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Improving Trucks Management

Parabolic Concentrating System

Highlights

The Thermal Properties of PVCs

A Modern Design and Development

Discovering Thoughts, Inventing Future

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Islamic Smart City Innovation, Concept, Application and Shari'ah Parameters: A Theoretical Assessment and Technological Advancement in Artificial Intelligence

By Auwal Adam Sa'ad, Adamu Abubakar Ibrahim, Aznan Hassan & Abubakar Usman

Islamic University

Abstract- It is the goal of this paper to establish mechanisms for smart cities to include Islamic approaches by interacting with the following components: "Smart Facilities", "Smart Devices", "Smart Governance", "Smart Data", and "Smart People "influence towards the adoption of Islamic smart city concepts, taking into account the wide range of smart city components. Assessment of these variables associated Islamic approach has been presented in this paper. It was revealed that in order to improve the quality of life, a smart city makes use of cutting-edge advance technology and technological tools like sensors and a sensor network, among other things. Furthermore, Smart city adoption in the Muslim world, Muslim communities, or in and around Muslim-majority areas has also been a long-standing quest for ways to improve the quality of life for Muslims. While also taking into consideration the Islamic approach to constructing a smart city, the concept will conserve and promote a more environmentally conscious community.

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Islamic Smart City Innovation,Concept, Application and Shari'ah Parameters: A Theoretical Assessment and Technological Advancement in Artificial Intelligence

Auwal Adam Sa'ad [α], Adamu Abubakar Ibrahim [σ], Aznan Hassan [ρ] & Abubakar Usman [ω]

Abstract- It is the goal of this paper to establish mechanisms for smart cities to include Islamic approaches by interacting with the following components: "Smart Facilities", "Smart Devices", "Smart Governance", "Smart Data", and "Smart People "influence towards the adoption of Islamic smart city concepts, taking into account the wide range of smart city components. Assessment of these variables associated Islamic approach has been presented in this paper. It was revealed that in order to improve the quality of life, a smart city makes use of cutting-edge advance technology and technological tools like sensors and a sensor network, among other things. Furthermore, Smart city adoption in the Muslim world, Muslim communities, or in and around Muslim-majority areas has also been a long-standing quest for ways to improve the quality of life for Muslims. While also taking into consideration the Islamic approach to constructing a smart city, the concept will conserve and promote a more environmentally conscious community.

I. Introduction

The impact of technology in today's Muslim's life has been tremendous in different Muslim's nations. Muslims were known to be the inventors of various innovations that led to the creation of many cities across the history. In today's Muslims societies, there are numerous Islamic Smart cities introduced and developed to cater to the Muslims need across the globe, Malaysia and Indonesia where seems to be leading in the design and development of the Islamic Smart cities. However, it is important to understand how different is the Islamic Smart city, and what made it Islamic as well as the origin of Islamic cities. This paper has endeavored to shade light on these issues by looking at the past, current and future developments of Islamic Smart cities and how Important it is in the current technology revolution 4.0. The original idea of Islamic smart city has been supported by the precise Shari'ah rules and regulations which were designated to actualize the healthy life style of the Muslims communities and emphases on green living society with strict care to the environment and other inhabitant within and surrounding the Muslims communities.

The Islamic economic system was known to have introduced principles that endeavored to respecting the environment through land management, water supply and air protection for sustainable living, and this has contributed to the effective ecological care and development of Muslims nations across the history. Prophet Muhammad peace be upon him has enacted a principle for land acquisition in the Islamic society and this principle was based on land development and investment, "whoever developed a land he owns it" this prophetic tradition has contributed to the land development and also the land acquisition process which was constituted on sustainable development. Land development is an integral part of an Islamic Smart city development, the principles of land acquisition in Islam is a part of the Islamic Smart city principles which is a merger of other Islamic principles on environmental care, principles for improving the quality of natural resources as well as the principles related to Islamic design and green planning which incorporated with the modern technology support, this has resulted in the introduction of the concept of Islamic Smart city development in today's Muslims societies.

II. The Concept of Smart City

A Smart city is a harmonious city in which information and communications technology (ICT)-driven technology enhances municipal services in order to improve the quality of life for citizens was first proposed by IBM in order to depict a harmonious city in which information and communications technology (ICT)-driven technology enhances municipal services in order to improve the quality of life for citizens (Chang, 2021). Smart city are Intelligent cities consider as harmonious places where data-driven services are set out to benefit interactions of people and their environment. That is, cities that are considered to be "smart" are harmonious places where everyone generated and share data with people and their

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surroundings (Bibri, 2021).Smart cities may connect their infrastructure with other sectors and areas of life based on data collection and analysis, and they can use new technologies to discover answers to problems, which makes things even more exciting (Hashem et al., 2016).

A significant role has been played by smart cities in the development of several aspects of human existence, affecting sectors such as education, health and many more (Ahad et al., 2020). The amount of data being collected and stored is expanding at rate where many human activities are tied to generating, processing and analyzing data, particularly in the case of businesses which requires instant report (Van Doorn & Badger, 2020).The ability to recognize and extract important information from huge volumes of transactional data can be highly beneficial in a variety of ways when it comes to human activities, typically those activities that depend on the online application (Ajah & Nweke, 2019). The analysis of transactional data of day-to-day human affairs can also aid in the early warning of potentially hazardous weather conditions to the general public, which can help to save lives (Porter & Heppelmann, 2015).

It wasn't that long ago that the phenomenon of "ethos" in technology was established to distinguished among those technologies that are defined by people against those technologies that defined people (Brett, 2009).The concept of ethical behaviour in technology has been introduced historically to realize that technology does not only define itself by the wide range of hardware, software and data it generates and networks it connects, but also by the way people place value on adopting a variety of new technologies at an increasingly rapid rate (Wang et al., 2020).Therefore, Islamic values should be included as a core component of any smart city design. When combined, these values will provide the opportunity to gain significant insights into the usage of vast amounts of technology, which is becoming increasingly widespread. Particularly when compared to human activity, several features of smart cities are characterised by their unstructured nature (Martucci et al., 2017). Every one of these considerations when taken into account when designing the Smart City concept will yield a better interactions of devices. The concept of values in smart city associated with Islam include themes as diverse as internet networks from Islamic perspective, city services, and infrastructure, among other things. There has been a plethora of criteria developed for their most well-known criterion classification.

In order to add value and increase engagement, the smart city makes advantage of developing technology, such as integrations of various wireless technology, while simultaneously increasing the overall quality of life. However, the application of Islamic values in the smart city is still in its infancy. When it comes to improving the quality of smart city services, Islamic values is a relatively new tool that has immense potential to do so. Among the many sources of large amounts of tool being generated today by a multitude of sources are smart services and components such as social networking sites, global positioning systems, sensors and cameras, commercial transactions, and video games to name a few (Raj & Kumar, 2017). In recent years, research into smart cities has grown at an exponential rate, and efficient components and processing facilities have posed a serious challenge to the traditional intelligent environment. The huge amounts of information produced by sensor equipment may be used to extract a substantial amount of useful information from the data (Hashem et al., 2016). The successful functioning of many enterprises and service industries, including the smart city application, is dependent on the analysis and exploitation of large amounts of data. Large processing and storage facilities are required to process the streams of information created in a smart city setting, which is one of the many benefits and problems associated with the implementation of Islamic values in a smart city. It is possible to acquire access to this benefit through the use of cloud computing services and the Internet of Things (IoT) technologies, both of which are now accessible on the market (Botta et al., 2016).

An improved ability of smart cities to instil Islamic values in their citizens is proven in the following case study, which shows how digital gadgets employed in conjunction with smart city infrastructure improve the ability of a smart city to instil Islamic principles in its residents. A positive development is that it encourages the flow of information about Islamic beliefs among city dwellers, which is a good thing. Large amounts of unstructured data generated by integrated devices in smart cities can be rearranged in a similar way with the assistance of intelligent technology (Chen et al., 2019). In order for information to be created and processed, a large number of servers must be present in order for the computer infrastructure to function. There will be no issues with this infrastructure because it is designed to manage enormous amounts of data without experiencing any difficulties. All of these bits of information are utilised to build a specific service or application, and they are propagated throughout a variety of services throughout the development and deployment process. In order to reap the greatest possible benefits from smart cities, it is imperative that Islamic principles be included into computer methodologies for data processing. Due to the fact that each component of data in smart cities can be applied to many various elements of human engagement, the greatest possible advantage can be obtained from each component (Perera et al., 2017).

Every day, new smart city concepts are being adopted by an increasing number of governments in

order to improve the living conditions of their citizens, and Islamic values are not being used to achieve this goal. It is possible that the technology of the smart city, which is based on large-scale data collection and analysis, will have a substantial impact on virtually all aspects of human activities in the future. The adoption of fundamental smart Islamic values features, such as realising the primary characteristics of a smart interaction of human-to-human as well as machine-to-human, is necessary in order to meet the learning principles and requirements of smart city applications. It is possible to achieve long-term viability and resilience of human activities engagement through the incorporation of critical components of Islamic values into smart city planning and implementation. Other advantages include an improvement in the overall quality of life, the careful use of natural resources, and the construction of sound infrastructures, among others. To do this, five important criteria are necessary namely.

III. The Technology of Islamic Smart City

Smart cities, in terms of technology, distinguish themselves by the extensive application of various electronic technologies and technological tools such as sensors and sensor networks, among other things, in order to reach an extremely high degree of efficiency (James et al., 2021). A smart city is comprised of a diverse range of components. This research examines the interaction of the following components: "Smart Facilities," "Smart Devices," "Smart Governance," "Smart Data," and" Smart People" in order to develop mechanisms for smart cities that incorporate Islamic approaches into their design (see Figure 1). The combination of these components has an impact on whether or not the Islamic smart city concept is adopted.

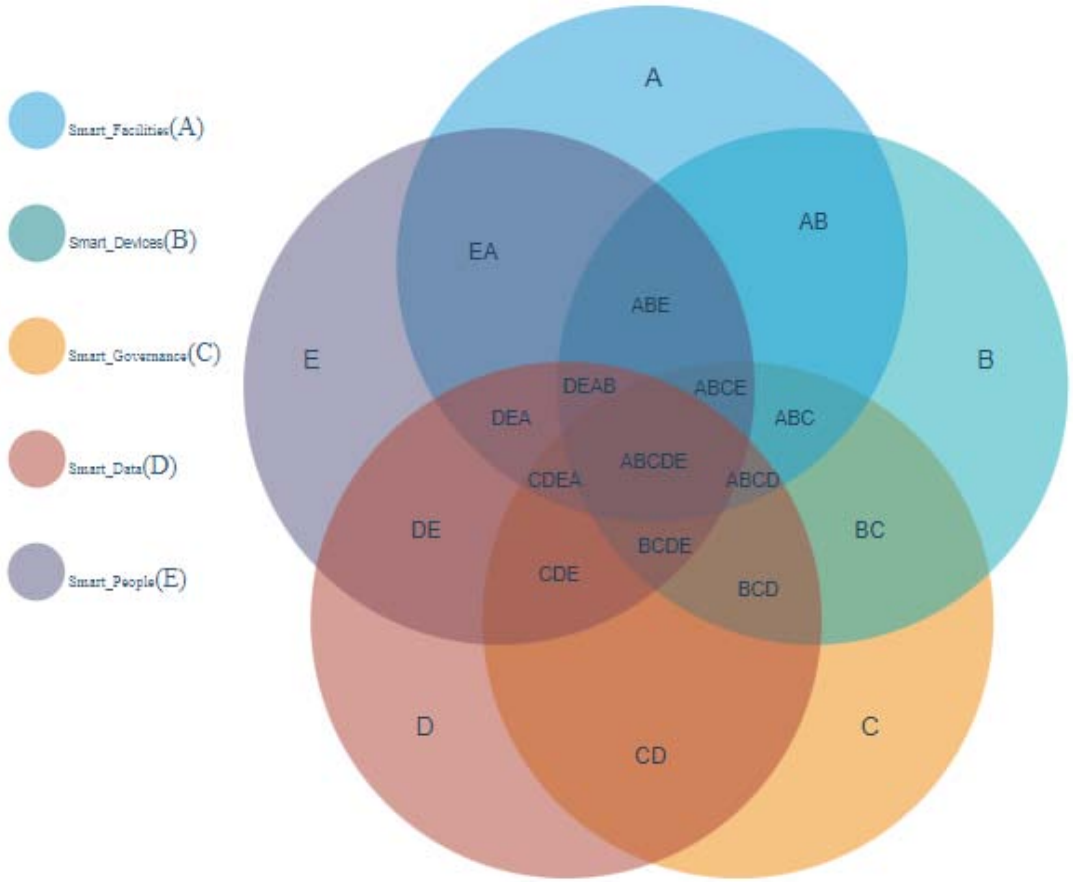

Figure 1: Components of Smart Cities Integrating Islamic Approach

The proposed components of Smart Cities that would integrate Islamic approach form the key point of (ABCDE) from the figure 1 above, which is a combination of infrastructures, devices, governance, data, and people. When dealing with a single component, however, there is a conceptual interaction between it and its neighbour that is distinct from the other's. This refers to the establishment of an Islamic approach in each of the components that interact with one another. The information gathered from each component is used to manage smart facilities more effectively and efficiently. The smart facility is positioned as the highest level of conceptualization in this paper, which is justified. In a similar vein, facilities in cities or

smart facilities are associated with more complex infrastructure and technologies, but they also have the resources to manage those infrastructure and technologies. For this reason, smart devices come first, followed by smart facilities, because smart devices are the tools that will assist in the operation of the facilities.

A situation will be created in which a decision will be required in order to put the smart devices into proper operation for the purpose of managing the smart facilities. When doing so, governance is required, and protocols should be defined in order to maintain an orderly and efficient operational environment. The concept proposes smart governance as a result, in order to establish and provide high-quality services to those who require them. When considering a scenario in which a smart building facility has evolved with the net effect of systems control that can be managed for entire buildings or for entire building areas, smart facilities, smart devices, and smart governance interaction could be envisioned.

In the course of operating smart facilities, smart devices, and smart governance, data is generated, which is also a component of the smart city and is referred to as intelligent data. The collection of interactivity among smart devices within Smart facilities in a smart city results in the generation of a large amount of data, which is used to improve the quality of life. When it comes to smart governance of smart city growth and security and how information is interpreted and stored is critical. Smart cities can take advantage of this by utilising smart data to improve efficiencies while also enhancing sustainability, fostering economic development, and improving quality of life factors for those who live and work in the city. Smart people band together to form intelligent communities. As a result, the number of people who are involved in smart cities has increased. Communities are made up of people who have a common interest and who collaborate with the government and other institutional organisations to promote the use of smart cities in order to improve the quality of daily life as a result of various deteriorations in daily activities. Furthermore, if a smart city strategy is not planned with people involved in its implementation in mind, it may result in the creation of new areas.

If we take into account the impact of the Islamic approach to each of the smart city components: "Smart Facilities", "Smart Devices", "Smart Governance", "Smart Data" and "Smart People" described above, it becomes possible for us to try to understand the concept of Islamic smart city.

IV. Conclusion

The term "Islamic city" refers to a city that was created in accordance with the Quran's and prophetic traditions' teachings, as well as general Islamic ideals that promoted healthy living, environmental stewardship, and sustainable development. There are significant distinctions between Islamic and Muslim cities. Muslims city is merely a city where Muslims dwell; it does not have to adhere to any of the Islamic city's specific norms and regulations. The Islamic Smart city can then be defined as a city that adheres to Islamic city ideals while adopting a modern perspective on Smart city equipment based on current technological advancements. Numerous studies noted that numerous towns were built inside an Islamdom to demonstrate that Islamic civilization is not only about developing a belief system, but also about developing fully functioning Islamic communities and cities based on religious regulations and divine laws. As a result, Islam has come to be considered as an urban religion. To comprehend the origins of the Islamic metropolis, we must look back at the Prophet Muhammad's life, peace be upon him. The Prophet Muhammad was an urbanite, as evidenced by his migration to Medina; the call for a weekly congregational prayer "Jumu'ah" in the mosque was an indication of urbanisation; Islam is a city-based religion, sharing similar qualities of sophistication and urbanity with Judaism and Christianity. According to Muslim geographers, one of the characteristics of Islamic cities is that they must have a Friday mosque and most have a market nearby. Additionally, a public bath should be available for Muslims to prepare for congregational prayers. The Islamic smart city's structural design and concept should begin with the design of a Masjid in the heart of the city; this concept was derived from the prophet Muhammad's initial plan upon his arrival in Madinah.

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Mathematical Models for the Calculation of the Thermal Properties of PVCs as a Function of Dosage with the Load of Palm Kernel Shell Powder from the Results of Experimental Practice

By Chantal Marguerite Mveh, Rolland Djomi, Joseph Voufo, Abel NJOM, Yves EMVUDU, Jean Raymond Lucien MEVA'A & Antoine Elimbi

University of Yaounde I, Yaounde

Abstract- The thermal characterization of industrially extruded PVC tubes (unloaded and loaded with micronized palm kernel shell powder) has been carried out according to the standard. The aim of this work is to elaborate mathematical models for the calculation of the experimental thermal properties of PVC tubes as a function of the shell powder dosage. We performed the TGA/DSC of unloaded PVC tubes and PVC tubes loaded with 12.54%, 32.03% and 51.01% of palm kernel shell powder using a TG coupled DSC apparatus of LENSEI brand. We obtained the TG/DSC thermograms and their recording which gave us the results of the thermal characteristics of the tubes. From those results, we obtained that the phase transition temperatures vary with the dosage. We have represented the curves of heat absorption as a function of the mass decrease.

Keywords: materials characterization, thermogravimetric analysis, thermodifferential analysis, thermal characterization, modeling of thermal parameters.

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MATHEMATICALMODELSFORTHECALCULATIONOFTHETHERMALPROPERTIESOFPVCSASAFUNCTIONOFDOSAGEWITHTHELOADOFPALMKERNELSHELLPOWDERFROMTHERESULTSOFEXPERIMENTALPRACTICE

Strictly as per the compliance and regulations of:

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Chantal Marguerite Mveh [α], Rolland Djomi [σ], Joseph Voufo [ρ], Abel NJOM [ω], Yves EMVUDU[¥], Jean Raymond Lucien MEVA'A[§] & Antoine Elimbi [χ]

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Keywords: materials characterization, thermogravimetric analysis, thermodifferential analysis, thermal characterization, modeling of thermal parameters.

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I. Introduction

In the literature, we find PVC in many sectors especially in packaging, electronics, electrical, aeronautical, naval, automotive, building construction, household, toys, entertainment and many others. PVC offers the advantages of mixing with other materials without complications, especially during its manufacture or shaping. This characteristic makes polyvinyl chloride (PVC) plastics a material that is financially accessible to all [1, 2, 3, 4].

Engineers use the materials in constructions according to specifications. In order to respect them, the engineer looks for the performances and the general characteristic parameters of the materials that they must use to satisfy his customers.

The work of characterization of plastic materials loaded with calcium carbide has known several advances because calcium carbide is the load by excellence used in the past. Its availability and especially its low cost and its shaping techniques facilitate its predominance in the world of plastic as a load. For this reason, in the characterization of plastic materials loaded with calcium carbides, several results are already recorded in journals [5, 6] and international standards already have banks of results in various characterizations.

It should be noted in passing that the plastic material loaded with calcium carbide has had a long period of negativity, particularly in the area of environmental pollution, due to its non-biodegradability and non-recyclability at the end of its life [7]. The consequences of this have led the human communities of the world to draw the attention of the public power, which has led the researchers to find a solution. This solution, which turned out to be positive by the addition or total substitution of the calcium carbide load by vegetable fillers in the chemical composition during the production of my plastic material, began to be a

concern of researchers: hence the appreciation of the work here present.

Thus, several works in the substitution of calcium carbide by another load today is in full evolution. More and more, publications in scientific journals confirm the feasibility of using vegetable and animal loads in the production of plastics as a load especially for reinforcement [1, 2, 3, 8].

The validation of the work in new materials goes through a series of characterization, in order to determine the intrinsic properties of the materials. These properties allow the engineer to validate and enhance the new material by using it in construction in general and allow international standards through publications to generalize them.

Thus, the work presented here, which consists of a study of the influence of palm kernel shell powder on the thermal behavior of extruded PVC tubes, this new material as those encountered in the literature, [1, 2, 3], must highlight the characteristic thermal parameters of the said material leading engineers to use it in constructions.

This work will consist in elaborating mathematical models to determine the characteristic parameters of PVC tubes to be extruded as a function of the dosage of palm kernel shell powder from the results of the practical thermal characteristic parameters of extruded PVC tubes loaded with palm kernel shell powder at dosages ranging from 0% to 51.02%

Taking into account the studies in the use of the shells of palm kernel dura as load for the polymers [8] and that of the elaboration of the tubes PVC loaded with the powder of shells of palm kernel [9], we obtained by the results that the shells of palm kernel are integral part of the materials that absorb heat and conserve it for a long duration. This study allows us to validate the use of palm kernel shells as a new material for heat conservation, since it was designed to solve thermal problems for engineers.

In the same way, this study allows to extend the research on the use of the shells of palm kernel on several polymers with the aim of solving the problems of exchange and exploitation of the heats for the resolution of the problems of the humans I quote coating of the walls, clothes for stays in localities with cold climate, protection of the objects requiring the conservation of the energies.

