's RenovaBio, which aims to reduce greenhouse gas emissions through biofuels. Also, Dr. stablish that remote sensing technologies provide critical insights for decision-making, including identifying optimal cultivation zones, ensuring compliance with environmental regulations, and assessing carbon sequestration potential. Also, Prof. Santos comments that this data-driven approach promotes the diversification of feedstocks and minimizes environmental impacts. As an important point, during the conference Brazil is presented as a prime example of integrating geotechnologies into biofuel production due to its vast and diverse territory. Also, it was stated that the country has a strong foundation for innovation in bioenergy, supported by strategic use of geospatial tools to monitor feedstocks and production systems.

Summary of the conference **Silica synthesis from biomass: sustainable use of agro-industrial waste, performed by Prof. Dr. Denise Alves Fungaro** (Fungaro, n.d.). In her speech, Prof. Fungaro discusses the sustainable use of waste for silica synthesis, emphasizing the importance of converting agricultural waste into valuable materials. The research highlights the significant amounts of biomass waste generated from agribusiness activities. The sol-gel technique is highlighted as a key method for synthesizing silica nanoparticles (SiNPs). The synthesis of SiNPs involves extracting silica from biomass waste, primarily through chemical methods, which allow for better control over the size and morphology of the particles. In addition, Prof. discusses about the applications of SiNPs due to their unique properties, such as stability and high surface area and their potential use in environmental remediation, including wastewater treatment and carbon capture, showcasing the value-added poducts that can be derived from agricultural waste.

In the lecture titled **Green valorization of highly underutilized tropical seeds as nutricosmeceutics and dermocosmeceutics, Prof. Dr. Atolani Olubunmi** (Olubunmi, n.d.) explores an innovative green synthetic route for the direct characterization of various underutilized tropical seeds. He emphasizes the potential of these seeds in developing plant-based cosmetics and nutricosmetics, aligning with sustainable development goals (SDGs). For his research utilized multistep and direct methylbutylation to obtain lipid and fatty acid methyl and butylisobutyl esters from the seeds, which were characterized using Fourier Transform Infrared Spectroscopy and Gas Chromatography-Mass Spectrometry. Prof. point out that the study also adopted principles of green chemistry to create cosmetics that are biodegradable and free from synthetic additives. Dr. Atolania highlight the development of natural cosmetics that are effective and cost-efficient compared to commercial products and also stated that these cosmetics are entirely plant-based and do not contain artificial antibiotics, colorings, fragrances, or preservatives, making them a safer choice for consumers.

3. Key Conclusions of the Second Southern Science Conference – 2024 edition.

More than a few important conclusions regarding the Second Southern Science Conference and its impact on international scientific community can be obtained. These are the main outcomes:

- Effectiveness of Hybrid Format: The conference successfully utilized a hybrid format, combining in-person and virtual attendance. This approach facilitated broader international participation and knowledge exchange, proving effective in fostering global scientific collaboration while addressing contemporary challenges.

- Significant Participation Metrics: The conference achieved notable participation metrics, with 65 approved papers and 242 contributing authors. This indicates a strong interest and engagement from the scientific community, particularly from Latin American institutions, which showcased their growing influence in international scientific dissertation.

- Collaboration Patterns: Most papers presented at the conference involved 2-5 collaborators, highlighting effective research collaboration patterns. The *Universidade de Vassouras*, *Universidad de Mendoza* and the *INFIQC-CONICET-Universidad Nacional de Córdoba* were

recognized as the leading institutions, reflecting its long-standing legacy of academic excellence.

- Future Directions: The success of this conference supports the planning of future iterations, with the next edition scheduled to be held in Vassouras (Universidade de Vassouras 2026), Brazil. Areas for improvement were identified, such as extending submission timelines and establishing a permanent management committee to enhance future events.

- International Scientific Collaboration: The conference underscored the growing importance of international scientific collaboration in addressing global challenges. It highlighted the significant contributions of Latin American institutions across various fields of research, reinforcing the need for cross-border academic partnerships.

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5. DECLARATIONS

5.1. Study Limitations

The note is limited to its content.

5.2. Acknowledgements

As Editor in chief of the Southern Science Journal I express my gratitude to all the invited speakers, to the authors of papers to be published in the Southern Science Journal and Tche Quimica, to the authors of posters, to all the participants (present and virtual) and to all the scientific community in general. I look forward to meeting you at the next event at the Third Southern Science Conference at the University of Vassouras in 2026.

5.3. Funding source

The author funded this note.

5.4. Competing Interests

The author participated in the conference and was extremely well-received in Argentina. Therefore, this amazing impression may have limited his judgment.

5.6. AI Usage Declaration

This manuscript was developed with the assistance of artificial intelligence tools. Specifically, Claude AI (Anthropic) was used to help organize and structure the content. All information and data presented are accurate and were verified by the author, with the AI serving only as a writing and organization aid. The final content, analysis, and conclusions were reviewed and validated by the author to ensure the accuracy and integrity of the scientific reporting.

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SOUTHERN JOURNAL OF SCIENCES ANNUAL TRANSPARENCY REPORT

Walter José Pelaez[1]; Luis Alcides Brandini De Boni[2]

[1] INFIQC, Departamento de Fisicoquímica. Facultad de Ciencias Químicas, Universidad Nacional de Córdoba, Córdoba, Argentina.

[2] Southern Journal of Sciences, Brazil.

** Correspondence author*
email: sjofsciences@sjofsciences.com

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In 2022, the Southern Journal of Science introduced the practice of producing an annual transparency report to give authors and institutions access to useful information about the journal. The main facts were presented in bullet format to make the report succinct.

- **Current Editor-in-Cheife**: Dr. Walter José Pelaez.
- **Past Editors**: Dr. Lavinel G. Ionescu; Dr. Luis A. B. De Boni.
- **Currently Edited by:** Aruacária Scientific Association CNPJ # 52.968.321/0001-8
- **Number of countries represented in the journal council**: 12.
- **Number of conferences the journal was invited to publish the resulting material**: 1.
- **Number of conferences that the journal published the resulting material**: 0.
- **Number of manuscripts received in 2024**: 23
- **Number of manuscripts published in 2024**: 13
- **Amount of manuscripts that will continue the publication process in 2025**: 3
- **Amount of improper submissions**: 3
- **Amount of rectified submissions**: 3
- **Innovative tools introduced in the journal**
    - *Abstract Maker tool*: <https://www.sjofsciences.com/Abstract-maker.php>
    - *Manuscript Sketch Tool*: <https://www.sjofsciences.com/manuscript-sketch-maker.php>
    - *Reference formatting tool**: <https://www.sjofsciences.com/doi_to_apa.htm>. This tool reflects the page https://citation.crosscite.org/
- **Financial support received from other institutions (in USD):** $ 0,00. A proudly independent journal.
- **Indexed in:** Index Copernicus International; Crossref; Google Scholar; ROAD (Directory of Open Access Scholarly Resources); Internet Archive Scholar (FATCAT); OpenAlex; SUDOC (French University Documentation System); ISSN Portal.

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