Then, a brief presentation of the materials (tubes extruded PVC loaded with the powder of shells of palm kernel dura) obtained in the previous works [9], then the results from the tests in laboratory of the thermal analyses carried out will be made. Then, mathematical models will be elaborated and presented, which will allow the engineer to choose the dosage of the shell powder according to the thermal characteristics of the PVC tubes to be extruded, or to choose the thermal characteristic parameters of the tubes (plastic materials) from the solicitations calculated according to the dosage of shell powder. Also the study of the heat absorption as a function of the decrease in the mass of the PVC loaded with palm kernel shell powder will be carried out. Finally an application of the obtained mathematical models will be carried out to determine the characteristic parameters of the extruded PVC tubes at calculated dosages whose analyses could not be carried out.

II. Materials and Experimental Methods

a) Materials

i. Materials of the study

The materials are PVC tubes which were elaborated industrially according to the methodology described in the work of Djomi and his team [9]. They were elaborated in the company SOFAMAC (Société de Fabrication des Matériaux du Cameroun) located in SOA, city of Yaoundé in Cameroon [10]. As a reminder, we used an industrial twin screw extruder for the extrusion. The extrusion was carried out continuously without interruption. The working conditions were the same. The dosages in terms of extrusion additive remained the same as when using calcium carbide as load. The only load used here is micronized palm kernel shell powder, the processing and characterization of which was described in the work of Djomi et al [8].

The raw PVC used was purchased from DANSUK & Cie [11] by SOFAMAC, one of the company's customers. The additives are those commonly used by SOFAMAC to satisfy the Cameroonian people in terms of plastic materials for construction for many years.

We produced the unloaded PVC tubes which we called F0, then we produced the PVC tubes loaded with micronized palm kernel shell powder with the following percentages: 4.01% called F4.01; 12.54% which we called F12.54; 23.03% called F23.03; 32.01% called F32.01; 38.02% which we called F38.02 and 51.01% called F51.0.

The tubes were checked by the team of the standards of the company in accordance with the respect of the laws that regulate the production of plastic materials in the companies of the production of plastic materials.

Figure 1 shows the photographs of the elaborated tubes for each formulation. We point out here after that we will call each tube by the percentage of the dosage of palm kernel shell powder as shown in figure 1.

Figure 1: Unloaded PVC tubes and PVC tubes loaded with micronized dura palm kernel shell powder.

From figure 1, we will say as a reminder that:

- All tubes are perfectly round.
- The colors go from light grey for F0 to black grey for F51.01 passing through grey and dark grey, confirming the presence of the purple color of the load of the micronized palm nut shell powder and the presence of the carbon black of the extrusion additives.
- The surfaces range from smooth shiny for F0 tubes to rough for F51.01 tubes confirming the presence of the micronized palm kernel shell powder in the tubes.
- The diameters are exactly 82mm for the internal diameter and 90 for the external diameter confirming the qualities of the dies and the seriousness of the company.

ii. *Materials for the characterization*:

Preparation of the specimens:

- 01 pestle: in ceramic, delivered with the analysis machine.
- 01 mortar: in ceramic, delivered with the analysis machine.
- 01 sieve: the sieve is AFNOR grade 100μ.
- 01 Digital precision balance of SEDITECH brand and precision at 1/1000th.
- 01 Plastics for packaging: transparent nylon plastic.

Machine of analysis:

The machine used for testing have been described in several works in which the laboratory was requested for thermogravimetric and differential analysis [8, 9, 12, 13]. As a reminder, the analysis machine is a Instrument brand LENSEIS; TGA / HDH Automatic robot, software incorporated into the machine with data acquisition controlled by computer; crucibles aluminum oxide, capacity 150mg; having a wide range of speed of measurement. The combustion gas is oxygen or nitrogen.

b) Experimental methods

i. *Preparation of the specimens*

We take the tube of a given formulation. We cut out some strips that we make into powder with an ordinary scraper. The powder is poured into the mortar and with the pestle we reduce the powder of the scraper into a very fine powder. We use the 100μ sieve to obtain a sufficient quantity which will be weighed with the balance before conditioning to await the analysis.

ii. *Thermogravimetric and differential analysis*

This methodology has been described in several works in which the laboratory has been requested for thermogravimetric and differential analysis [9, 12].

As a reminder : The thermogravimetric and thermodifferential analyses were carried out on a LINSEIS STA PT-1000 C thermal analyser with the type Platinum Evaluation V1.0.182, coupled to a computer and programmed for this purpose. The thermal treatment of the device ranges from room temperature (20-35°C) to 1000°C. The heating rate varies between 1°C and 100°C. The crucible is made of alumina oxide with a capacity of 150 mg and a control crucible of alumina. The mass of the powder to be characterised is

20 to 25 mg. The load mass is between 100mg and 125mg; the initial heating temperature depends on the ambient temperature at the time of measurement. The heating rate according to the literature is 10°/min. The computer plots the ATG/DSC thermograms by recording the data. We carry out the analyses in the Laboratories of Physicochemistry of Materials of the Faculty of Sciences of the University of Yaoundé 1-Cameroon.

III. Results and Discussions

a) Results of the preparation of the samples

The specimens prepared for the thermogravimetric and thermodifferential analyses are powders crushed with a pestle and mortar and then packaged in plastic bags to comply with the standard.

b) Results of thermogravimetric and differential analyses of elaborated tubes

We elaborated 7 materials and we were given 4 thermograms with the data of the recordings of the curves. The figures 2, 3, 4 and 5 represent the curves of the elaborated tubes obtained from the LENSEI machine.

i. *Curves obtained from the analysis machine of each tube*

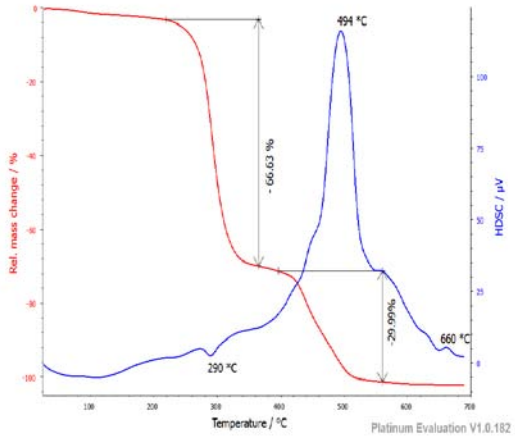

Figure 2: TG/DSC of F0

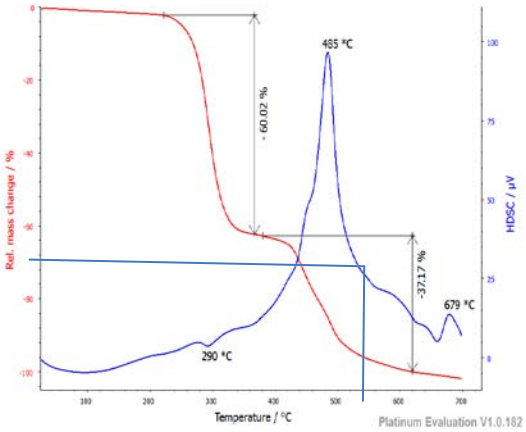

Figure 3: TG/DSC of F12.54

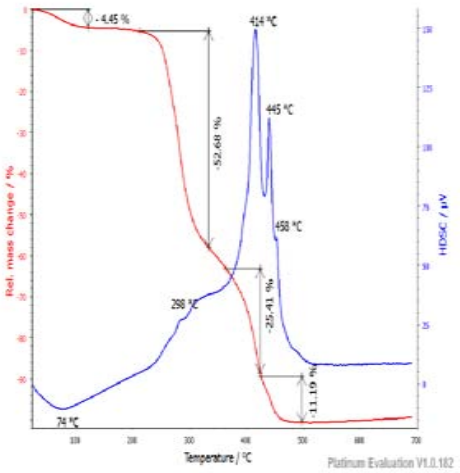

Figure 4: TG/DSC of F32,01

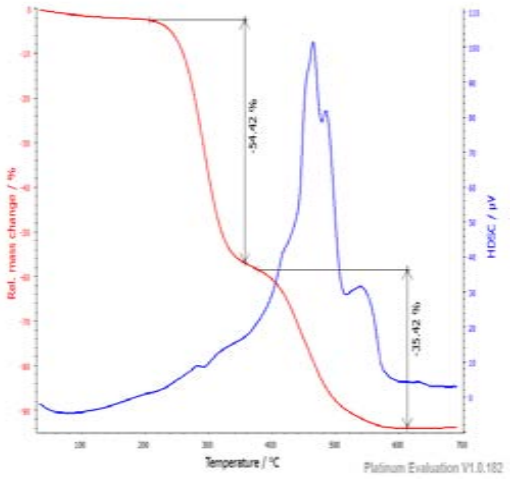

Figure 5: TG/DSC of F51,01

Figure 2 is the TG/DSC thermogram of PVC tubes unloaded with palm kernel shell powder while Figure 3 is that of F12.54 of PVC tubes loaded with 12.54% of palm kernel shell powder. Then, Figure 4 is the TG/DSC thermogram of F32.01 of the PVC tubes loaded with 12.54% of palm kernel shell powder while Figure 5 is that of F51.01 of the PVC tubes loaded with 51.01% of palm kernel shell powder.

We obtain from the 4 curves that all have the same curves representing the curves of PVC in general according to the literature [8, 14, 15].

We note for the 4 curves that the particular point which marks the temperature at which the TG curve meets the DSC curve is totally different for all formulations. This divergence reassures that the thermal characteristic parameters of the material will be different from one formulation to another. This explains precisely why palm kernel shell powder influences the thermal properties of PVCs loaded with palm kernel shell powder

ii. *TG/DSC curves obtained from the recordings of each tube*

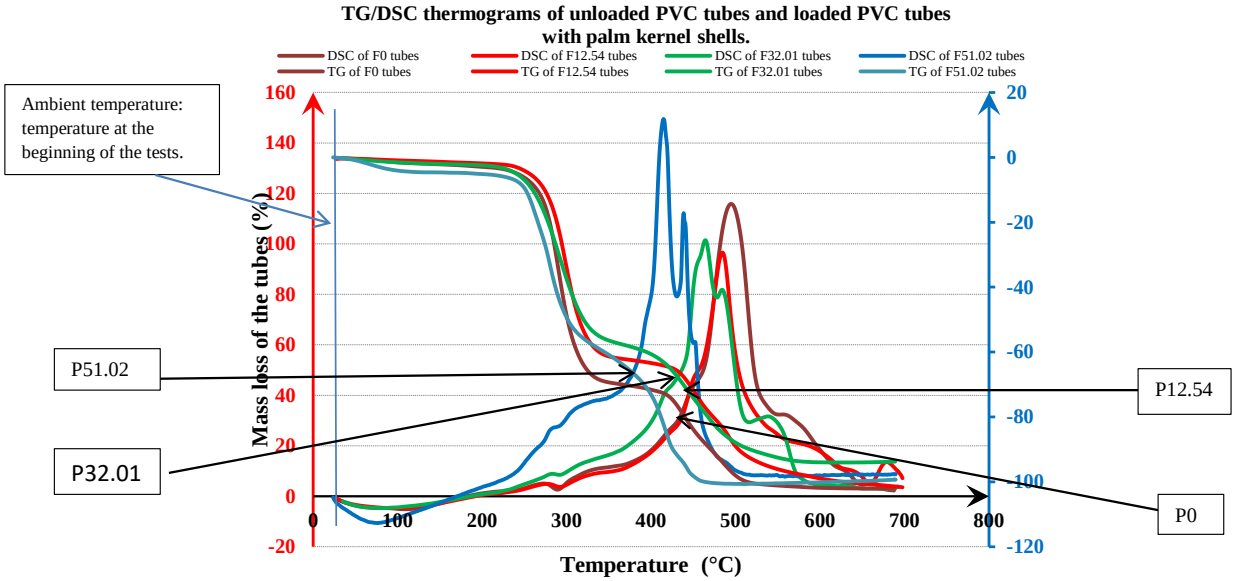

Figure 6: TG/DSC thermogram of all tubes

We obtain from figure 6 that the point P which is the particular point representing the meeting of the TG and DSC thermograms of the tubes of each formulation is totally different from each other justifying the differences in the thermal results of the tubes of each formulation. We obtain that the temperatures of P0, P12.54, and P32.01 are very close explaining that the thermal behaviors will also be different but close.

The point P51.01 is very low, below 400°C while the other points are almost above this temperature, we can undoubtedly understand that the 4 materials will have a tendency to present a ductile mechanical behavior for low loads in palm kernel shell powder as from F0 to a neighborhood of F12.54, that the material of the tubes F31.01 and its neighborhood will have a tendency to a semi-fragile behavior and those of F51.01 will have a tendency to a fragile behavior.

Moreover, we note that all the tubes have the start of the recordings higher than 0 (zero), which means that the start of the analyses is a function of the temperature at the time of the tests (ambient temperature). But this ambient temperature does not affect the quality of the results of the analyses. Also, we obtain that all the temperatures of phase change that it is in the TG as in the DSC, as close as it is, are all different.

Finally, let us point out the very strong heat absorption of the overloaded tubes (F51.01) before the relaxation. This can be explained by the work on the characterization of dura palm kernel shells from Cameroon as a load for synthetic polymers: case of PVC [8] where we note that palm kernel shells absorb heat slowly and retain it for a long time while PVC absorbs heat quickly and calcines quickly. This explains the double enthalpy relaxation when the PVC is overloaded and the amount of heat required to reach the ash high.

From the data of the recordings, we present the separate TG and DSC thermograms of the tubes in order to better observe the physical behavior of the materials and the evolutions of the heat absorption until the degradation. This will allow us to highlight the results resulting from the analysis of each material at different phase changes [5] .

iii. *DSC curves of the analyzed tubes*

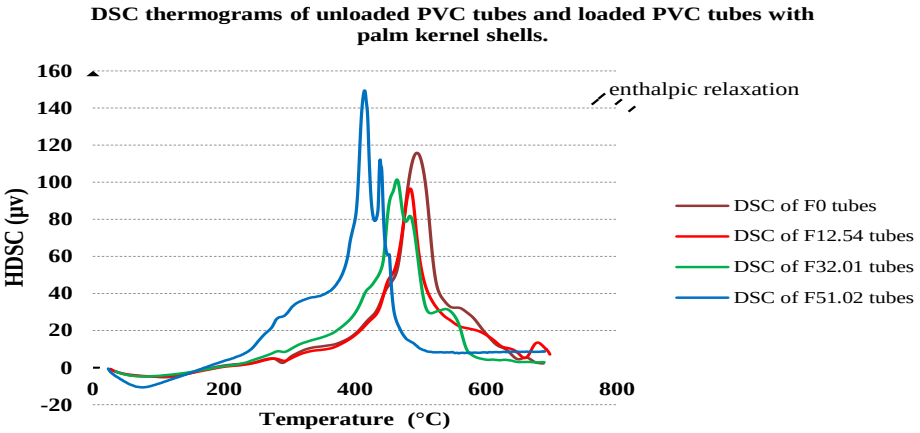

Figure 7: DSC thermograms of the elaborated tubes.

We obtain from Figure 7 for all materials the classical domains for a PVC [14] namely: the wet domain sanctioned by its moisture content (Th), followed by the glassy domain at temperatures below the glass transition (Tg); the rubbery domain, between Tg and cold crystallization (Tcf), the semi-crystalline domain between cold crystallization and melting (Tf). The molten liquid domain (Tlf) and finally the ash domain (Tce). We observe, confused with the glass transition, a fine endothermic peak reflecting a phenomenon called enthalpic relaxation [16]. Cold crystallization is a typical phenomenon of high molecular weight polymers. During the cooling of the molten (liquid) polymer, the latter, because of its high molar masses and the great length of its macromolecular chains, does not manage to crystallize. The liquid polymer then freezes in a disordered state which is the glassy state. When this amorphous polymer is heated, its chains start to vibrate and eventually acquire enough energy to start moving and eventually, after the passage of the glassy transition, adopt positions favorable enough to crystallize before passing to the ash state. This phenomenon has been observed in the literature [14,16, 17] , and then argued in work based on PVC thermogravimetry [18].

iv. *TG curves of the analyzed tubes*

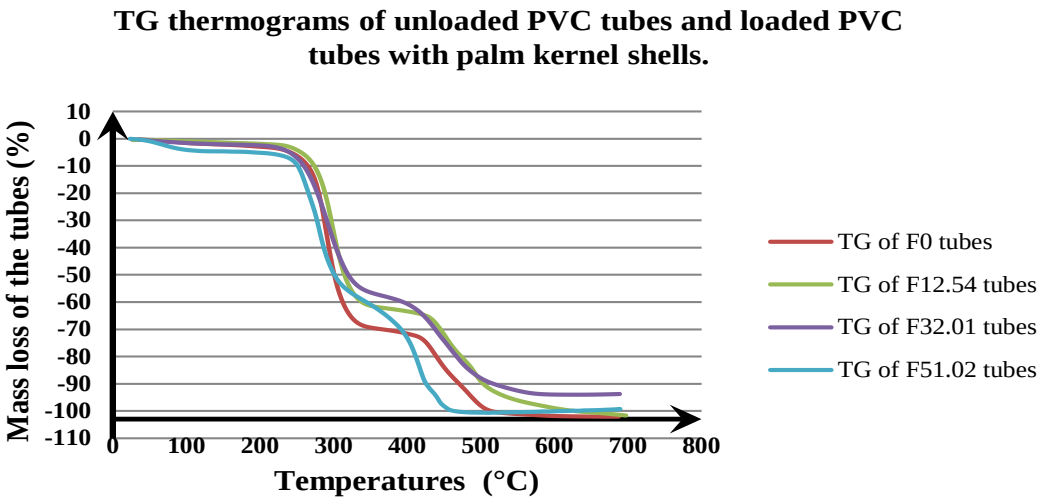

Figure 8: TG thermograms of elaborated tubes.

From figure 8, we obtain for all materials that:

The dehydration starts around 30 °C and ends at the temperature Th and leads to a loss of mass Mh. it is the disappearance of free water (H2O).

The dehydrochlorination begins towards the temperature THCl by losing a mass MHCl. This phase corresponds to the disappearance of HCl and polyene structures, and the possible formation of benzene, naphthalene and phenanthrene.

The condensation starts around the temperature TCO by losing a mass MCO. A significant amount of HCl is released, the polyene molecules rearrange and, through cyclization reactions, the cross-links form aromatic hydrocarbons and cullet.

The fragmentation starts around the temperature Tfr losing a mass Mfr. The C-C bonds that formed the polymer chains and the hydrocarbons are broken. A large part of the material is pyrolyzed. A residual cullet remains at temperature Tcar losing a residual Mcar mass.

iv. *Heat absorption curves of extruded PVC tubes as a function of mass decrease*

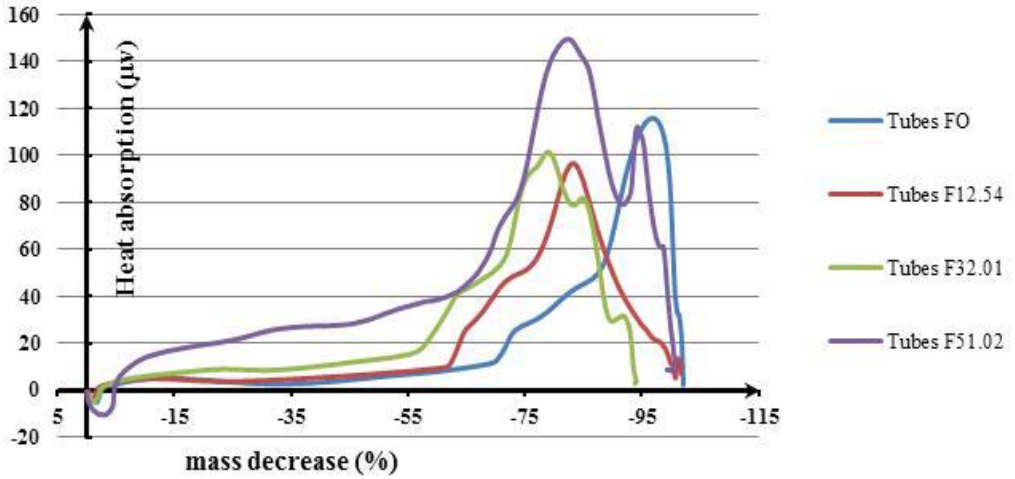

Figure 9: Heat absorption curves of extruded PVC tubes as a function of mass decrease

PVC tubes are subjected to an increasing temperature rise of 10°C/min. Thus, to reach total ash, a material must absorb heat. Thus, Figure 9 above represents the thermal behavior curve of the physics of heat absorption as a function of mass decrease). This means that a plastic material that has been obtained using PVC as matrix and palm kernel shell powder as load, when subjected to a temperature rise (case of fires or case of heated enclosures such as heat engine environments and habitats in areas with strongly cold climate), then :

For unloaded PVC and PVC weakly loaded with palm kernel shell powder, we get that the PVC first contracts by losing a quantity of mass, this loss of mass allows it to take its thermal equilibrium and enter the glass transition. When the heat continues to increase, it absorbs heat very weakly (less than 10μv) by decreasing its mass very quickly (up to more than 60%). The phenomenon of physical mass concentration results in the entry into the melting zone where the PVC is considerably softened and ready to flow. At this point, the removal of heat can still allow the material to solidify, but with a noticeable physical deformation. The PVC is already in its crystallization zone. Further heat absorption pushes the PVC to melt followed by fluidization. We observe a strong conservation of the mass and a brutal absorption of heat which leads to an ignition followed by a total combustion of the whole material.

On the other hand, for PVC tubes loaded with hull powder in large quantities, the materials subjected to a continuous rise in temperature first contract and then equilibrate. This is a phenomenon specific to PVC. This is the entry into the glass transition. As a result of their rise in temperature, the loaded PVC tubes absorb a considerable amount of heat (more than 40μv) while also decreasing its mass (more than 60%), especially when it is loaded with palm kernel shell powder with a high percentage. The increase in heat shows that, the material absorbs heat suddenly and enters in combustion. The end of the combustion shows that a phenomenon called relaxation occurs before the total ash is concentrated. This phenomenon of the relaxation is translated by the absorption of the residues of the material which could not absorb sufficient heat to the combustion and sees itself obliged to reabsorb again before being transformed into total ash. This is justified by the curve of heat absorption as a function of mass decrease obtained in the work on the characterization of palm kernel shells as a load for polymers [8], where it is found that palm kernel shells absorb about 40 μv of heat, retain it for a long time while decreasing in mass and immediately become ash. Thus, the phenomenon of relaxation is reflected in the fact that the PVC rises suddenly in temperature, the shell load has not yet absorbed the amount of heat necessary to become ash. So this powder absorbs heat again so that the entire initial mass of the material becomes the ash.

Physically and practically, when PVC takes on heat, it absorbs a large amount of heat without deforming: this is the behavior of PVC that allows plumbing departments to change the diameter of tubes

without having to use bends. Thus, a scientific approach to the practice of pipe bending research shows that when the amount of heat to be supplied to the PVC is insufficient, such as glass transition, then increasing the bending diameter becomes impossible. Also, if the PVC is supplied with abundant heat, it will rather deform and the tube will create a kind of burning in the concerned area. Many such situations are applied in companies by engineers.

At the same time, we get from the point of view of experimental physics and applied PVC loaded with palm kernel shell powder that, the PVC absorbs very little heat and to become very light (up to more than 70% of its mass down). By observing the behavior of palm kernel shells raised in temperature, these shells absorb a quantity of heat, retaining it for a long time before entering the combustion.

This phenomenon can be exploited by several constructions especially aeronautical constructions where the device must first be light and must systematically operate in a considerably cold and icy environment, by providing heat to the material, it becomes very light and it retains heat for a long time.

c) *Results of the Thermal Parameters of the Elaborated Tubes*

i. *Thermo differential analyses results of extruded tubes*

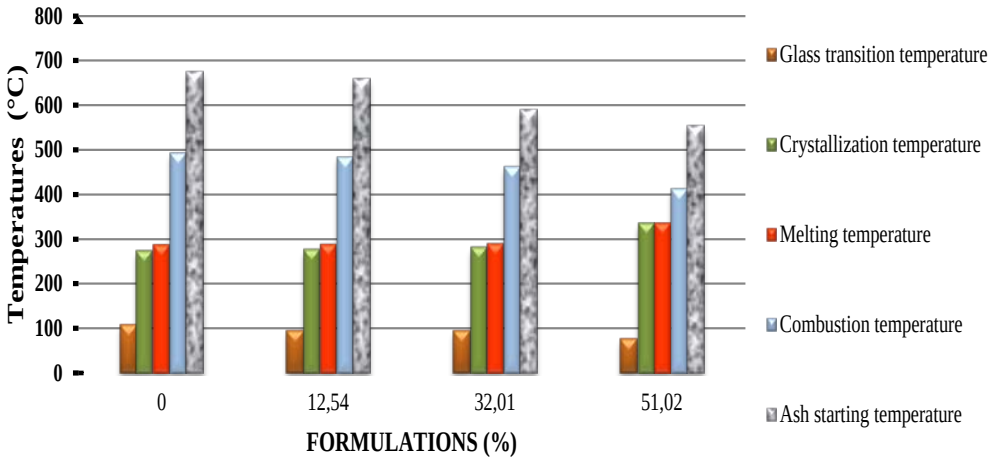

Figure 10: Results of thermo differential analysis of elaborated tubes

From the thermograms Figure 7 of the thermo differential analyses, in Figure 10, we obtained that :

- The glass transition temperature (Tg) of the unloaded PVC tubes is Tg=108.78°C, that of the 12.54% loaded PVC tubes is Tg=98.58°C, that of the 32.01% loaded PVC tubes is Tg=96°C and that of the 51.02% shell powder loaded tubes is Tg=76.56°C.
- The thermal combustion temperature (Tc) of the unloaded PVC tubes is Tc=494.71°C, that of the 12.54% loaded PVC tubes is Tc=485.58°C, that of the 32.01% loaded PVC tubes is Tc=464°C, that of the 51.02% loaded PVC tubes is Tc=414.56°C.
- The temperature of the beginning of the ash (Tce) of the unloaded PVC is Tce=475.71°C, that of the PVC tubes loaded to 12.54 is Tce=659.58°C, that of the PVC tubes loaded to 32.01% is Tce=591°C, and that of the PVC tubes loaded to 51.02% of the palm kernel shell powder is Tce=555.56°C.

The DSC results confirm the observations of Corbet in his memotech [20] and Trotignon in "Précis de matières plastiques" [21]. These same observations are comparable to those obtained in several works validated by several newspapers [4, 17]. We obtained the glass transition of Tv=108.58°C at unloaded PVC while the literature gives Tv=98°C at unloaded PVC. This may be due to the percentage of plasticizer used. We have observed that the plasticizer rates used are higher than ours. Also Trotignon and Corbet reported that a high plasticizer content lowers the glass transition temperature of polymers [1, 20, 21]. On the other hand, we observe, as in some works, that the vegetable fillers modify the glass transition temperature and associated with the plasticizer, this glass transition temperature is doubly affected when the rate of charge or reinforcement is high [1, 4].

ii. *Results of the thermal gravimetric behavior*

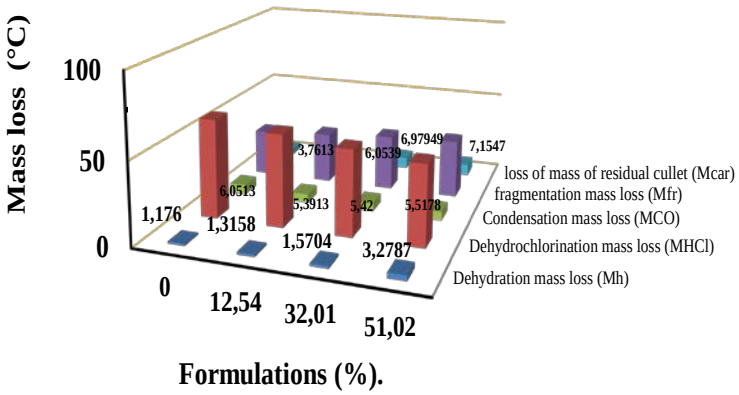

Figure 11: Result of mass decrease at phase transitions.

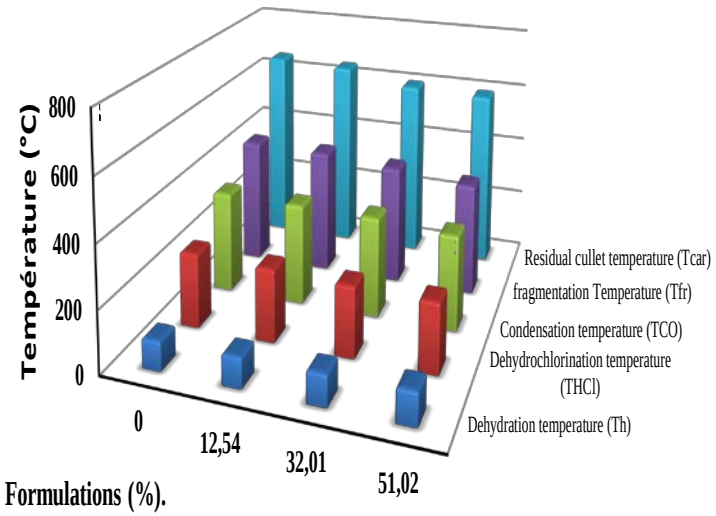

Figure 12: Results of the phase transition temperatures.

From the thermograms of the thermo gravimetric analyses of figure 8, we obtained the results of the phase change of the tubes. We consigned them in figures 11 and figure 12.

It appears that :

- The dehydration temperature of the unloaded PVC tubes is Th=96.71°C and its mase loss is 1.176%, similarly the dehydration temperature of the 12.54% loaded PVC tubes is Th=99.58°C and its mase loss is 1. 3158%, then the temperature of dehydration of PVC tubes loaded to 32.01% is Th=103°C and its mass loss is 1.5704%, finally the temperature of dehydration of PVC tubes loaded to 51.01% is Th=107.56°C and its mase loss is 3.2787%.
- The dehydrochlorination temperature of unloaded PVC tubes is THC=244.71°C and its mase loss is 60.4106%, similarly the dehydrochlorination temperature of loaded PVC tubes at 12.54% is THC=238.58°C and its mase loss is 56. 0327%, then the temperature of dehydrochlorination of PVC tubes loaded to 32.01% is THC=271°C and its mass loss is 51.8931%, finally the temperature of dehydrochlorination of PVC tubes loaded to 51.01% is THC=227.56°C and its mase loss is 48.5464%,
- The condensation temperature of unloaded PVC tubes is TCO =335.71°C and its mase loss is 6.0513%, similarly the condensation temperature of loaded PVC tubes at 12.54% is TCO =333.58°C and its mase loss is 5. 3913%, then the condensation temperature of the PVC tubes loaded at 32.01% is TCO =331°C and its mass loss is 5.42%, finally the condensation temperature of the PVC tubes loaded at 51.01% is TCO =314.56°C and its mase loss is 5.5178%,
- The fragmentation temperature of unloaded PVC tubes is Tfr =420.71°C and its mase loss is 28.6009%, similarly the fragmentation temperature of loaded PVC tubes at 12.54% is Tfr =416.58°C

and its mase loss is 31. 2063%, then the fragmentation temperature of the PVC tubes loaded to 32.01% is Tfr =357°C and its mass loss is 34.13701%, finally the fragmentation temperature of the PVC tubes loaded to 51.01% is Tfr =272.56°C and its mase loss is 35.5024%,

– The ash starting temperature of unloaded PVC tubes is Tcar=657.71°C and its mase loss is 3.7613%, similarly the ash starting temperature of 12.54% loaded PVC tubes is Tcar=646.58°C and its mase loss is 6. 0539%, then the starting temperature of the ashes of the PVC tubes loaded at 32.01% is Tcar=603°C and its mass loss is 6.97549%, finally the starting temperature of the ashes of the PVC tubes loaded at 51.01% is Tcar=594.56°C and its mase loss is 7.1547%

Figures 13, 14, 15, 16, below represent the distribution of mass lost during thermal degradation of tubes for each formulation.

iii. *Distribution of mass losses at phase transitions of thermogravimetric degradation of the analyzed tubes*

Formulation F0 : During the total dehydration of the unloaded PVC processed at 96.71°C, we record that it loses 1.176% of its initial mass: this is the free water that evaporates. The further rise in temperature causes the dehydrochlorination of the PVC which begins at 244.71 °C and ends at 335.71 °C losing 60.41 % of its initial mass before condensing. At the end of its condensation at 420.71 °C, it loses 6.05 % of its initial mass and then enters fragmentation, the totality of which is reached at around 657.71 °C, leaving residual cullet of 3.76 % of the initial mass of the material: this is the ash. See figure 13.

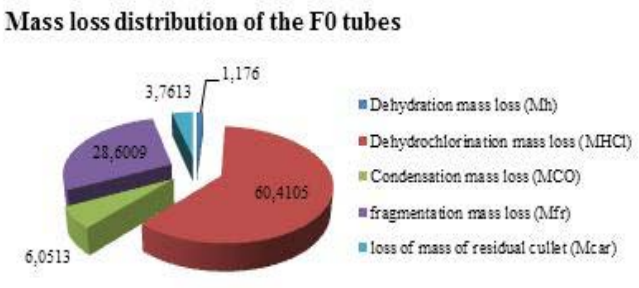

Figure 13: Distribution of the FO mass decrease

Formulation F12.54 : During the dehydration of PVC loaded to 12.54% of the powder of palm kernel shells at a temperature of 99.58 ° C, we obtain that it loses 1.315% of its initial mass: this is the disappearance of free water. Then the rise in temperature creates the dehydrochlorination of PVC that begins at 238.58 ° C and ends at 333.58 ° C losing 56.032% of its initial mass before entering the condensation. Once condensation is complete at 420.71°C, there is a reduction in its mass equivalent to 6.05% of its initial mass, then fragmentation begins, which ends at 657.71°C, leaving residual cullet of 6.053% in the crucible: this is the ash. See figure 14.

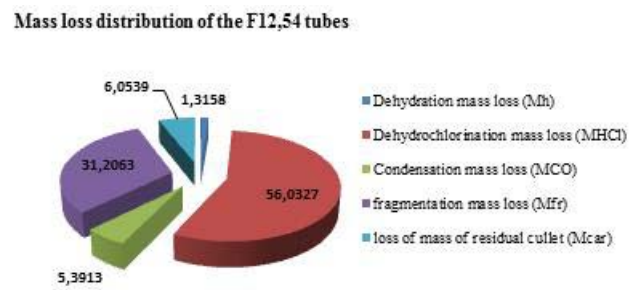

Figure 14: Distribution of the mass decrease of F12.54.

Formulation F32.01 : During the dehydration of the PVC loaded with 32.01 % of the shell powder in the vicinity of 103 °C, the free water equivalent to 1.176 % of its initial mass evaporates. The further rise in temperature causes the dehydrochlorination of the PVC which starts at 231 °C and ends at 335 °C losing 51.89 % of its initial mass before condensing. At the end of condensation at 397°C, it loses 6.979% of its initial mass and fragmentation begins and ends at 657.71°C leaving residual cullet of 6.979% of its initial mass: this is the ash that remains in the crucible. See figure 15.

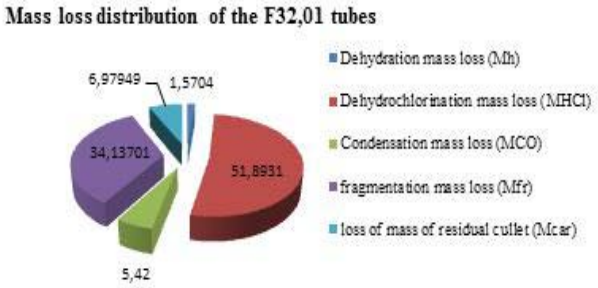

Figure 15: distribution of the mass decrease of F32.01.

Formulation F51.02 : During the dehydration of the unloaded PVC processed at 107.56°C, we record that it loses 3.278% of its initial mass: this is the free water that evaporates. The further rise in temperature causes the dehydrochlorination of the PVC which begins at 227.56 °C and ends at 314.56 °C losing 48.546 % of its initial mass before condensing. At the end of the condensation towards 372.56 °C, it loses 5.517 % of its initial mass then enters the fragmentation whose totality is reached towards 594.56 °C leaving residual cullet of73154 % of its initial mass as ash in the crucible. See figure 16.

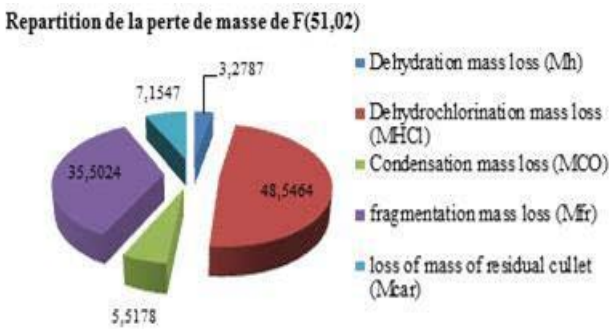

Figure 16 : distribution of the mass decrease of F51.02

d) *Development of mathematical models for the calculation of thermal parameters of the tubes according to the dosage with shell powder*

i. *Mathematical models for the calculation of thermodiférential parameters (DSC) of tubes*

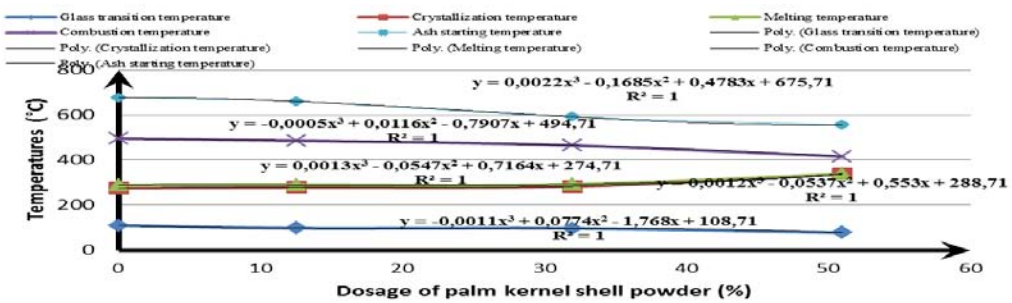

Figure17: Influence of shell powder on phase change temperatures of elaborated PVC

Figure 17 shows the results of the influence of palm kernel shell powder on the phase change temperatures, namely: glass transition temperature (Tg), melting temperature (Tf), crystallization temperature (Tcf), combustion temperature (Tc) and the ash temperature (Tce) of the elaborated PVCs. We observe that:

The glass transition temperature of PVC F0 is Tg =108.71, that of F12.54 is Tg = 96.58, that of F32.01 is Tg = 96 and F 51.02 is Tg =76.56. The temperatures decrease as the loading rate of the palm kernel shell powder increases. The regression of the results shows that Tg has a polynomial trend. The arrangements of the results on the right hand side show that the mathematical equation governing the glass transition results is y = -0.0011x3 + 0.0774x2 - 1.768x + 108.71 with the regression coefficient $R^2 = 1$. This correlation shows the reliability of the results as obtained in some works in the literature [18, 19, 22].

In the same way asfor the F0 formulation (unloaded PVC tubes), from the F0 formulation to the F51.02 formulation, the results of the Tg, Tc and Tce measurements progressively decrease while those of Tf and Tcf, rather increase. The straight lines connecting the results of the measurements of each temperature have trends whose equations are polynomials of the type y=ax3+bx2+cx+d (where y represents the Thermal Properties and x the loading rate of the palm kernel shell powder in the tube). The arrangements of the results with respect to the lines show that they pass through all the points representing the measured temperature results. The calculated correlations are exactly 1, showing that the errors in formulation, elaboration and analysis are negligible, allowing us to write the mathematical models for the calculation of the thermo differential properties of the PVCs loaded with palm kernel shell powder in Table 1

Table 1: Mathematical models for the calculation of thermo differential properties of PVC.

Properties	Mathematical models	Types	Correlations
Glass transition temperature (Tg)	$y = -0{,}0011x^3 + 0{,}0774x^2 - 1{,}768x + 108{,}71$	Polynomial	$R^2 = 1$
Crystallization temperature (Tcf)	$y = 0{,}0013x^3 - 0{,}0547x^2 + 0{,}7164x + 274{,}71$	Polynomial	$R^2 = 1$
Melting temperature (Tf)	$y = 0{,}0012x^3 - 0{,}0537x^2 + 0{,}553x + 288{,}71$	Polynomial	$R^2 = 1$
Combustion temperature (Tc)	$y = -0{,}0005x^3 + 0{,}0116x^2 - 0{,}7907x + 494{,}71$	Polynomial	$R^2 = 1$
Ash temperature (Tce)	$y = 0{,}0022x^3 - 0{,}1685x^2 + 0{,}4783x + 675{,}71$	Polynomial	$R^2 = 1$

Table 1 above shows that the mathematical models for calculating the characteristic parameters in the phase transition temperatures are mathematical models of the polynomial type. The degree of the polynomials is 3 (two). The R2 correlation obtained for each equation in the phase transitions is exactly 1.

So, since we obtained a mathematical equation whose degree is 3, it shows that there were small errors somewhere during the practices. The degree of the polynomial should have been 1. So:

- ✓ Maybe we can say that the errors come from the elaborated tubes ;
- ✓ Can we say that the errors come from the additives?
- ✓ Can we say that the errors come from the assumptions of the characterization ;

But the regression coefficient brings us answers in the sense that the errors observed are negligible given that the degree of the polynomials has remained at 3 for all the equations. So we can use these mathematical models to calculate the dosage of shell powder or to calculate the thermal parameters of the tubes during its elaboration according to the parameters or technical assumptions that we have available.

ii. Mathematical models for the calculation of thermogravimetric (TG) parameters of tubes

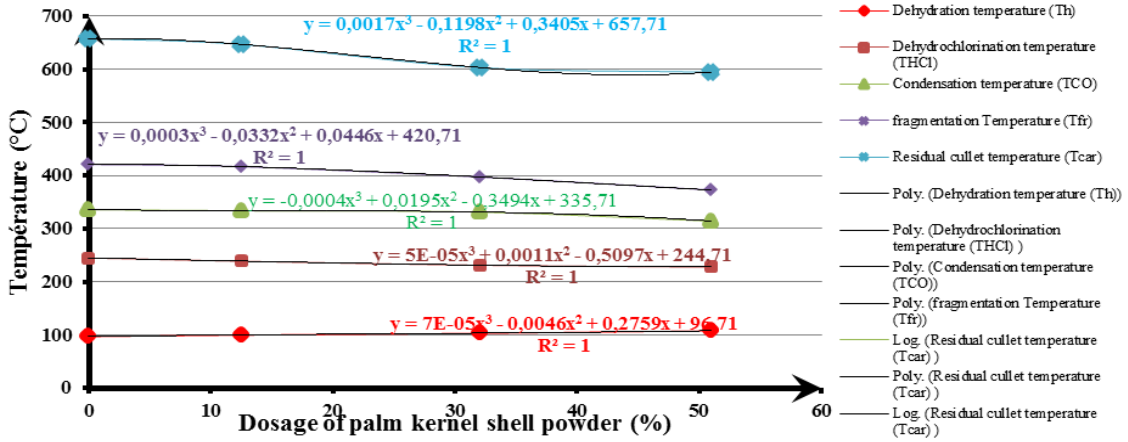

Figure 18: Influence of shell powder on phase change temperatures of elaborated PVC.

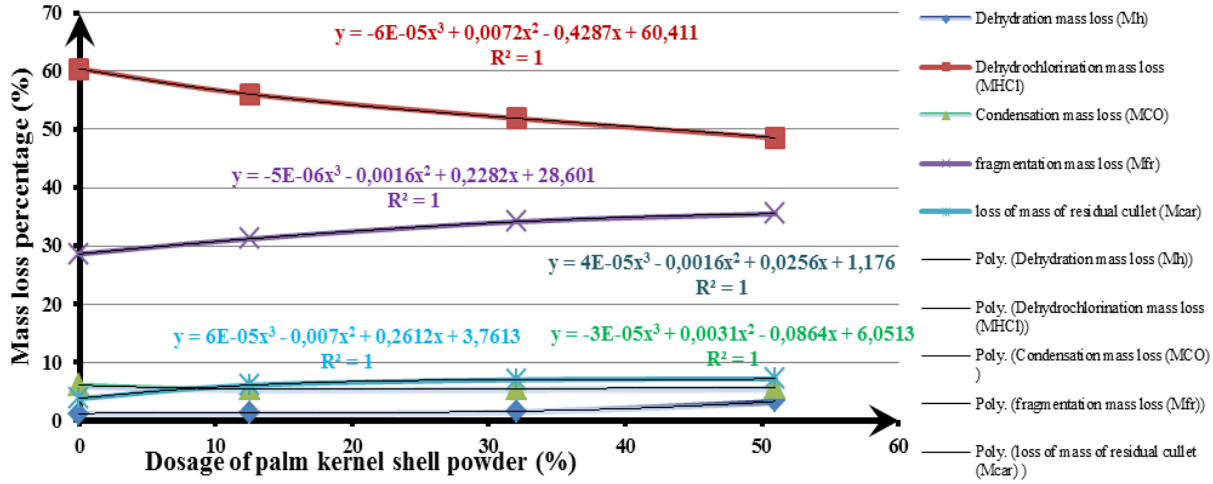

Figure 19: Influence of palm kernel shell powder on mass losses during thermogravimetric phase changes of PVC.

Figure 18 shows that the THCl, Tco Tfr and Tcar measurement results obtained in Figure 11 vary from the F0 formulation to the F51.02 formulation. The trend lines connecting each point representative of the results of each formulation remain polynomial of the type y=ax3+bx2+cx+d (where y represents the Thermal Properties and x the loading rate of the palm kernel shell powder in the tube). The layouts of the results show that all points pass through the different straight lines. The regression of the measurements shows that it is exactly 1 presenting the precision in the formulations, elaborations and analyses.

In the same way, when we go through the results of the thermal decrease of the masses of the unloaded PVC tubes to the PVC tubes loaded with 51.02% of the palm kernel shell powder figure 12, we obtain that the results of the decrease of mass at the phase transitions of dehydration (Mh), dehydrochlorination (MHCl), condensation (Mco), fragmentation (Mfr) and residual calcination (Mcar) have the same observations as those observed at the temperatures of the phase transition. Thus, we obtain in figure 19 that the trend lines connecting each point representative of the results of each formulation remain polynomial of the type y=ax3+bx2+cx+d (where y represents the Thermal Properties and x the rate of load of the palm kernel shell powder in the tube), and The regression of the measurements shows that it is exactly 1, confirming the accuracy in the formulations, elaborations and analysis of the tubes.

Table 2 shows the mathematical models to be used for the calculation of the thermogravimetric phase transition properties of PVCs with palm kernel shell powder as load.

Table 2: Mathematical models for the calculation of thermogravimetric properties of PVC.

Properties		Mathematical models	Types	Correlations
Phase transition temperatures	Dehydration (Th)	$y = 7E\text{-}05x^3 - 0{,}0046x^2 + 0{,}2759x + 96{,}71$	Polynomial	$R^2 = 1$
	Dehydrochlorination (THcl)	$y = 5E\text{-}05x^3 + 0{,}0011x^2 - 0{,}5097x + 244{,}71$	Polynomial	$R^2 = 1$
	Condensation (Tco)	$y = -0{,}0004x^3 + 0{,}0195x^2 - 0{,}3494x + 335{,}71$	Polynomial	$R^2 = 1$
	Fragmentation (Tfr)	$y = 0{,}0003x^3 - 0{,}0332x^2 + 0{,}0446x + 420{,}71$	Polynomial	$R^2 = 1$
	Ash (Tcar)	$y = 0{,}0017x^3 - 0{,}1198x^2 + 0{,}3405x + 657{,}71$	Polynomial	$R^2 = 1$
Decrease in mass at the phase transitions	Dehydration (Mh)	$y = 4E\text{-}05x^3 - 0{,}0016x^2 + 0{,}0256x + 1{,}176$	Polynomial	$R^2 = 1$
	Dehydrochlorination (MHcl)	$y = -6E\text{-}05x^3 + 0{,}0072x^2 - 0{,}4287x + 60{,}411$	Polynomial	$R^2 = 1$
	Condensation (Mco)	$y = -3E\text{-}05x^3 + 0{,}0031x^2 - 0{,}0864x + 6{,}0513$	Polynomial	$R^2 = 1$
	Fragmentation (Mfr)	$y = -5E\text{-}06x^3 - 0{,}0016x^2 + 0{,}2282x + 28{,}601$	Polynomial	$R^2 = 1$
	Ash (Mcar)	$y = 6E\text{-}05x^3 - 0{,}007x^2 + 0{,}2612x + 3{,}7613$	Polynomial	$R^2 = 1$

e) Application: calculation of phase transitions of elaborated tubes from the obtained mathematical models

We unloaded tubes to formulations of F0 (0% loading), F4.01 (4.01% loading), F12.54 (12.54% loading), F23.03 (23.03% loading), F32.01 (32.01% loading), F38.02 (38.02% loading), F51.01 (51.01% loading). We only performed thermodifferential analyses of the F0 (0% load), F12.54 (12.54% load), F32.01 (32.01% load) and F51.01 (51.01% load) tubes. The table below represents the results of the different phase changes of the elaborated PVC tubes for which the thermogravimetric and differential analyses could not be performed. These are the tubes F4.01 (4.01% load), F23.03 (23.03% load), F38.02 (38.02% load).

Table 3: Results of thermogravimetric and differential analysis of the tubes

Properties			Formulations						
			F0	*F4.01*	F12.54	*F23.03*	F32.01	*F38.02*	F51.01
Results of the thermo gravimetric analyses	Phase transition temperatures	Dehydration temperature (Th)	96,71	***97,7469***	99,5844	***101,4792***	103,124	***104,3951***	108,108
		Dehydrochlorination temperature (THCl)	244,71	***242,687***	238,589	***234,165***	231,161	***229,671***	228,208
		Condensation temperature (TCO)	335,71	***334,596***	333,606	***333,119***	331,386	***328,635***	315,520
		Fragmentation (T_{fr})	420,71	***420,374***	416,640	***407,792***	397,959	***390,913***	376,406
		Cendre (T_{car})	657,71	***657,258***	646,493	***622,777***	601,615	***601,6153***	589,0101
	Decrease in mass at the phase transitions	Dehydration mass loss (Mh)	1,176	***1,256***	1,324	***1,406***	1,668	***2,034***	3,630
		Dehydrochlorination mass loss (MHCl)	60,411	***58,804***	56,049	***53,624***	52,098	***51,223***	49,312
		Condensation mass loss (MCO)	6,0513	***5,753***	5,396	***5,339***	5,478	***5,599***	5,728
		fragmentation mass loss (Mfr)	28,601	***29,490***	31,201	***32,947***	34,102	***34,689***	35,415
		loss of mass of residual cullet (Mcar)	3,7613	***4,700***	6,054	***6,797***	6,918	***6,871***	6,835
Results of the thermo differential analyses	Phase transition temperatures	Glass transition temperature (Tg)	108,710	***102,794***	96,541	***95,608***	95,345	***92,926***	73,894
		Crystallization temperature (Tcf)	274,710	***276,787***	277,656	***278,076***	284,232	***294,302***	341,524
		Melting temperature (Tf)	288,710	***290,141***	289,567	***287,622***	290,747	***298,044***	336,509
		Combustion temperature (Tc)	494,710	***491,694***	485,633	***476,545***	464,886	***453,957***	418,160
		Ash starting temperature (Tce)	657,710	***657,060***	641,549	***606,228***	572,526	***553,262***	535,676

We did thermogravimetric and differential analysis of the tubes with 0% (F0), 12.54% (F12.54), 32.01% (F32.01), 51.01% (F51.01) of the palm kernel shell powder in order to obtain the thermal characteristic parameters of the PVCs loaded with the palm kernel shell powder We observed the results of each property for each formulation and found that they follow a logic that we sought to find. The search for this logic led us to elaborate mathematical models allowing us to calculate either the dosage with palm kernel shell powder when we know the thermal properties of the plastic tubes we

are looking for, or to determine the thermal properties of the plastic bubbles we are soliciting when we have the dosage in palm kernel shell powder. Thus, we obtained results that we represented respectively on figures 17, 18 and 19. These results summarized in Tables 1 and 2 have allowed us to present in Table 3 the results of the thermal properties of elaborated PVC tubes loaded with palm kernel shell powder. We have highlighted the results of the properties of the PVC tubes we elaborated (F4.01, F23.03 and F38.02) but which were not analyzed. From the observations, we found a logic in the results of the thermal parameters of all the elaborated tubes.

We can say that the elaborated mathematical models are applicable. These results show that all the tubes have been :

- Characterized under the same assumptions ;
- Elaborated with the same assumptions and under the same working conditions;
- Analyzed with the same laws and in the same standards.

Thus, the engineer has mathematical models to determine the thermal parameters of plastics loaded with palm kernel shell powder in the company.

In the same launches, we propose for the future, that after the validation of this fastidious work, we will lean on the conception and the realization of a computer program having to manage the calculations of the thermal properties of the plastic materials when we will use the powder of shells of palm kernel micronized.

At the same time, in the same objectives, we will consider the creation of abacuses allowing to find the thermal characteristic parameters of plastics according to the dosage of palm kernel shell powder. This method of abacuses was formerly used in research [24] especially after the manufacture of machine tools allowing the operators and the workers on machine to determine the parameters of work without each time to resort to calculations, which makes it possible to limit the displacements and to support the industrial productivity.

IV. Conclusion

The availability of palm kernel shells in the world in general (South-East Asia, Africa), and Cameroon in particular is real. Their use as load for the production of plastic tubes in PVC was the subject of work. The research of the characterization and the tests of the valorization of these tubes remain the concerns related to the success of the shells of palm kernel as the only load for the synthetic polymers.

The thermal characterization of the tubes of some formulations was done according to the standard, with a LENSEI apparatus which provided us with TG/DSC thermograms of the tubes for each formulation. The careful analysis of these thermograms and the data from the TG/DSC recordings gave us the results of the thermal parameters of the tubes of each formulation. We plotted the heat absorption curves as a function of the decrease in mass of the loaded PVCs which showed us that the loaded PVCs absorb a considerable amount of heat but gradually before burning out completely.

The analysis of these results allowed us to elaborate mathematical models allowing to establish the laws of behavior of all the elaborated tubes and to be able to determine the thermal characteristic parameters of the tubes to be elaborated with a given formulation whatever the dosage of palm kernel shells powder and, Reciprocally, these models also allow to determine the dosage of the tubes by the palm kernel shells powder with precision when the engineer calculated and obtained the thermal parameters of the tubes for his construction. Thus, the knowledge of these technical data represents a favorable asset for the engineers because the risks of supplying the manufacturers without sure data are minimized. Finally, the data obtained during this work leads us to apply the results not only for tubes but also for many other forming methods depending on the construction to be performed by the engineer.

V. Declaration of Interests

The authors declare that they have no financial interests or personal relationships that could influence the work reported in this article.

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I cannot thank the General Manager of SOFAMAC who was willing to take the risk of putting a whole production line of PVC tubes at my disposal for an experiment.

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Zonificación por Riesgo de Explosiones de Gas Metano en La Minería Del Carbón En Boyacá (Colombia)

By Juan Sebastián Arteaga
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Abstract- In Boyacá, the number of deaths from methane explosions in coalmines constitutes the greatest mining risk, and the victims can be around 10 deaths per year. Therefore, the province was zoned to determine the mining areas with the highest risk from the measurements of methane concentrations on the mining fronts. From the database of the National Mining Office, the methane gas contents reported in percentage during the inspection visits were reviewed. This information was organized and tabulated in a GIS platform, then filtered to use the most useful data. The area of greatest risk is between Tasco and Socotá, where the highest gas contents have also been reported in desorption tests; therefore, this area will require more attention and care during follow-up visits in order to avoid accidents.

Keywords: *colombia, coal, mining, methane, explosions, gis.*

GJRE-J Classification: *DDC Code: 333.82330973 LCC Code: HD9579.M4*

Strictly as per the compliance and regulations of:

Zonificación por Riesgo de Explosiones de Gas Metano en La Minería Del Carbón En Boyacá (Colombia)

Juan Sebastián Arteaga

Resumen- En Boyacá el número de muertes por explosiones de metano en minas de carbón constituye el mayor riesgo minero, y las victimas pueden estar alrededor de 10 muertos por año. Por lo tanto, se zonifico el departamento para determinar las zonas mineras con mayor riesgo a partir de las mediciones de las concentraciones de metano en los frentes minero.De la base de datos de la Agencia Nacional de Minería, se revisaron los contenidos de gas metano reportados en porcentaje durante las visitas de fiscalización. Dicha información se organizó y tabulo en una plataforma SIG, luego se filtró para utilizar los datos de mayor utilidad. La zona de mayor riesgo está entre Tasco y Socotá, donde también se han reportado los mayores contenidos de gas en los ensayos de desorción; por lo tanto, dicha zona requeriría mayor atención y cuidado durante las visitas de seguimiento a fin de evitar accidentes.

Palabras claves: colombia, carbón, minería, metano, explosiones, sig.

Abstract- In Boyacá, the number of deaths from methane explosions in coalmines constitutes the greatest mining risk, and the victims can be around 10 deaths per year. Therefore, the province was zoned to determine the mining areas with the highest risk from the measurements of methane concentrations on the mining fronts. From the database of the National Mining Office, the methane gas contents reported in percentage during the inspection visits were reviewed. This information was organized and tabulated in a GIS platform, then filtered to use the most useful data. The area of greatest risk is between Tasco and Socotá, where the highest gas contents have also been reported in desorption tests; therefore, this area will require more attention and care during follow-up visits in order to avoid accidents.

Keywords: colombia, coal, mining, methane, explosions, gis.

I. Introducción

En el Departamento de Boyacá, el número de muertes por explosiones de metano en minas de carbón constituye el mayor riesgo minero, y las victimas pueden estar alrededor de 10 muertos por año. Dicha cifra es alarmante ya que las cifras no disminuyen con el tiempo, a pesar de que el reglamento de seguridad en labores subterráneas establece que los porcentajes máximos permisibles de metano en los frentes de explotación de carbón son de1 % (Decreto 1886 de 1915 del Ministerio de Minas y Energía) [1]. Además de la presencia del metano en porcentajes mayor al 1 %, también se requiere un agente de ignición; porque las explosiones pueden iniciarse por distintas fuentes como lo son, las llamas abiertas, cortos circuitos, circuitos eléctricos no sellados intrínsecamente, descargas eléctricas y electricidad estática.

Algunos investigadores han reconocido el problema y han investigado al respecto. Mariño et al. [2] encontraron que, aunque las compañías mineras hacen un seguimiento continuo de los contenidos de gases con ayuda de multidetectores, desconocen los contenidos reales del gas en el carbón *in situ*; por lo tanto, el planeamiento minero y demás medidas de prevención se estarían haciendo sobre valores relativos de contenido de gas.

La UPME [3] indica que las cifras por accidentes son altas y que el drenaje o utilización previa del gas metano en las minas de carbón ayudaría a disminuir los accidentes. El grupo de investigación en minería de la Universidad Nacional - sede Medellín realizo mediciones de concentraciones de metano durante el arranque en minas a lo largo de la cuenca del Sinifaná, a partir de las cuales se realizaron perfiles y correlaciones para determinar los factores más influyentes para las acumulaciones de gas y por ende explosiones [4]. Finalmente, Mariño y Bedoya determinaron los contenidos de gas en las minas de carbón a diferentes profundidades a partir de los ensayos de desorción cánisters de muestras obtenidas en perforaciones [5].

Aunque se tiene una idea de los contenidos de gas a partir de perforaciones utilizando ensayos de desorción, y aunque se conocen algunas generalidades sobre los riesgos de explosión en la minería del carbón, no se tiene un análisis sistemáticos de las mediciones con metanometros en la atmósfera de los frentes de las minas que establezca cuales son las zonas con más riesgo; por lo tanto, el propósito de esta investigación es zonificar el departamento de Boyacá, mediante un polígono, donde se presenten las áreas y zonas mineras con mayor riesgo a partir de las concentraciones de metano en los frentes, y así generar un planteamiento nuevo para el análisis del problema y

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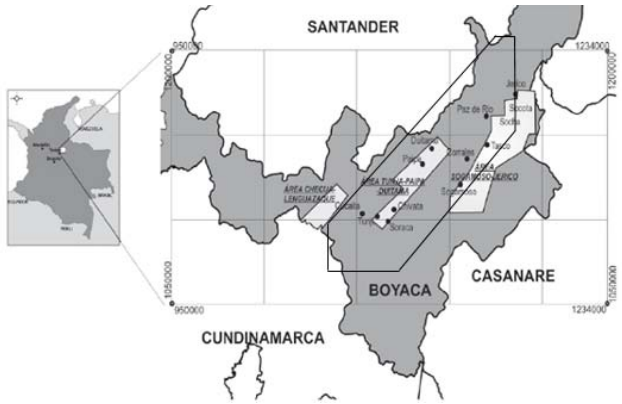
para enfocar y mejorar la efectividad de las visitas de fiscalización (Figura 1).

Los objetivos son: organizar y tabular los datos que se tienen para el análisis, Filtrar los datos más representativos, procesar lo datos y, mediante interpolación, presentar las zonas más representativas en cuanto a riesgo por explosión; y finalmente, delimitar las zonas vulnerables por explosión de gas metano.

Las limitaciones de este estudio están dadas por la información disponible sobre contenido de metano en los frentes de las minas, ya que la información disponible está limitada a la reportada durante las visitas de fiscalización.



Fuente: Los autores

Figura 1: Ubicación de dos áreas carboníferas estudiadas en Boyacá, y del polígono de la zona de estudio.

II. Marco Teórico Sobre el Gas en el Carbón

El gas asociado al carbón (CBM) está compuesto aproximadamente en un 80 % o más de metano; el resto, por lo general, suele ser dióxido de carbono (CO_2), nitrógeno (N_2) y etano. El gas asociado al carbón también conocido como gas de los mantos de carbón, CBM o CBG por sus siglas en inglés (GMAC, CBG o GAC en español), esuna fuente de gas no convencional, que se obtiene a partir de la extracción del metano contenido en las capas de carbón. El CBM se genera en el carbón durante el proceso de carbonización de la materia orgánica por incrementos de presión y temperatura producto de los procesos geológicos. También incluye el gas que se origina en el carbón por procesos bioquímicos, debido a la intervención de bacterias [2].

Las altas presiones debajo de la superficie conservan el gas metano en la matriz del carbón en un estado de adsorción y absorción. Estas altas presiones son creadas tanto por la profundidad, como por el agua que está contenida en la matriz del carbón. Para liberar el metano, los pozos productores de los mantos de carbón o los túneles mineros permiten que el agua sea bombeada para bajar la presión, lo que ayuda a desorber el gas del carbón. El metano migra dentro y fuera de los mantos de carbón hasta encontrar una barrera que lo atrape; de lo contrario, continúa migrando hasta alcanzar la superficie terrestre y finalmente se incorpora a la atmósfera como gas de efecto invernadero (GEI).

Los mantos de carbón más profundos son extraídos a través de túneles y labores subterráneas, mejor conocidas como "minería subterránea" como la que se trabaja en el Altiplano Cundiboyacense, Norte de Santander y Antioquia. Por la profundidad a la que se realizan las actividades mineras subterráneas, estas tienden a emitir más metano que las minas a cielo abierto. Además de la profundidad, el contenido de gas en el carbón se determina por 4 variables adicionales: 1) rango del carbón (grado de maduración termal), 2) tipo de carbón (composición maceral), 3) Contenido de materia mineral, y 4) espesor de la cobertera e historia del enterramiento y subsidencia.

El contenido del gas en el carbón se puede determinar a partir de métodos indirectos y directos. Los **métodos indirectos** no miden el gas en la capa de carbón, sino que se infiere a partir de alguna variable como la calidad del carbón, la profundidad, la reflectancia de la vitrinita o las isotermas de adsorción. Dichos métodos suponen la presencia del gas, pero no lo demuestran directamente. **Los métodos directos** se dividen en dos grandes grupos: 1) la **medición relativa** del contenido en la atmósfera de la mina utilizando metanometros que miden el porcentaje de metano en la ventilación de la mina, tal como se midieron los resultados de la presente investigación, y 2) **medición absoluta** del contenido de metano en los mantos de carbón sobre corazones de perforación que se introducen en contenedores herméticos llamados cánister, el contenido del gas se mide por desplazamiento de una columna de agua y se conocen como ensayos de desorción. En este caso los contenidos se reportan en m^3/ton o $pies^3$ de gas por tonelada de carbón [2].

Como el gas metano es explosivo, se deben medir y conocer muy bien los contenidos de metano en cada macizo rocoso a fin de diseñar el planeamiento minero sobre esos valores y evitar accidentes; por ejemplo en Boyacá, a partir de ensayos de desorción se determinó que entre 0 y 200 m de profundidad el contenido de gas estaría entre 10 y 50 $pies^3$/ton, y que entre 200 y 400 m de profundidad el contenido de gas estaría entre 50 y 130 $pies^3$/ton que equivalen a 1,41 y 3,68 m^3/ton [5].

La búsqueda de la información y el análisis se hizo en 2 de las 10 áreas carboníferas existentes en Boyacá: área carbonífera Tunja-Paipa-Duitama (802), y área carbonífera Sogamoso - Jericó (803) [6]. Acontinuación, se presentan los aspectos más relevantes por área carbonífera.

Área carbonífera Tunja-Paipa-Duitama (802).

La estructura principal del área es el Sinclinal Tunja-Paipa, con dirección suroeste-noreste. Asociados a esta estructura, se desarrollan pliegues anticlinales y sinclinales con dirección similar. En el área 802 la formación Guaduas se ha dividido en tres miembros que de base a techo se conocen como miembros Inferior (110 m), Medio (210 m) y Superior (210 m). El miembro medio contiene los carbones y está comprendido desde el manto pequeño hasta un banco de arenisca de grano medio, con un espesor de 30 m, que aflora en la mayor parte del área y que sirve como nivel guía. Esta unidad está compuesta por arcillolitas grises, intercaladas con areniscas de grano fino y hasta nueve mantos de carbón[7] [8].

Los contenidos de gas encontrados en las perforaciones adelantadas en Chivatá, Tunja, Cucaita, Soracá y Paipa son muy bajos y fluctúan entre 0 y 65 pie^3/ton a profundidades entre 35 y 350 m; los pozos con mayores contenidos se encontraron en Chivatá y Cucaita con 33 y 65 pie^3/ton, respectivamente, en las mejores muestras [9]. Los bajos contenidos de gas se pueden explicar a partir de la cercanía de los carbones a la superficie y a partir del intenso fracturamiento en la zona, producto de la prolongación de la Falla de Boyacá, lo que igualmente ha impedido el desarrollo de una industria extractiva de carbón en las cercanías a Tunja [10] [8].

Área carbonífera Sogamoso - Jericó (803).

El área se extiende sobre la parte centro - nororiental del Departamento de Boyacá, entre Cuítiva en el sur y Jericó en el norte (Figura 1). El espesor de la Formación Guaduas disminuye de 480 m en Sogamoso a 350 m en Socotá. En el área la formación ha sido dividida en dos conjuntos: Superior, constituido por una serie continua de intercalaciones de limonitas, lutitas grises, arenitas de cuarzo y entre seis y ocho mantos de carbón explotables, con un espesor de 300 m; en el Inferior no se encuentran mantos de carbón de suficiente espesor para desarrollar minería y consta de lodolitas y arcillolitas grises oscuras a negras prevalecientes sobre intercalaciones de arenitas [8].

Los valores encontrados en los frentes de minas de carbón del Municipio de Sogamoso son bajos (0-2 pie^3/ton) debido a que se muestreó en frentes de minas relativamente superficiales. Los mayores contenidos de gas en Sogamoso se encontraron en los Bloques Chiguatá y Morcá con valores que están entre 1,9 y 1,6 pie^3/ton y esto se explica porque estos bloques hacen parte de un sinclinal y están menos fallados [11] [12] [8].

En una perforación hacia el sur de Sogamoso, que alcanzó los 150 m, se encontraron valores entre 1 y 6 pie^3/ton, lo que se considera bajo para dichas profundidades y se explica por el intenso fallamiento, ya que se encontraron repeticiones en los mantos; pero también por errores de procedimiento. En general, los valores de gas encontrados en Sogamoso están entre 0,2 y 6 pie^3/ton, y son bajos si se comparan con carbones del mismo rango (bituminosos alto volátiles) y profundidades de alrededor de 50 m o más, medidos en Cesar-Ranchería en el Caribe Colombiano y en otras partes del mundo, donde se obtuvieron valores cercanos a 100 pie^3/ton [13][14][8].

En Corrales, los contenidos de gas están entre 5 y 69 pie^3/ton, a profundidades entre 250 y 350 m con el gas desorbido representando más del 90%. Estos valores también se consideran bajos para las profundidades alcanzadas. Para el Municipio de Tasco, los valores encontrados están entre 50 -100 pie^3/ton a profundidades que alcanzaron los 600 m, lo que muestra un incremento significativo con respecto a los bloques ubicados en Sogamoso. En estas muestras no se midió gas residual y los valores de gas perdido están muy bajos, por lo que los valores reales podrían objetivamente estar cerca a los 150 pies^3/ton. En Tasco-Paz de Rio se encontraron valores totales entre 0-165 pies^3/ton; los valores de gas residual se consideran bajos y en general los valores de todas las muestras deberían estar por encima de 100 pies^3/ton porque el rango de los carbones es bituminoso medio volátiles. En Socha se encontraron valores de contenido gas que están entre 0-275 pie^3/ton a profundidades entre 100 y 300 m. En Socotá se encontraron valores de gas que están entre 2-50 pie^3/ton a profundidades entre 400 y 600 m. Los contenidos de gas superiores a 200 pie^3/ton se consideran aceptables para las condiciones de la zona debido a la profundidad y al incremento del rango hacia el norte en que el rango de los mantos más inferiores es bituminoso medio volátil [8].

En general, Los contenidos de gas en el área de Sogamoso-Socotá evidencian un aumento de sur a norte, lo que concuerda con el aumento del rango del carbón hacia el norte, donde se encuentran carbones de rango medio a bajo volátiles, que son coquizables. Generalmente, el aumento del rango del carbón se relaciona directamente con el incremento en el contenido de gas. En esta área, el rango del carbón y la reflectancia de la vitrinita se relacionan así: en la zona de Sogamoso, el rango del carbón es bituminosos alto volátil con valores de reflectancia de la vitrinita de 0,45-0,65%, mientras que, en la parte norte, cerca a Socotá, el rango del carbón es bituminoso medio volátil, con valores de reflectancia de la vitrinita de 1-1,2%, y con propiedades coquizables [6]. Estos valores de vitrinita están sobre los valores mínimos (0,6-0,8%), a partir de los cuales se pueden generar grandes volúmenes de gas termogénico [15]. El aumento del rango de los carbones hacia el norte coincide no solamente con el aumento en el contenido de gas, sino también con la mayor subsidencia de la cuenca hacia el norte donde se encuentra el depocentro de la Cuenca del Cocuy [16][8].

III. Metodología

De la base de datos de la Agencia Nacional de Minería se revisaron los contenidos de gas metano en porcentaje reportados durante las visitas de fiscalización desde al año 2017 hasta la fecha [17]. De acuerdo con la información disponible se decidió analizar la información de dos áreas carboníferas: 802 - Tunja - Paipa - Duitama, y 803 - Sogamoso - Jericó. En total se analizaron y graficaron las mediciones adelantadas en 107 títulos mineros. Aunque en Boyacá se ha determinado 10 áreas carboníferas, solo se analizaron dos por la disponibilidad de datos y por la actividad minera [6]. Es evidente que la información existente podría mejorar y que la información deberá ser actualizada a medida que se generan las visitas.

Dicha información se organizó y tabulo en Excel. Posteriormente, se filtró la información para utilizar los datos de mayor utilidad. Los contenidos de gas con sus respectivas coordenadas se graficaron en el sistema de información geográfica (SIG). Se procesaron los datos mediante interpolación para resaltar las zonas más representativas en cuanto a riesgo de explosión. El software permite cargar cada punto correspondiente al título minero con su determinada información, y así implementar cada procesamiento y uso de las herramientas que este ofrece sobre cada punto de manera individual y llegar a obtener un resultado que, en conjunto, presente patrones sobre los cuales se pueda llegar a dar una concreta y fundamentada interpretación.

Se empleó el método Inverse Distance Weighted (IDW) con el fin de interpolar los valores más altos y más bajos, y así dar énfasis en los puntos más cercanos, como resultado, los datos cercanos tendrán mayor influencia, y la superficie tendrá más detalles, a medida que aumenta la potencia, y los valores interpolados comienzan a acercarse al valor del punto de muestra más cercano. Al especificar un valor mas bajo de potencia, los puntos circundantes adquirirán más influencia que los que están más lejos, lo que resulta en una superficie más suave. Finalmente se delimitaron las zonas más vulnerables por riesgo de explosión de gas metano.

Posterior a esto se genera una reclasificación sobre los rangos dados, donde se le da 1 y 2 para los rangos de 0 a 5%, 3 y 4 para los rangos de 5 a 10.4 %, y 5 para los rangos mayores a 10 %; esto con el fin de dejar clases e intervalos definidos, y así lograr agrupar la mayor cantidad de datos en 5 tipos diferentes. En este caso los valores que se encuentran dentro del grupo 1 son de muy bajo riesgo, los del grupo 2 son de bajo riesgo, los del grupo 3 de medianoriesgo, grupo 4 de alto riesgo y los de grupo 5 de muy alto riesgo.

Después de tener los datos reclasificados, se empleó la herramienta de dissolve con el fin de simplificar los datos a partir de los que ya se tenían, esto para generar una nueva cobertura mediante la fusión de polígonos adyacentes con el mismo valor para un elemento especificado, y así obtener un solo polígono dependiendo el rango; ya con esto se puede modificar el símbolo de los puntos de gas metano en cada título y asignarles un tamaño que incremente o disminuya proporcional al porcentaje presentado, esto para poder evidenciar las zonas con mayor amenaza y hacer un close up sobre cada una y llegar a interpretarla de la mejor manera.

IV. Resultados

Las dos áreas mencionadas en el marco teórico se analizaron conjuntamente y se reportaron en un gran polígono que comprende a las áreas 802 y 803 (Figura 2).

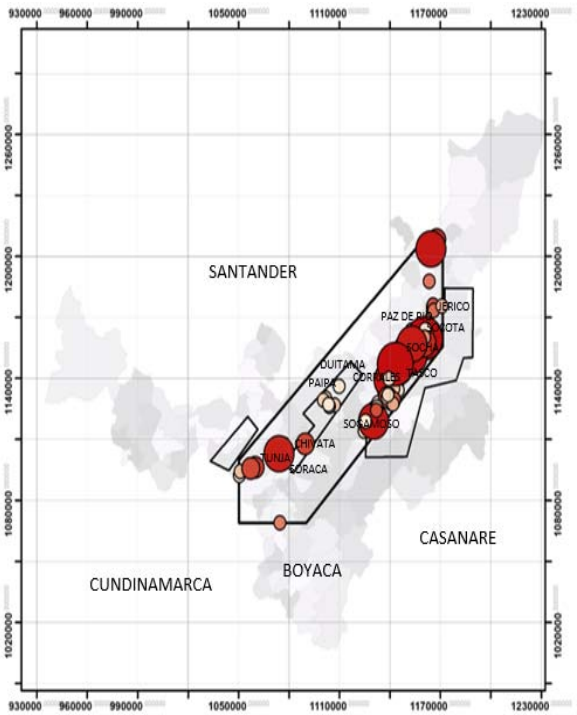


Figura 2: Ubicación del polígono del área de estudio.
Fuente: Los autores

En cada caso se introdujeron los datos de porcentaje de contenido de gas metano reportados durante las visitas. Se establecieron intervalos de porcentaje de 0 a 5 de 5 a 20 y mayores de 20 basados en las tres fases del gas metano; deflagrante, explosivo y asfixiante respectivamente, donde las zonas más altas presentaran tonalidades rojizas y anaranjadas para mostrar las zonas de mayor riesgo, tonalidad de amarillo para las zonas de mediano riesgo, y tonalidades verdosas para las zonas de bajo riesgo, y así poder determinar sobre qué zonas se implementarán medidas de mayor importancia a fin de prevenir accidentes, dependiendo el nivel de riesgo (Figura 3).

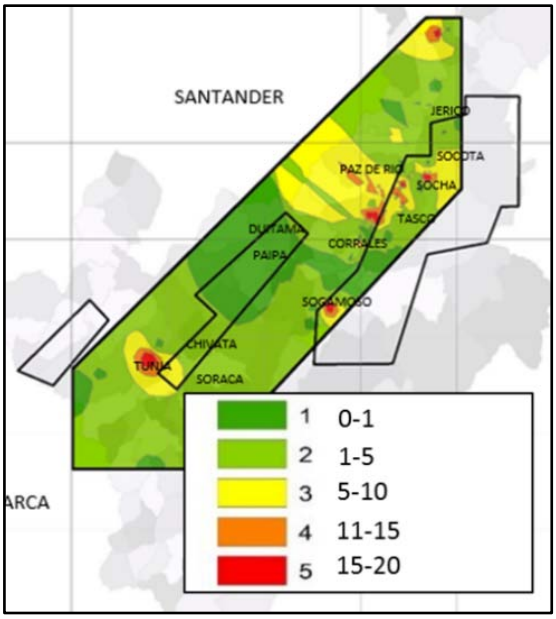


Figura 3: Mapa IDW de intervalos de contenido de gas del polígono de estudio. Fuente: Los autores.

Finalmente, los datos de contenido de gas se agruparon no por contenido de gas sino por el grado de riesgo dependiendo del contenido; donde grupo 1 son de muy bajo riesgo, los del grupo 2 son de bajo riesgo, los del grupo 3 de mediano riesgo, grupo 4 de alto riesgo y los de grupo 5 de muy alto riesgo. Como se fusionaron los de polígonos adyacentes con el mismo valor para poder evidenciar las zonas con mayor amenaza y facilitar la interpretación, se presentan las tres áreas carboníferas conjuntamente (Figura 4).

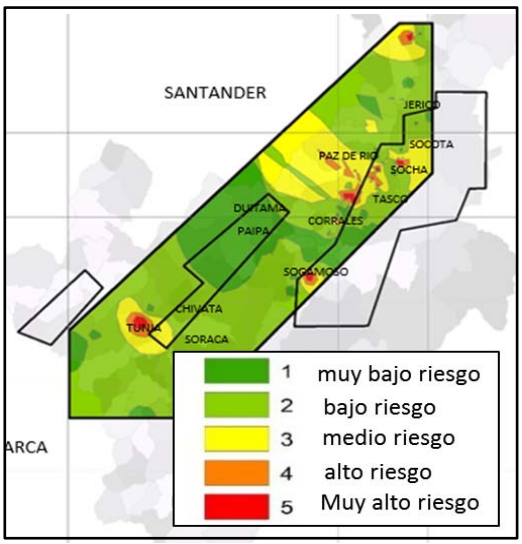


Figura 4: Mapa de reclasificación por riesgo de explosividad. Fuente: Los autores.

Después de tener los datos reclasificados se usó la herramienta de dissolve con el fin de simplificar los datos a partir de los que ya se tenían, esto para generar una nueva cobertura mediante la fusión de polígonos adyacentes con el mismo valor para un elemento especificado, y así obtener un solo polígono dependiendo el rango, ya teniendo esto se pueden modificar símbolo de los puntos de gas metano en cada título y asignarles un tamaño que incremente o disminuya proporcional al porcentaje presentado, esto para poder evidenciar las zonas con mayor amenaza y hacer un close up sobre cada una y llegar a interpretarla de la mejor manera. Como resultado se obtuvieron 3 zonas de amenaza (Figura 5)

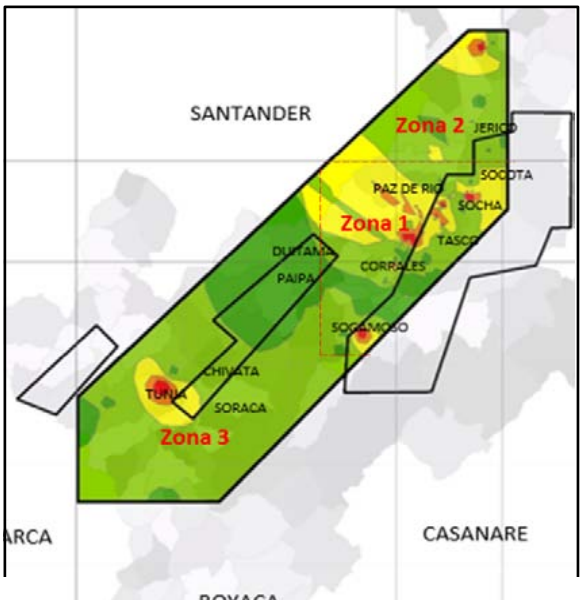


Figura 5: Mapa de Disolución de las tres zonas de amenaza. Fuente: Los autores.

V. Análisis

Con el mapa de dilusión que permite resaltar mejor las zonas con mayor potencial o probabilidad que ocurra un accidente, se superpusieron dichas zonas con las áreas carboníferas mencionadas en el marco teórico (Figura 1).

Finalmente resultaron tres zonas las cuales se clasifican en orden dependiendo el riesgo, donde la zona 1 es la de mayor riesgo y la zona 3 la de menor riesgo.

Zona de Amenaza 1. Para la zona 1 o zona de mayor riesgo, los mayores porcentajes de metano están entren 20.9, 20.8, 20.4, 18, 16, 12, 2.5, y 2.2 %; que corresponden con la parte central del área carbonífera 804 - Sogamoso-Jericó; específicamente, coincide con las explotaciones carboníferas de los municipios de tasco, Socha y Socotá (Figura 5). Los estudios de gas asociado al carbón en los que se mide el contenido de gas sobre corazones de perforación, y utilizando sistemas de desorción cánisters, han concluido que la zona de Socha-Socotá presenta altos contenidos de gas de hasta 250 pies^3/ton a profundidades cercanas a 400 m de profundidad [5]. En esta zona son frecuentes los accidentes relacionados con la presencia de metano posiblemente relacionada con el incremento del rango

del carbón en Boyacá hacia el norte, al punto que en esta zona los carbones son coquizables.

Zona de amenaza 2. Para la zona 2 o zona de riesgo intermedio, los mayores porcentajes de metano reportados fluctúan entre 20.8 y 3.38 %, que corresponden con la parte norte del área carbonífera 804-Sogamoso-Jericó, en los alrededores del municipio de San Mateo en el norte de Boyacá (Figura 5). No se conocen resultados de los ensayos de desorción, pero como el rango del carbón mejora hacia el norte, se esperaría que el contenido del gas mejore proporcionalmente.

Zona de amenaza 3. Para la zona 3 o zona de riesgo menor, el mayor porcentaje de gas metano es del 19.4 % y corresponde con el área 803 - Tunja-Paipa-Duitama carbonífera 801 - Sogamoso-Jericó, entre los municipios de Tasco y Socotá, donde se ha reportados porcentajes entre 2 y 20,4 % de metano.

El riesgo de la zona 3 se confirma por los relativamente altos contenidos de metano (pies^3/ton) encontrados en (Figura 5). Los estudios de desorción realizados en la zona por el SGC, UPTC y la ANH muestran que los contenidos son bajos. Lo anterior podría estar relacionado con el fracturamiento de la zona y el alto buzamiento de los carbones lo que facilitaría el escape del gas [9][18].

A pesar de la frecuencia de los accidentes mineros relacionados con la presencia del gas metano, los estudios de desorción indican que los contenidos de gas en Boyacá no son altos porque no sobrepasan los 350 pies^3/ton (10 m^3/ton) establecido por Naciones Unidas [19]; y que por lo tanto, no habría necesidad de drenas los macizos carboníferos antes de la explotación minera; por lo tanto, los altos porcentajes de metano reportados y la frecuencia de los accidentes se relacionarían más con deficiencias en el diseño de la ventilación, condiciones mecánicas y circuitos eléctricos.

Se sugiere que a ANNA, la plataforma digital que utiliza la Agencia Nacional de Minería (ANM) y que integra la información minero ambiental, se le podría agregar una sección donde se pueda actualizar la información en cada visita y con el visor geográfico tener la posibilidad de percibir estos patrones de riesgo, los cuales podrían servir de soporte al momento de crear las rutas de fiscalización.

VI. Conclusiones

El propósito principal de la investigación es zonificar el departamento de Boyacá por riesgo de explosión de gas metano en la minería del carbón a partir de las mediciones en los frentes mineros con multidetectores durante las visitas de seguimiento y fiscalización.

Se confirmó la hipótesis de que el riesgo de accidente por presencia de gas metano es proporcional a los contenidos de gas reportados durante las visitas de fiscalización.

La zona de mayor riesgo de explosión por presencia de metano corresponde a la zona 3 o parte central de la zona 3.

los estudios de desorción, y por los frecuentes accidentes reportados en lazona.

Se concluye que los mayores porcentajes de metano encontrados entre tasco y Socotá indican que el seguimiento por parte del estado y las nuevas rutas de fiscalización deberán dar prioridad a la parte central del área carbonífera 801.

Después de obtener los resultados se evidencia que el alto porcentaje de gas metano de algunos títulos puede presentar una influencia indirecta en los títulos circundantes, generando un efecto domino negativo; cabe aclarar que para estos estudios se necesitan de otro tipo de datos y un mayor número de muestras, ya sea para evidenciar la afectación a nivel del subsuelo y para ver cómo se podría ver a
yacimiento.

Como resultado de este proyecto se determinó que la información deberá ser ampliada y actualizada a medida que se generan las visitas, y así se podrá actuar con anticipación a los hechos. Igualmente, que la fiscalización debe dar prioridad a las zonas con mayor riesgo.

Se concluyó también que en la herramienta ANNA minería, se podría agregar una sección donde se pueda actualizar la información en cada visita y con el visor geográfico tener la posibilidad de percibir estos patrones de riesgo, los cuales podrían servir de soporte al momento de crear las rutas de fiscalización.

Por último, se llega a la conclusión de que si estas medidas llegan a implementarse, se podrían estar evitando y mitigando los accidentes producto de explosiones por gas metano en el departamento de Boyacá; por lo tanto, reduciendo el número de fallecidos y las pérdidas económicas.

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Improving Trucks Management at Dumpsites through the Application of Queue Theory- The Case of Solous III Dumpsite, Igando, Lagos State

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Abstract- Queue models are potent and veritable tools for urgent allocation of resources and basis for planning officers, resource managers and corporate organizations to respond to the demand rate with appropriate service rate. The usefulness of queue model in developing relevant policies for allocating and managing resources at the dumpsites has been emphasized in this study. Some factors (number of trucks and average waiting time in the system and in the queue etc.) were used to measure the performance of Solous III dumpsite based on the trucks' arrival rate and corresponding service rate rendered by the managers of this dumpsite. This study used simple queue model (M/M/1) of First Come, First Served (FCFS) to evaluate trucks activities at the dumpsite. The performance measures include: numbers of trucks in the queue and in the system, waiting time of trucks in the queue and in the system as well as the probabilities associated with the trucks at the dumpsite. The queue analysis indicated that the traffic intensity was 0.96 which is close to 1 and that an average of 24 trucks are in the system while an average of 23 trucks are in the queue per hour. Average waiting time in the queue and in the system accounted for 28mins and 30mins respectively.

Keywords: *queue, queue models, performance measures, trucks, dumpsites etc.*

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I. Introduction

The need for orderliness in most human activities that could result in chaos informed the art and science of queuing. Precious hours and resources are always lost to chaotic situations that occur in our everyday life. Queues are waiting lines which are common experiences at public places such as hospitals' drug dispensaries (Green, 2003), hospitals' General Out-Patient Department (GOPD) (Ameh, et al 2013), Bus Stops (Koko, 2018), Bus Stations, Port Terminals (Oyatoye, et al), Petrol Filling Stations (Akinnuli, 2014), Banks and ATM points (Famule, 2010), Shopping Malls (Hall, 1990), Arrival and Departure Rooms of Airports, Eateries (Onoja, et al, 2018) to mention but a few. Queues also occur in service industries – when jobs have to wait for machine process or at telecommunication centres when calls are on hold until they are mature (Sharma, 2004) and vehicles have to wait until Traffic Signal Lights (TSL) turn green at road intersections (Anokye, et al 2013), among others. At Dumpsites, trucks have to wait in-lines to get served due to limited service facilities to prevent unnecessary traffic congestion.

Queue theory is an important tool used to model many supply chain problems and it is mostly applicable to situations where customers form a line and wait to be served by the service facility (Odior, 2013). A queue generally can be formed by vehicles, jobs or humans especially when the rate of arrival of items exceeds that of service required (Paul and Akpofire, 2015). Where arriving customers are being attended to by a single server, the queue system is said to be a simple or single queue system. If it is two or more, the queue system is referred to as multiple or multi-servers system (Saaty, 1983).

At any point a customer arrives and the server is busy, the customer has to join a queue to be served. The rate at which customers arrive for service is known as arrival rate per unit of time (Taylor, 1994), while the average number of completed service per unit of time is known as service rate. The service rate depends on the service system adopted by the organization's management (single or multiple) and the service discipline which could be First Come, First Served or Last Come, First Out (Tanner, 1995). There is the probability that arriving customer at a service point has to wait for some moment before being attended to especially if on arrival, it finds one or more customers already at the service point. This process is otherwise

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referred to as traffic intensity which lies between zero (0) and one (1) (Okoko, 2000). It must be less than 1, otherwise there will be an infinite queue and the system needs to operate for a long time to return to a steady state – where arrival rate can be easily managed by the system's service facilities at any time.

Generally, customers may display different types of behaviour when they see a long queue on arrival (Ojo and Adebisi, 2018). Where customers decide to leave the line or queue without being served is known as Reneging or Abandonment. Where customers do not join the line but try to look for any available opportunity to enter the queue illegitimately is referred to as Baulking or Shunting. Others may move forward and backward in-between queues, looking for a fast-moving queue, thereby exhibiting a behaviour known as Jockeying.

In queue theory, a model is constructed so that queue lengths and waiting times can be predicted (Anokye, et al. 2013). This also helps in predicting the number of servers that will be needed in a system for cost minimization and profit optimization. A reduction in the average service time, E(t) through the addition of another service point will lead to a further reduction in the average queue length and waiting time as well as other queue performance measures especially in a multi-channel situations (Odior, 2013).

Queue Modeling as a mathematical one involves formulation of mathematical equations and it is useful in making some predictions about any system of study. The model is an offshoot of either probabilistic or stochastic modeling. Queue studies involve a number of systems. These consist of four sub-systems, comprising arrival pattern, a queue discipline, service facility and the outlet. The arrival pattern concerns ways through which trucks or items come into the system in a discrete manner. The queue discipline describes the arrival time of items versus when the service is performed and this follows some set of rules i.e. first come, first served or last come, first served. The service deals with the length of time a customer is served, i.e. number of servers and the service pattern. The length of time to serve a customer is known as the service rate. The queue in the system can be single or multiple and service points can be single and multiple too. However, the service rate normally has a negative exponential distribution. The outlet is the exit or departure from the system and this can influence the arrival and service rates in one way or the other (Wright and Ashford 1989; Lucey 1992).

At Solous III dumpsite in Igando, Lagos State, it is a recurrent decimal to find waste trucks forming long queues on both sides of LASU-Iba Expressway waiting for long period of time before being served. Frequent maneuverings of these trucks creates incessant traffic congestion which result in huge man-hour loss to commuters and motorists (Olorunfemi, 2003). Delays experienced by these trucks before service is rendered, affect their level of turn-around and this level of performance of the dumpsite have implications for the city's waste management (Odewunmi, 2004; Taylor, 1994). This development informed the interest to study the likely causal factors of such long queues of trucks at the Solous III dumpsite at Igando, Lagos State towards evolving some useful way to manage trucks at the dumpsite.

a) Objectives of the study

i. Evaluate the queue system parameters such as the arrival rate, the service rate and the traffic intensity of trucks at Solous III dumpsite, Igando, Lagos State.
ii. Determine the queue systems performance measures such as the number of trucks in the system and in the queue, the waiting time of trucks in the system and in the queue as well as probabilities of events (trucks) at the dumpsites,
iii. Suggest some ways to improving dumpsites performance measures at Solous III dumpsite, Igando, Lagos State.

b) Hypothesis Testing

The study will also test the following hypothesis, as a way of validating the results of this research work.

H_0: Trucks Arrival rate does not follow a Poisson distribution at the dumpsite.
H_1: Trucks Arrival rate follows a Poisson distribution at the dumpsite.

II. Methodology: Using M/M/I Queue Model

Data collection process for this study was based on Arrival rate and Service rate of Trucks at Solous III dumpsite situated along LASU-Iba Expressway at Igando, Lagos State. Solous III is the only functional dumpsite within Igando Area at the moment where trucks arrive in a Poisson process, discharge waste and exit the system after service has been completed (Magnus, 2015). This is synonymous to what is known as birth and death process in queue system. Birth refers to the arrival of trucks to join the existing queue at the dumpsite and death means departure or exit from the system having received service (Gross and Harris, 1985).

It is assumed that the time interval between successive arrivals and service time is independent and identically distributed especially in a simple queue formation (Anokye, et al 2013). A queue is said to be simple queue, if it is a single queue, single server and the pattern of arrival follows a random type and Poisson probability distribution. On the other hand, the service time is also random, having a negative exponential distribution (Wright and Ashford 1989; Lucey 1992).

The queue system adopted at the dumpsite is a simple queue model (M/M/I) and a queue discipline of First-Come-First-Served (FCFS) and data were collected

on first Monday of March, 2020 from 7am to 7pm. Data collected were analysed manually using some queue model formulae (see table 1) to determine the queue parameters such as the Traffic Intensity, Arrival rate and Service rate as well as other performance measures (Number of Trucks in the system, waiting time and other related probabilities associated with trucks behaviours at the dumpsites). The queue parameters are as listed in item 2.1 for clarity and the notations are frequently reflected in the analysis. Data used in determining the performance of the queue system were obtained through direct monitoring of both arrival rate and service rate. The time a truck joined and exited the system was noted using designed templates, pens and watches. The results of analysis were validated through the use of chi- square (X2) statistics and variance methods. The outcome of the model analysis was presented using tables and graphs.

Some Queue Performance Notations (Parameters)

λ: Average Arrival Rate
μ: Average Service Rate
R: Traffic Intensity
Ls: Average Number of Trucks in the System
Ln: Average Number of Trucks in the Queue (when there is no queue or length of queue).
Lq: Average Number of Trucks in the Queue (when there is a queue)
Wq: Average Waiting Time in the Queue
Ws: Average Waiting Time in the System
Pq: Probability that a Truck will queue on arrival
Pa: Probability that a Truck will not queue on arrival
Pn: Probability of having exactly 'n' number of Truck in the system
Pm: Probability of having n or more Trucks in the system
Po: Probability of having no Truck at all in the system

Table 1: Some already established Simple Queue model formulae in Literature

s/n	Parameters/Performance measures	Model Formulae: Single Queue Single Server
1	*Traffic Intensity*	$R = \frac{\lambda}{\mu}$
2	Average Number of *Trucks in the System*	$n = \frac{\lambda}{\mu-\lambda}$ or $n = \frac{R}{1-R}$
3	Average Number of Trucks when *there is no Queue* or Average length of the Queue	$m = \frac{\lambda}{\mu(\mu-\lambda)}$ or $m = \frac{R^2}{1-R}$
4	Average Number of Trucks in the Queue when *there is a Queue*	$n = \frac{1}{1-R}$
5	*Average Waiting Time in the Queue*	$\frac{R}{1-R} \times \frac{1}{\mu}$ or $\frac{\lambda}{\mu(\mu-\lambda)}$
6	Average Waiting Time in the System (both in the Queue and in the those receiving Service)	$\frac{1}{1-R} \times \frac{1}{\mu}$
7	Probability that *a Truck will queue on arrival*	$P_r = R$
8	Probability that *a Truck will not queue on arrival*	$P_r = 1 - R$
9	Probability of having *exactly "n" number of Trucks in the System*	$P_{(n)} = \left(\frac{\lambda}{\mu}\right)^n \left(1 - \left\|\frac{\lambda}{\mu}\right.\right)$
10	Probability of *having "n" or more Trucks in the System*	$P = R^n$
11	Probability of *having "no" Trucks at all in the System* (the percentage of *time that the server will be idle*)	$P_{(o)} = R^o(1\text{-}R)$

III. Data Analysis and Presentation of Results

Data obtained on Arrival rate and Service Rate were computed and their performance measures were determined accordingly. Table 2 showed the trucks' Arrival rate and the Service rate at Solous III dumpsite against the period of the day.

The outcome of the relationship was plotted as depicted in Figure 1.

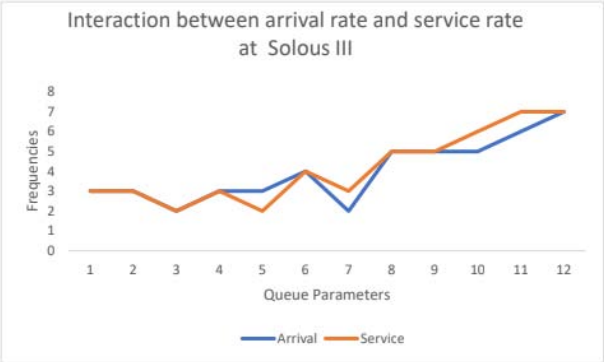

Figure 1: Interaction between Variables of Arrival rate and Service rate

Table 2: Relationship between Arrival rate and Service rate

S/N	Hour	Arrival rate	Service rate
1.	7 – 7.59	3	3
2.	8 – 8.59	3	3
3.	9 – 9.59	2	2
4.	10 – 10.59	3	3
5.	11 – 11.59	3	2
6.	12 – 12.59	4	4
7.	1 – 1.59	2	3
8.	2 – 2.59	5	5
9.	3 – 3.59	5	5
10.	4 – 4.59	5	6
11.	5 – 5.59	6	7
12.	6 – 6.59	7	7
	Total	48	50

$$R = \frac{\lambda}{\mu} = \frac{48}{50} = 0.96$$

a) Number of Trucks in the System

i. *Average number of trucks in the system*

$$\tilde{n} = \frac{\lambda}{\mu-\lambda} \text{ or } \tilde{n} = \frac{R}{1-R} \qquad \frac{48}{50-48} = \frac{48}{2} = \mathbf{24\ Trucks}$$

$$\frac{0.96}{1-0.96} = \frac{0.96}{0.04} = \mathbf{24\ Trucks}$$

ii. *Average number of trucks in the queue (no queue or length of the queue)*

$$m = \frac{\lambda^2}{\mu(\mu-\lambda)} \quad \text{or} \quad m = \frac{R^2}{1-R}$$

$$\frac{48^2}{50(50-48)} = \frac{2304}{2500-2400} = \frac{2304}{100} = 23.04 = \mathbf{23\ Trucks}$$

or

$$\frac{R^2}{1-R} = \frac{0.96^2}{1-0.96} = \frac{0.9216}{0.04} = 23.04 = \mathbf{23\ Trucks}$$

iii. *Average number of Trucks in the queue (when there is a queue)*

$$\frac{1}{1-R} = \frac{1}{1-0.96} = \frac{1}{0.04} = 25\ \text{Trucks}$$

b) Time spent in the system

i. *Average waiting time in the queue*

$$\frac{R}{1-R} \text{ x } \frac{1}{\mu} \quad \text{or} \quad \frac{\lambda}{\mu(\mu-\lambda)}$$

$$\frac{0.96}{1-0.96} \text{ x } \frac{1}{50} = \frac{0.96}{0.04} \text{ x } \frac{1}{50} = 24 \text{ x } 0.02 = 0.48 \text{ of an hour} \quad \text{OR} \quad 0.48 \text{ x } 60 = 28.8$$

(28mins, 8sec)

$$\frac{48}{50(50-48)} = \frac{48}{2500-2400} = \frac{48}{100} = \text{O.48 of an hour} \quad \text{OR} \quad 0.48 \text{ x } 60 = 28.8 \text{ (28min,}$$

48secs)

ii. *Average waiting time in the system (both queue and receiving service)*

$$\frac{1}{1-R} \text{ x } \frac{1}{\mu} = \frac{1}{1-0.96} \text{ x } \frac{1}{50} = \frac{1}{0.04} \text{ x } 0.02 = 25 \text{ x } 0.02 = 0.5 \text{ of an hour} = \mathbf{30mins}$$

c) Probabilities Associated with events in the system

1. The probability that a Truck will queue on arrival R = **0.96** or **96%**
2. The probability that a Truck will not queue on arrival = 1-R = **0.04** or **4%**
3. Probability of having exactly 'n' number of Truck in the system

the system

$$P(n) = \left(\frac{\lambda}{\mu}\right)^n \left(1 - \frac{\lambda}{\mu}\right)$$

If n = 6 Trucks

$$\therefore P_{(6)} = \left(\frac{48}{50}\right)^6 \left(1 - \frac{48}{50}\right) = \frac{221184}{250000} \text{ x } (1 - 0.96) = 0.8847 \text{ x } 0.04 = \mathbf{0.0354} \text{ or } \mathbf{3.54\%}$$

4. Probability of having 'n' or more cars in the system = Rn
   Probability of having 6 Trucks or more in the system = 0.96^6 = **0.7828** or **78.28%**
5. Probability of having no Truck at all in the system P(o) = $(R)^o(1 - R) = (0.96)^o$ x (1 – 0.96) = **0.04** or **4%**

Table 3: Summary of Model Results

λ	μ	R	Ls	Ln	Lq	Wq	Ws	Pq	Pa	Pn	Pm	Po
48	50	0.96	24	23	25	28.8	30	0.96	0.04	0.0354	0.7828	0.04

IV. Results and Discussion

In this study, traffic intensity stood at 0.96 which was close to 1, indicating that the queue situation was getting to an infinite state in which long queue could be observable at the dumpsite throughout the day. As revealed in table 3, the average number of trucks in the system, average number of trucks in the queue (length of queue) and average number of trucks in the queue (where there is queue) were 24 trucks, 23 trucks and 25 trucks respectively. Average waiting time in the queue and in the system accounted for 28mins and 30mins respectively.

The study's results also showed 96% probability that a truck will queue on arrival before being served while the probability that a truck will not queue on arrival is just 4%. The probability of having exactly 'n' number of Truck in the system stood at 3% and probability of having 'n' or more trucks in the system was 78%. Probability of having no Truck at all in the system (idle time) was 4%. This is so as the traffic intensity is running to 1 and queue development is bound to occur, meaning that the system will always be busy from time to time.

Again, it is clear that an average of 25trucks will be waiting in line and each will spend at least 28mins before receiving service. Apart from this, the 96% of traffic waiting in line is indicative that the long queue is affecting the truck drivers negatively. Consequently, some of them may want to leave without being served (baulking or abandonment), or look for available space upfront to enter the queue illegitimately (shunting), thereby worsening the traffic situation on the major road due to frustration.

a) Model Validation

In this study, Chi square test (X2) was used to test whether the values of the arrival rate followed Poisson distribution or not at 5% level of significance and this was carried out in relation to its variance.

Table 4: Model Hypothesis

Mean (x)	Variance	X2
4	2.333	1.8955

Ho: Trucks Arrival rate does not follow a Poisson distribution at the dumpsite.
H1: Trucks Arrival rate follows a Poisson distribution at the dumpsite.

The expected or predicted service rate was set at 4 trucks/hour. The critical value of $X^2(X^2CV)$ was set at a=0.05 and 11 degree of freedom.

The table value is 19.675. Since the calculated (P-value) value (1.8955) is less than the table value (19.675), the result is not significant. Ho is accepted – meaning that the truck arrival rate does not follow a Poisson distribution at the dumpsite. Although there exists a close fit in the observed arrival rate and the predicted service rate as well as X2 value (1.8955) and the value of the variance (2.3333).

V. Conclusion

Applying queue model for trucks management at Solous III dumpsite in Igando showed that queue always exists at the dumpsite as revealed by the level of the traffic intensity but this can be reduced drastically if more service points are created by the management. The simple queue model and possibly multiple server model could be applied as monitoring or evaluation tools for either the dumpsite performance or management of the trucks that arrive the dumpsite for waste disposal. It is believed that better improvement can be achieved by using the multiple queue model to manage trucks at the dumpsite by the Lagos Waste Management Authority (LAWMA). This can go a long

way in making vital socio-economic decisions in truck scheduling to reduce incessant traffic congestion around the dumpsite's location.

VI. Recommendation

In view of the 4% (low) probability of the system being idle, this study asserts that, there will be problem of long queues, waiting times and high utilization of the system (being always busy), this situation may not aid efficiency of the system in future. To further reduce the waiting time of trucks at the dumpsite from 30mins to somewhat 15mins, it is recommended that another service channel be opened by the dumpsite's management to enhance the service rate and rapid turnaround of trucks. It also suggested that officials of the Lagos State Traffic Management Authority (LASTMA) be drafted into this area to control traffic.

There is need for Lagos State Government to create a slip road of at least 500meters on both side of the major road to serve as waiting area for the trucks to reduce traffic congestion at the dumpsite's area and the access road to the dumpsite should be re- surfaced. This will consequently improve the trucks' service time and the level of trucks' turn-around from the dumpsite.

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Appendix

S/n	E	O	O – E	$(O-E)^2$	$(O-E)^2/E$	E^2
1.	3	4	-1	1	0.0208	9
2.	3	4	-1	1	0.0208	9
3.	2	4	-2	4	0.3333	4
4.	3	4	-1	1	0.0208	9
5.	3	4	-1	1	0.0208	9
6.	4	4	0	0	0	16
7.	2	4	-2	4	0.3333	4
8.	5	4	1	1	0.0208	25
9.	5	4	1	1	0.0208	25
10.	5	4	1	1	0.0208	25
11.	6	4	2	4	0.3333	36
12.	7	4	3	6	0.75	49
	48	48	0	25	$X^2=1.8955$	220

$$X^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$$

O – Observed Frequencies

E – Expected Frequencies

n – Number of Categories

$$\text{Variance} = \frac{\Sigma E^2}{n} - x^2$$

$$= \frac{220}{12} - 4^2$$

$$= 18.33 - 16$$

$$= \mathbf{2.333}$$

Standard Deviation =

$$\sqrt{2.333}$$

$$= 1.5275$$

$$\text{Mean (x)} = \frac{\Sigma E}{n} = \frac{48}{12} = 4$$

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Status of Boundaries and Boundaries of Water Strips and Rounds in America and Colombia: Achievements and Difficulties

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Abstract- The delimitation and delimitation of the water rounds has been an environmental determinant of great importance in the instruments of territorial planning, however there have been no effective criteria when it comes to delimiting and aligning the water rounds, that is why in the present study, The normative review of the delimitation of riparian zones in Latin America and Colombia was carried out, from which it was found that the guidelines issued by the Ministry of the Environment have not been efficient for the delimitation of said areas, therefore it is considered important that the Ministry of the Environment should Reconsider said rule, if it is the case that it is considered that the delimitation of the water sources would be categorized according to the width of the channel, the slope of the land and the strategic ecosystem in which they are found.

Keywords: *belts, water rounds, conservation areas and environmental protection.*

GJRE-J Classification: *DDC Code: 338.2 LCC Code: HD9506.L253*

Strictly as per the compliance and regulations of:

Status of Boundaries and Boundaries of Water Strips and Rounds in America and Colombia: Achievements and Difficulties

Estado Del Acotamiento Y Alinderamiento De Las Franjas Y Rondas Hídricas En Colombia: Logros Y Dificultades

Edinson Fabián Monroy Avila

Resumen- La delimitación y acotamiento de las rondas hídricas ha sido una determinante ambiental de gran importancia en los instrumentos de planeación territorial, sin embargo no han existido criterios eficaces a la hora de acotar y alinderar las rondas hídricas, es por ello que en el presente estudio, se realizó la revisión normativa del acotamiento de zonas ripiarías en Latinoamérica y Colombia, de donde se encontró que los lineamientos expedidos por el Ministerio de Ambiente no han sido eficientes para la delimitación de dichas areas, por ello se considera importante que el Ministerio de Ambiente debería reconsiderar dicha norma, llegado el caso que se considere que el acotamiento de las fuentes hídricas estaría categorizadas en función del ancho del cauce, la pendiente del terreno y el ecosistema estratégico en las que estas se encuentren.

Palabras clave: fajas, rondas hídricas, zonas de conservación y protección ambiental.

Abstract- The delimitation and delimitation of the water rounds has been an environmental determinant of great importance in the instruments of territorial planning, however there have been no effective criteria when it comes to delimiting and aligning the water rounds, that is why in the present study, The normative review of the delimitation of riparian zones in Latin America and Colombia was carried out, from which it was found that the guidelines issued by the Ministry of the Environment have not been efficient for the delimitation of said areas, therefore it is considered important that the Ministry of the Environment should Reconsider said rule, if it is the case that it is considered that the delimitation of the water sources would be categorized according to the width of the channel, the slope of the land and the strategic ecosystem in which they are found.

Keywords: belts, water rounds, conservation areas and environmental protection.

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I. Introducción

La planeación y ordenamiento de los Recursos Hídricos, permite diseñar estrategias e instrumentos de intervención mediante los cuales las autoridades y entidades administren, preserven e intervengan demanera tal que se garantice la protección y conservación de los mismos. De este modo el estado colombiano, desde hace más de dos décadas buscó establecer el mecanismo mediante el cual los municipios pueden promover el ordenamiento de su territorio, el uso equitativo y racional del suelo, la preservación y defensa del patrimonio ecológico y cultural localizado en su ámbito territorial y la prevención de desastres en asentamientos de alto riesgo.

Las rondas hídricas también conocidas como zona de manejo de cauce, zonas ripiaras en Holanda (CATIE, 2005), faja marginal en Perú (MinAgricultura& ANA, 2011), servidumbre ecológica en Bolivia (Decreto Supremo N° 24453 1996), rangos marginales y/o área de preservación permanente en Brasil (Presidencia de la Republica, 2012), playa fluvial, fajas de protección forestal, zona ribereña en Chile (Romero, Cozano, Gangas, &Naulin, 2014) , Zonas de Manejo y Preservación Ambiental – ZAMPA, son franjas contiguas a los cuerpos de agua lenticos y loticos, también conocidas como región de transición y de interacciones entre los medios terrestre y acuático, es decir, un ecotono (MINAMBIENTE, 2018), estas áreas son consideradas en los instrumentos de planeación territorial como zonas estratégicas para la provisión de bienes y servicios ecosistémicos, y se delimitan como áreas de protección y conservación ambiental.

Johnson et al. (1984) citado por Corpoamazonia (2019, p. 14), menciona que las zonas riparias o rondas hídricas pueden clasificarse en tres áreas, la primera corresponde a áreas hidroriparias, que están asociadas con corrientes permanentes o intermitentes, es decir que presentan suelos hídricos o substratos, que pocas veces o en cortos períodos de

tiempo están secos, las segundas áreas mesoriparias asociadas con corrientes intermitentes o efímeras, donde los suelos no son hídricos y hay substratos que permanecen secos estacionalmente, la vegetación no siempre está presente y si la hay ésta puede ser una mezcla de vegetación riparia, facultativa y no riparia y las terceras a áreas xeroriparias, están asociadas a corrientes efímeras, donde los suelos no son hídricos y están secos gran parte del año, y la vegetación puede ser la mezcla de vegetación riparia facultativa y no riparia.

Es por ello que la zona ribereña es una importante zona de transición entre ecosistemas acuáticos y terrestres, (Gebhardt, Prichard, Crowley & Stevenson. 2005), y por tanto requieren de acciones de gestión para la restauración, conservación, o simplemente para proporcionar una base de información en el ordenamiento del territorio.

La importancia de la vegetación ribereña es crucial en todos los procesos físicos, morfológicos, químicos y ecosistémicos (Goodwin et al. 1997). Físicamente la franja de ronda hídrica altera las condiciones del flujo en eventos de riesgo actuando de barrera de protección ante avenidas torrenciales e inundaciones, desde la perspectiva morfológica las rondas hídricas determinan la metamorfosis de los cuerpos, en cuanto a los procesos químicos la vegetación de la ronda hídrica apoya los ciclos biogeoquímicos de los sistemas fluviales, dado que el efecto amortiguador mejora las propiedades químicas y físicas de la calidad del agua que se impacta en la cuenca por la contaminación de fuentes no puntuales (Sabater et al., 2003).

Los procesos ecosistemicos se ven favorecidos por la vegetación ribereña, dado que es la zona más biodiversa del ecosistema, con ello se favorece el hábitat y funciones del ecosistema dado que sirve de nicho para las especies propias de la zona de vida, otra de las ventajas de la influencia de la vegetación ribereña en cuerpos lentigos es la capacidad de regulación climática, dado que el microclima favorece la temperatura del agua para la existencia de la bióta acuática, algunas de estas funciones se han catalogado esenciales para moderar los efectos locales de los cambios globales, tales como las condiciones térmicas de las corrientes (Trimmel et al., 2018), la identidad del paisaje,y los servicios culturales y recreacionales. (Dufour & Rodríguez., 2019).

Los estudios sobre las rondas hídricas se han realizado principalmente sobre la sistemática y diversidad de especies (Magbanua et al 2017), estudios de vegetación existentes se centraron netamente en la flora (Lubos et al. 2015) y por ahora muy pocos estudios relacionados con el acotamiento de franjas hídricas, por ejemplo Donald L., Grebner Pete B., Jacek P. (2013), estableció que el tamaño y el ancho de las zonas pueden variar enormemente de 3 a 50 metros en ambos lados del cuerpo de agua.

Otro estudioes el adelantado porBentrup (2008), quien recomienda que los anchos de amortiguación estrechos de 5 a 15 metros mantienen la estabilidad del banco y proporcionan algo de regulación, pero son inadecuados para la reducción de sedimentos y nutrientes, por ello para mantener el hábitat de reproducción de aves y corredores de vida silvestre para el movimiento de grandes mamíferos se requiere anchos de amortiguación más amplios de 30,5 a 91,4 metros, finalmente Muscutt et al. (1993) &Parkyn (2004), establecieron que las zonas de amortiguamiento menores 10 m, es deficiente, razón por la cual Hickey y Doran (2004), recomendaron zonas de amortiguamiento ribereñas mayores a 30 metros para una reducción de nutrientes del subsuelo completamente efectiva de la fauna y flora ribereña.

Actualmente, los usos permitidos de estas áreas están determinadas en los instrumentos de Planeación Territorial, y catalogadas como áreas de conservación y protección de los recursos naturales. De esta manera se ha evidenciado que existen falencias en la formulación e implementación de los instrumentos de planeación y ordenamiento territorial, asociados a la desmesurada permisibilidad de las entidades territoriales que permiten la intervención antrópica y construcciones civiles que no consideran las llanuras de inundación y efectos sobre la biodiversidad silvestre que superan la capacidad de carga de los ecosistemas (U.S. Department. 2004), razón por la cual se realizó esta investigación a fin de conocer cuál es el estado de la protección y conservación de las Rondas Hídricas en Colombia, vistas desde el contexto internacional.

Con base en lo anteriormente expuesto se buscó analizarel estado de la planificación del recurso hídrico en Colombia para elestablecimiento franjas y rondas hídricas como zonas de protección o conservación ambiental materializadas en los planes y esquemas de ordenamiento territorial.

Para ello fue necesario realizar la revisión de la información disponible en Colombia y en Latinoamérica sobre las rondas hídricas y sus franjas de protección y conservación. De este modo serealizó el análisis normativo del acotamiento y delimitación de rondas en algunos países de américa latina, posteriormente se realizó la revisión normativa de los actos administrativos de las determinantes ambientales de las 34 autoridades ambientales colombianas, para posteriormente analizar la información recopilada anteriormente y determinar las dificultades relacionadas con el acotamiento y alinderamiento de las rondas hídricas en Colombia.

II. Marco Normativo De Rondas Hídricas En Latinoamérica

En Ecuador elMinisterio de Ambiente, (2006), mediante el Acuerdo Ministerial 128 del 2006, estableció que las Zona(s) de protección permanente: son las áreas con bosquesy/o vegetación nativa que se ubican a lo largo de ríos, de quebradas, de ojos de agua o de cualquier curso de agua permanente o intermitente, para estas áreas definió tres escalas de rondas. (i) para cuerpos de hasta 3 metros de nacho se definieron 20 metros a cada lado de la franja, (ii) para cuerpos de 3 hasta 6 metros de ancho se definieron 30 metros a lado y lado y (iii) para cuerpos hídricos de más de 6 metros se definieron 50 metros a lado y lado. Para el caso de las areas ubicadas alrededor de lagos, lagunas, reservorios y represas; naturales o artificiales, en franja paralela al margen con un ancho mínimo de 40 m. De otra parte, el artículo 13 de la Ley orgánica de recursos hídricos, usos y aprovechamiento del agua, estableció que son formas de conservación y de protección de fuentes de agua, las servidumbres de uso público, zonas de protección hídrica y los terrenos que lindan con los cauces públicos están sujetos en toda su extensión longitudinal a una zona de servidumbre para uso público, que se regulará de conformidad con el Reglamento y la Ley.

Según Romero F., Cozano M., Gangas R., &Naulin P., (2014), en Chile,la protección de loscauces y las zonas ribereñas han sido reguladas desde el año 1931, en la cual se fijó que los cursos de agua permanentes contarán con una franja de protección de 30 metros de ancho a cada lado del afluente. Respecto de los cursos de agua no permanentes, se protegen con una franja de 15 metros de ancho como mínimo, también se protege de cualquier intervención, las áreas de pendientes iguales o superiores a 60 % por más de 30 metros.

En el caso de Honduras, el Congreso Nacional de Honduras (2007), estableció en la Ley forestal - Artículo 123, que la Protección de Fuentes y Cursos de Agua, serán en los ríos y quebradas permanentes en los cuales seestablecen fajas de protección de ciento cincuenta metros (150 mts), medidos en proyección horizontal a partir de la línea de ribera, si la pendiente de la cuenca es igual o superior a treinta por ciento (30%); y de cincuenta metros (50 mts) si la pendiente es inferior de treinta por ciento (30%).

En Bolivia el Decreto Supremo 24453 de 1996, el Artículo 35 estableció que las servidumbres ecológicas entre otras las siguientes servidumbres 10 metros por lado en las riberas de quebradas y arroyos de zonas no erosionables ni inundables; 20 metros por lado en las quebradas y arroyos de zonas erosionables o inundables; 50 metros por lado en las riberas de los ríos en zonas no erosionables o inundables; 100 metros por lado en las riberas de los ríos en zonas erosionables o inundables; 100 metros a la redonda en lagunas y lagos.

En Brasil, el Código Forestal estableció que el Área de Preservación Permanente, en áreas rurales o urbanas, se considera a los efectos de esta Ley los rangos marginales de cualquier curso de agua natural desde el borde de la canaleta de la cama regular hasta un ancho mínimo de 30 (treinta) metros, para cursos de agua de menos de 10 (diez) metros de ancho; 50 (cincuenta) metros, para cursos de agua de 10 (diez) a 50 (cincuenta) metros de ancho; las áreas alrededor de los lagos y lagunas naturales, con un ancho mínimo de 100 (cien) metros, en áreas rurales, excepto el cuerpo de agua con hasta 20 (veinte) hectáreas de superficie, cuyo rango marginal será de 50 (cincuenta) metros;30 (treinta) metros, en zonas urbanas (Presidencia de la Republica de Brasil, 2012).

De otra parte, en Argentina la Ley 12.257 de 1999, "P*or medio de la cual se adopta el código de aguas",* estableció que se prohíbe se modificar el uso actual de la tierra con excepción de las obras y accesorios necesarios para su actual destino o explotación en una franja de cincuenta (50) metros aledaña a los ríos, canales y lagunas de dominio público (Senado y Cámara de Diputados de la Provincia de Buenos Aires, 1999)

Otro de los casos de reglamentación y protección de las rondas hídricas se evidencia en Paraguay, donde el Ministerio de Agricultura (2012), estableció los parámetros mínimos que se deberán conservar en las zonas de bosques protectores de cauces hídricos, siendo esta entre los 10 metros a lado y lado para cuerpos menores de 1.5 metros de ancho, de 1.5 a 4.9 metros se recomienda 20 metros a lado y lado, de 5 a 19 metros de ancho se estableció 30 metros de margen en las rondas hídricas.

En Uruguay, se estableció que los terrenos lindantes con el Océano Atlántico, con los ríos de la Plata, Uruguay, Cuareim y Yaguarón y con la Laguna Merín estarán sujetos a servidumbre de salvamento, en una faja de veinte (20) metros desde la margen de las aguas, los terrenos contiguos a los demás ríos, arroyos, lagos y lagunas navegables o flotables estarán sujetos a idéntica servidumbre, en una faja de cinco (5) metros determinada en la misma forma.

En Venezuela, la Ley de Aguas del 2007, estableció que son Bienes del Dominio Público de la Nación, todas las áreas comprendidas dentro de una franja de ochenta metros (80) a ambas márgenes de los ríos nonavegables o intermitentes y cien metros (100) a ambas márgenes de los ríos navegables, medidos a partir del borde del área ocupada por las crecidas, correspondientes a un período de retorno de dos comastreinta y tres (2.33) años.

Asímismo, el Congreso Constitucional de Costa Rica (1996), promulgo la Ley Forestal no. 7575 del 1996, en la cual estableció que las áreas de protección

constituyen una figura jurídica importante en la protección del recurso hídrico, así como de la biodiversidad autóctona de dichos ecosistemas, razón por la cual se protegen las áreas que bordeen nacientes permanentes, definidas en un radio de cien (100) metros medidos de modo horizontal y una franja de quince (15) metros en zona rural y de diez (10) metros en zona urbana, medidas horizontalmente a ambos lados, en las riberas de los ríos, quebradas o arroyos, si el terreno es plano, y de cincuenta (50) metros horizontales, si el terreno es quebrado y una zona de cincuenta (50) metros medida horizontalmente en las riberas de los lagos y embalses naturales y en los lagos o embalses artificiales.

En Panamá, la Autoridad Nacional del Ambiente (1994), mediante la el Decreto - Ley 1 de 3de febrero de 1994 en el Artículo 23, estableció que queda prohibido el aprovechamiento forestal; el dañar o destruir árboles o arbustos en las zonas circundantes al nacimiento de cualquier cauce natural de agua, así como en las áreas adyacentes a lagos, lagunas, ríos y quebradas. Esta prohibición afectará una franja de bosques de la siguiente manera:Las áreas que bordean los ojos de agua que nacen en los cerros en un radios de dos cientos (200) metros, y de cien (100) metros si nacen en terrenos planos; en los ríos y quebradas, se tomará en consideración el ancho del cauce y se dejará a ambos lados una franja de bosque igual o mayor al ancho del cauce que en ningún caso será menor de diez (10) metros; y una zona de hasta cien (100) metros desde la ribera de los lagos y embalses naturales.Estos bosques a orilla de los cuerpos de aguas, no pueden ser talados bajo ningún argumento y serán considerados bosques especiales de preservación permanente.

En el caso de Nicaragua, el Congreso de ese país, mediante la Ley 217 (Gaceta, 1996) optaron por declarar el recurso agua como de dominio público y reservar al estado la propiedad de las playas marítimas, fluviales y lacustres; el álveo de las corrientes y el lecho de los depósitos naturales de agua; los terrenos salitrosos, el terreno firme comprendido hasta de treinta 30 metros después de la línea de marcas máximas o a la del cauce permanente de los ríos y lagos y los estratos o depósitos de las aguas subterráneas.

Otro de los casos analizados, es el caso de México, ya que según Xóchitl Peñaloza R. & González Verdugo J. (s.f). en el artículo 3, fracción XLVII, de la Ley de Aguas Nacionales (LAN), se definecomo “Ribera o Zona Federal” las fajas de diez (10) metros de anchura contiguas al cauce de las corrientes o al vaso de losdepósitos de propiedad nacional, medidas horizontalmente a partir del nivel de aguasmáximas ordinarias.

De este modo en la tabla 1, se recopilan las franjas de protección y conservación de rondas hídricas en Latinoamérica.

Tabla 1: Acotamiento de rondas hídricas en Latinoamérica.

Bolivia	10 metros por lado en las riberas de quebradas y arroyos de zonas no erosionables ni inundables
	20 metros por lado en las quebradas y arroyos de zonas erosionables o inundables
	50 metros por lado en las riberas de los ríos en zonas no erosionables o inundables
	100 metros por lado en las riberas de los ríos en zonas erosionables o inundables
	100 metros a la redonda en lagunas y lagos.
Ecuador	Para cuerpos de hasta 3 metros de nacho se definieron 20 metros a cada lado de la franja
	Para cuerpos de 3 hasta 6 metros de ancho se definieron 30 metros a lado y lado
	Para cuerpos hídricos de más de 6 metros se definieron 50 metros a lado y lado.
Brasil	Para cursos de agua de menos de 10 (diez) metros de ancho 50 (cincuenta) metros
	Para cursos de agua de 10 (diez) a 50 (cincuenta) metros de ancho
	Las áreas alrededor de los lagos y lagunas naturales, con un ancho mínimo de 100 (cien) metros
Paraguay	Para cuerpos menores de 1.5 metros de ancho entre los 10 metros a lado y lado
	De 1.5 a 4.9 metros entre los 20 metros a lado y lado
	De 5 a 19 metros de ancho se estableció 30 metros
Costa Rica	Una franja de quince metros en zona rural medidas horizontalmente a ambos lados, en las riberas de los ríos, quebradas o arroyos, si el terreno es plano, y de cincuenta metros horizontales, si el terreno es quebrado y una zona de cincuenta metros medida horizontalmente
	De diez metros en zona urbana, medidas horizontalmente a ambos lados, en las riberas de los ríos, quebradas o arroyos, si el terreno es plano, y de cincuenta metros horizontales, si el terreno es quebrado y una zona de cincuenta metros medida horizontalmente
Chile	Los cursos de agua permanentes contarán con una franja de protección de 30 m de ancho a cada lado
	Los cursos de agua no permanentes, una franja de 15 m de ancho como mínimo,

Honduras	Los ríos y quebradas permanentes cuentan con fajas de protección de ciento cincuenta metros (150 mts),
Argentina	Una franja de cincuenta metros aledaña a los ríos, canales y lagunas de dominio público
Uruguay	Una faja de veinte metros desde la margen de las aguas, los terrenos contiguos a los demás ríos, arroyos, lagos y lagunas navegables o flotables estarán sujetos a idéntica servidumbre
Venezuela	Una franja de ochenta metros (80mts) a ambas márgenes de los ríos nonavegables o intermitentes
	Cien, metros (100 mts.) a ambas márgenes de los ríos navegables
Nicaragua	Hasta 30 metros después de la línea de marcas máximas o a la del cauce permanente de los ríos y lagos y los estratos o depósitos de las aguas subterráneas.
Panamá	En los ríos y quebradas, una franja de bosque igual o mayor al ancho del cauce que en ningún caso será menor de diez (10) metros; y una zona de hasta cien (100) metros desde la ribera de los lagos y embalses naturales.
Mexico	Diez metros de anchura contiguas al cauce de las corrientes o al vaso de los depósitos de propiedad nacional, medidas horizontalmente a partir del nivel de aguas máximas ordinarias.

Fuente: el Autor

III. Marco Legal De Rondas Hídricas En Colombia

La legislación vinculada con las áreas de rondas hídricas en Colombia inicia con el Decreto 2811 de 1974 "*Por el cual se dicta el Código Nacional de Recursos Naturales Renovables y de Protección al Medio Ambiente"* es el primer instrumento jurídico que define el DOMINIO DE LAS AGUAS Y SUS CAUCES, estableciendo en el artículo 83 literal d, que salvo derechos adquiridos por particulares, son bienes inalienables e imprescriptibles del Estado entre otras (..) una faja paralela a la línea de mareas máximas o a la del cauce permanente de ríos y lagos, hasta de treinta (30) metros de ancho.

Seguido de ello el Decreto 1449 de 1977, estableció que en relación a la protección y conservación de los bosques, los propietarios de predios están obligados a mantener en cobertura boscosa dentro del predio las áreas forestales protectoras, entendiéndose por lo menos de 100 metros a la redonda, en nacederos de agua medidos a partir de su periferia y una faja no inferior a 30 metros de ancha, paralela a las líneas de mareas máximas, a cada lado de los cauces de los ríos, quebradas y arroyos, sean permanentes o no, y alrededor de los lagos o depósitos de agua y en terrenos con pendientes superiores al 45%.

Posterior a ello el Decreto Nacional 1541 de 1978 en el Artículo 11, define un cauce natural es la faja de terreno que ocupan las aguas de una corriente al alcanzar sus niveles máximos por efecto de las crecientes ordinarias; y por lecho de los depósitos naturales de aguas, el suelo que ocupan hasta donde llegan los niveles ordinarios por efectos de lluvias o deshielo.

El mismo Decreto en el artículo 281, estableció que la administración, conservación y manejo del recurso hídrico, corresponde al Instituto Nacional de los Recursos Naturales Renovables y del Ambiente - INDERENA, y tendrá a su cargo, determinar la faja paralela al cauce permanente de los ríos y lagos a que se refiere el artículo 83 del Decreto-ley 2811 de 1974.

Con la expedición de la Ley 99 de 1993 y creación del Ministerio del Medio Ambiente, las funciones que antes estaban a cargo del INDERENA fueron asumidas por el Ministerio

Más adelante en 1997 la expedición de la ley 388 en el artículo 104 numeral 1, definió que incurrirán en una infracción urbanística y por lo tanto deberán pagar una multa, quienes desarrollen en terrenos de protección ambiental, o localizados en zonas calificadas como de riesgo, tales como humedales, rondas de cuerpos de agua o de riesgo geológico. A raíz de ello y desde 1997 los municipios en Colombia empezaron a materializar la delimitación de rondas hídricas en sus esquemas y planes de ordenamiento, delimitando las rondas hídricas de acuerdo con los lineamientos que las autoridades ambientales adoptaban en las determinantes ambientales y/o delimitando 30 metros de ancho a cada lado tal como lo definió el Decreto Ley 2811 de 1974 para la faja paralela a la línea de mareas máximas o a la del cauce permanente de ríos y lagos.

Posterior a dicha norma el Decreto 3600 del 2007, reglamentó las determinantes de ordenamiento del suelo rural, en el artículo 4, definió entre las *categorías de protección en suelo rural l*as áreas de especial importancia ecosistémica, tales como páramos y subpáramos, nacimientos de agua, zonas de recarga de acuíferos, rondas hidráulicas de los cuerpos de agua, humedales, pantanos, lagos, lagunas, ciénagas, manglares y reservas de flora y fauna

Luego el Decreto 3930 de 2010 que tiene como objeto reglamentar el ordenamiento del recurso hídrico, faculta que las Autoridades Ambientales Competentes deberán realizar el Ordenamiento del Recurso Hídrico, sin embargo, advierte que no se permiten vertimientos en cuerpos de agua y áreas declaradas dignas de protección, de esta manera se empieza a dar el ordenamiento del recurso hídrico y de cauces naturales en Colombia.

El Decreto 1640 de 2012 *"Por medio del cual se reglamentan los instrumentos para la planificación, ordenación y manejo de las cuencas hidrográficas y acuíferos, y se dictan otras disposiciones", definió en el artículo* 28, que la armonización de los instrumentos debe ser ajustados y armonizados por la respectiva autoridad ambiental competente en la fase de ejecución, teniendo en cuenta la delimitación de Rondas Hídricas.

Al mismo tiempo el artículo 18 estableció que la ordenación de cuencas se hará teniendo en cuenta el carácter especial de conservación de las Áreas de Especial Importancia Ecológica y los ecosistemas y zonas que la legislación Ambiental ha priorizado en su protección, tales como: páramos, subpáramos, nacimientos de aguas, humedales, rondas hídricas entre otras.

Posteriormente el artículo 206 de Ley 1450 de 2011 (hoy vigente, según lo dispuesto en el artículo 267 de la Ley 1753 de 2015), dispuso que "*Corresponde a las Corporaciones Autónomas Regionales y de Desarrollo Sostenible, los Grandes Centros Urbanos y los Establecimientos Públicos Ambientales efectuar, en el área de su jurisdicción y en el marco de sus competencias, el acotamiento de la faja paralela a los cuerpos de agua a que se refiere el literal d) del artículo 83 del Decreto-Ley 2811 de 1974 y el área de protección o conservación aferente, para lo cual deberán realizar los estudios correspondientes, conforme a los criterios que defina el Gobierno Nacional."*, en cumplimiento de ello el Decreto 2245 de 2017, definió que el desarrollo de los criterios deberá ser contemplado en una Guía técnica, Guía adoptada por el Ministerio de Ambiente y Desarrollo Sostenible a través de la Resolución 957 de 2018 "*Por la cual se adopta la guía técnica de criterios para el acotamiento de las rondas hídricas en Colombia y se dictan otras disposiciones".*

La guía mencionada establece la metodología que deberán seguir las Autoridades ambientales para definir el acotamiento, límites físicos y directrices para el manejo ambiental de las rondas hídricas en cada una de sus jurisdicciones y luego remitir a los municipios y distritos las áreas delimitadas en el acotamiento de la ronda hídrica que se deben adoptar en materia de reglamentación de usos del suelo.

La Resolución 957 de 2018 estableció en el artículo segundo que las autoridades ambientales competentes tendrían un plazo de hasta seis (6) meses, contados a partir de la publicación de la Resolución, para establecer mediante acto administrativo, el orden de prioridades con el cual se iniciará el acotamiento de las rondas hídricas en sus jurisdicciones, a partir de allí cada año serán acotadas las rondas hídricas que la Autoridad Ambiental haya definido priorizar estando en función de la capacidad financiera de cada Autoridad Ambiental (MINAMBIENTE, 2018).

IV. Situación De Las Corporaciones Autónomas Ambientales Y El Acotamiento De Rondas Hídricas

Una vez analizada la reglamentación y protección de las rondas hídricas en Latinoamérica y los antecedentes en Colombia es importante conocer los avances en el acotamiento *de la faja paralela a los cuerpos de agua a que se refiere el literal d) del artículo 83 del Decreto-Ley 2811 de 1974 y el área de protección o conservación aferente, por parte de las Corporaciones Autónomas Regionales y de Desarrollo Sostenible, teniendo en cuenta las facultades dadas mediante el* artículo 206 de Ley 1450 de 2011, el Decreto 2245 de 2017, y la Resolución 957 de 2018, la cual fijaba un plazo de hasta seis (6) meses, contados a partir de la publicación de la Resolución, para establecer mediante acto administrativo, el orden de prioridades con el cual se iniciará el acotamiento de las rondas hídricas en sus jurisdicciones.

Es por ello que a continuación se presenta el análisis de cuáles son las Corporaciones Autónomas Regionales y de Desarrollo Sostenible que a la fecha ya iniciaron con el acotamiento de las rondas hídricas en cada una de sus jurisdicciones:

De acuerdo con la información publicada en cada uno de sus portales web, se evidencia que entre las corporaciones que no han definido por acto administrativo la priorización del acotamiento de las rondas hídricas, se encuentra; la Corporación Autónoma Regional para el Desarrollo Sostenible del Chocó – CODECHOCÓ, la Corporación para el Desarrollo Sostenible del Archipiélago de San Andrés, Providencia y Santa Catalina – CORALINA, la Corporación Autónoma Regional del Centro de Antioquia – CORANTIOQUIA, la Corporación para el Desarrollo Sostenible del Área de Manejo Especial de La Macarena – CORMACARENA, la Corporación Autónoma Regional del Magdalena – CORPAMAG, la Corporación Autónoma Regional de Boyacá – CORPOBOYACÁ, la Corporación Autónoma Regional del Cesar – CORPOCESAR,Corporación Autónoma Regional de La Guajira – CORPOGUAJIRA, la Corporación para el Desarrollo Sostenible de La Mojana y El San Jorge – CORPOMOJANA, la Corporación Autónoma Regional de Nariño – CORPONARIÑO, Corporación Autónoma Regional de la Frontera Nororiental – CORPONOR, Corporación para el Desarrollo Sostenible del Urabá – CORPOURABA, Corporación para el Desarrollo Sostenible de La Mojana y El San Jorge – CORPOMOJANA, Corporación Autónoma Regional del Tolima – CORTOLIMA, la Corporación Autónoma Regional del Atlántico – CRA, Corporación Autónoma Regional del Cauca – CRC, la Corporación Autónoma Regional de la Orinoquia –

CORPORINOQUIA, la Corporación Autónoma Regional del Sur de Bolívar – CSB, la Corporación Autónoma Regional del Valle del Cauca – CVC, la Corporación Autónoma Regional de los Valles del Sinú y del San Jorge – CVS, la *Corporación Autónoma Regional del Alto Magdalena – CAM, la* Corporación Autónoma Regional de Sucre – CARSUCRE, La Corporación Autónoma Regional de Santander – CAS, la Corporación para el Desarrollo Sostenible del Norte y el Oriente Amazónico – CDA.

Lo mismo sucede en la Corporación Autónoma Regional de Risaralda - CARDER, no se encontró acto administrativo que dé Cumplimiento a la Resolución 957 de 2018, razón por la cual a la fecha en los Esquemas y Planes de Ordenamiento Territorial se aplica lo establecido en la Resolución número 1723 de 2017, *"por la cual se actualizan y adoptan las determinantes ambientales para la elaboración de los planes de ordenamiento territorial municipal en jurisdicción del departamento de Risaralda"*, en la cual se estableció que se deben reconocer e identificar las áreas forestales protectoras de los nacimientos y corrientes de agua en las cuencas abastecedoras, estas áreas se deben reconocer como suelos de protección de la siguiente forma: para los nacimientos de fuentes de agua tendrán una extensión de veinte metros (20 m) a la redonda, medidos a partir de su periferia (resolución CARDER 061 de 2007 modificada por la Resolución 1371 de 2009 o aquella que la modifique o sustituya). Para corrientes de agua, en suelo rural se debe delimitar la zona forestal protectora de acuerdo a la Resolución CARDER 061 de 2007 Modificada por la Resolución 1371 de 2009; En suelos urbanos, de expansión y suburbanos, se debe delimitar la zona forestal protectora según el Acuerdo CARDER 028 del 2011.

Igualmente sucede en la Corporación Autónoma Regional de Cundinamarca – CAR, desde antes de lo dispuesto en la Resolución 957 de 2018, había construido la Guía metodológica para la delimitación de zonas de ronda en la jurisdicción de la Corporación Autónoma Regional de Cundinamarca – CAR, con la cual ha venido adelantando el acotamiento de las rondas hídricas en su jurisdicción, además de establecer en los Determinantes ambientales de Ordenamiento Territorial que las rondas hídricas son zonas que hacen parte de la dinámica natural de los ríos, las cuales se deben conservar y proteger los 30 metros (mínimos) adyacentes que constituyen área forestal protectora.

De este modo se evidencia que de las 34 corporaciones solo 8 ya cuentan con *priorización de las rondas hídricas en sus jurisdicciones, entre ellas es de resaltar el caso de la* Corporación Autónoma Regional del Quindío – CRQ, mediante el Convenio interadministrativo No. 004-2018 Corporación Autónoma Regional del Quindío y la Universidad del Tolima, realizo la priorización de cuerpos de agua para el acotamiento de su ronda hídrica en jurisdicción de la CRQ, siendo un proceso de jerarquía analítica (AHP) para el acotamiento de la ronda hídrica en cuerpos de agua en la jurisdicción de la CRQ permitió ajustar los pesos relativos de valoración para cada criterio principal de priorización, en concordancia con las particularidades regionales, lo que permite entender que la priorización de los cuerpos hídricos se realizó en función de la guía técnica de criterios para el acotamiento de las rondas hídricas en Colombia fue desarrollada en cumplimiento del Decreto 2245 de 2017.

Otra de las corporaciones es la Corporación Autónoma Regional del Canal del Dique – CARDIQUE, mediante la Resolución 1674 del 29 de noviembre de 2018 "*Por medio de la cual se prioriza las rondas hídricas de la jurisdicción de CARDIQUE y se dictan otras disposiciones",* adopta el orden de alinderamiento de los cuerpos hídricos en su jurisdicción, la Corporación Autónoma Regional de Caldas – CORPOCALDAS, la cual adopto mediante acto administrativo la Priorización para el acotamiento de rondas hídricas en su jurisdicción, y derogo la Resolución 077 del 02 de marzo de 2011 "*Por la cual se fijan los lineamientos para demarcar ña faja forestal protectora de los nacimientos y corrientes de las aguas localizadas en suelos rurales de la jurisdicción de CORPOCALDAS".*

De igual modo la Corporación Autónoma Regional del Guavio – CORPOGUAVIO, mediante la Resolución no. 1275 del 28 de noviembre de 2018 *"por medio de la cual se establece el orden de priorización de los cuerpos de agua de la jurisdicción de CORPOGUAVIO para el acotamiento de la ronda hídrica",* definió el orden en función de la sub zona hidrográfica, además de establecer que el orden de prioridad para el acotamiento de la ronda hídrica de los cuerpos de agua con el mismo valor de priorización y con múltiples empates entre sí, de igual o diferente Sub zona Hidrográfica, estará sujeto a disposición de la Subdirección de Gestión Ambiental de la Corporación, quien será la encargada de determinar la fuente hídrica que será objeto de acotamiento.

Así mismo la Corporación Autónoma Regional de Chivor – CORPOCHIVOR a través de la Resolución 938 del 28 de Diciembre de 2018 "Por medio de la cual se prioriza los cuerpos de agua para el acotamiento de las rondas hídricas de la jurisdicción de la Corporación Autónoma Regional de Chivor – CORPOCHIVOR", definiendo dichos cuerpos por subcuencas y resaltando que el número de cuerpos de agua que serán anualmente objeto de acotamiento de rondas hídricas, dependerá del presupuesto asignado para la actividad en el respectivo Plan de acción de la Corporación, en el caso de la Corporación para el Desarrollo Sostenible del Sur de la Amazonia – CORPOAMAZONIA, mediante la Resolución número 1186 de 2019, *por la cual se adopta*

el documento técnico: "Priorización para el acotamiento de rondas hídricas, en la jurisdicción de Corpoamazonia"

Finalmente la Corporación Autónoma Regional de las Cuencas de los Ríos Negro y Nare – CORNARE, a través de la Resolución 112-4927 del 26 de noviembre de 2018 la Corporación Autónoma Regional de las Cuencas de los Ríos Negro y Nare CORNARE, ha definido el orden de prioridades para el inicio del acotamiento de las rondas hídricas mediante el documento técnico "Priorización para el acotamiento de las rondas hídricas en la jurisdicción Cornare", y la Corporación Autónoma Regional para la Defensa de la Meseta de Bucaramanga – CDMB, mediante la Resolución 1239 de 2018 "Por la cual se establece el orden de prioridades para iniciar el acotamiento de rondas hídricas en la jurisdicción de La Corporación Autónoma Regional para la Defensa de la Meseta de Bucaramanga – CDMB", el 30 de noviembre estableció 29 órdenes de priorización, fijando además incorporar el presente acto al plan de acción para definir el número de órdenes a realizar cada año, al igual que la Corporación Autónoma Regional del Guavio (2018), la cual definió la priorización mediante la Resolución no. 1275 del 28 de noviembre de 2018 *"por medio de la cual se establece el orden de priorización de los cuerpos de agua de la jurisdicción de corpoguavio para el acotamiento de la ronda hídrica",*

V. Dificultades y Oportunidades Del Acotamiento De Rondas Hídricas Con La Expedición De La Resolución 957 De 2018

De acuerdo con la Guía Técnica de criterios para el acotamiento de las rondas hídricas en Colombia, adoptada por la Resolución 957 del 2018, se buscó definir el acotamiento, límites físicos y directrices para el manejo ambiental de las rondas hídricas, mediante la metodología que se basa en dos fases, la primera busca delimitar el cauce permanente o de la línea de mareas máximas, para ello plantea la metodología de identificación preliminarmente las formas del terreno asociadas al cauce permanente , delimitación del ancho del cauce permanente y verificarlo en campo, identificación en campo de los descriptores, delimitación del cauce permanente desde la amplitud del pulso de y la línea de mareas máximas, la segunda fase se basa en la definición del límite físico y de estrategias para el manejo ambiental de la ronda hídrica, para ello define la delimitación de cuatro componentes entre ellos el geomorfológico, el hidrológico, el ecosistémico el límite físico de la ronda hídrica, además de presentar herramientas para la identificación de servicios ecosistemicos, metodología que a la fecha solo ha sido implementada por 8 de las 34 corporaciones autónomas regionales y que de las 8 que realizaron la priorización podría decirse que a la fecha cada una de ellas llevan un 10% del acotamiento de las fuentes hídricas en sus jurisdicciones.

Es por ello que es importante considerar que la implementación de esta resolución puede tardarse más de 15 años aproximadamente dado que los municipios que no estén priorizados en el acto de acotamiento de la autoridad ambiental y se encuentren en revisión del plan de ordenamiento territorial tendrán que acogerse a lo definido en el Decreto 2811 de 1974, sin posibilidad alguna de incluir el ordenamiento hídrico definido en la Resolución 957 del 2018, lo que conllevara a que en determinado municipio 30 metros a cada lado de las fuentes hídricas queden delimitadas como areas de protección y por esta razón el municipio no pueda aumentar o disminuir la ronda hídrica de determinados cuerpos hídricos.

Sin embargo y con el transcurrir de las administraciones en cada una de las autoridades ambientales se han generado una gran variedad de criterios de orientación, planificación, y administración del territorio (Ardila, 2016), entre ellos el acotamiento y/o delimitación de las rondas hídricas ya que durante más de dos décadas las corporaciones ambientales definían nuevos límites o simplemente ratificaban lo establecido en el Decreto – Ley 2811 de 1974, dejando de lado los criterios particulares de protección ambiental, y áreas en condición de riesgo.

Cabe resaltar que si bien la metodología de la Resolución 957 del 2018, presenta criterios geomorfológicos, hidrológicos, ecosistémicos y límites físicos de la ronda hídrica, en la realidad es un trabajo muy dispendioso sabiendo que la información requerida para la implementación de dichas fases es limitada en algunas de las jurisdicciones de Corporaciones Autónomas.

Si bien es cierto, la delimitación de las rondas hídricas es un aspecto ambiental que determina el uso del suelo en los instrumentos de Planeación territorial (EOT, PBOT, POT), la priorización y acotamiento de las rondas hídricas deberían estar previo a la adopción del EOT, PBOT, POT, a fin de garantizar articulación entre el uso del suelo y las areas acotadas para cada una de las fuentes hídricas en determinada jurisdicción.

Es importante considerar que otro de los retos que hoy tiene el Ministerio de Ambiente, es el realizar el seguimiento a la implementación de la Resolución 957 de 2018, y la aplicación de cada uno de los criterios adoptados, de lo contrario debe reconsiderarse la forma de acotamiento y alinderamiento de fuentes hídricas en el país, por ejemplo que sea el Municipio quien priorice cada uno de sus cuerpos hídricos y de este modo en trabajo conjunto con la respectiva corporación inicie la aplicación de los criterios o en segundo lugar que la delimitación y el acotamiento de rondas hídricas en el país sean categorizadas en función del ancho del cauce, la pendiente del terreno y

el ecosistema estratégico en las que estas se encuentren.

Sin embargo y para no detener el ordenamiento del territorio, es importante acotar y alinderar las rondas hídricas de los municipios antes de iniciar el proceso de revisión y ajuste de los instrumentos de planeación con el fin de que estos no vayan en viacontraria a los determinantes ambientales, usos y polígonosdel uso del suelo posteriormente.

VI. Conclusiones

Si en países como Bolivia, Ecuador, Brasil, Parguay y Costa Rica se definieron franjas de rondas hídricas en función del ancho de los cuerpos hídricos, de las características erosionables, inundables y topografía del terreno, se puede considerar viable dicha categorización en Colombia debido a la baja implementación de los criterios definidos por el Ministerio de Ambiente.

La falta de información técnica y cartografía requerida para el alinderamiento de rondas hídricas en las Corporaciones se traduce en la baja implementación de la Resolución 957 de 2018 y la cual estaría en desarticulación con los instrumentos de planeación de cada uno de los municipios que adelantes proceso de revisión y ajuste de los EOT, PBOT y POT.

Teniendo en cuenta que a la fecha la implementación de los criterios de la Resolución 957 de 2018, son relativamente baja pues en dos años de ejecutoriada solo el 33% de las corporaciones han acatado dichos lineamientos el Ministerio de Ambiente debería reconsiderar dicha norma, llegado el caso que se considere que el acotamiento de las fuentes hídricas estaría categorizadas en función del ancho del cauce, la pendiente del terreno y el ecosistema estratégico en las que estas se encuentren.

Es importante resaltar que si hoy existe una normatividad consagrada en el POT, PBOT y EOT vigentes cuyos aspectos ambientales han sido concertados con las Corporaciones, no es necesario modificar la parte correspondiente al establecimiento de rondas hídricas consignadas en ellos, teniendo en cuenta que el parágrafo del artículo 2.2.3.2.3A.3 del Decreto 2245 de 2017, el cual establece que en el proceso de implementación de los criterios, las autoridades competentes evaluarán las situaciones particulares y concretas que hayan quedado en firme y adoptarán las decisiones a que haya lugar.

Actualmente al momento de realizar la revisión y ajuste del POT en un municipio priorizado, pero no acotado, todas las corrientes hídricas del municipio se deberán acotar con 30 metros de ancho a cada lado, según lo dispuesto en el Decreto – Ley 2811 del 1974, enunciado que demuestra la ineficiencia de los criterios adoptados por la Resolución 957 de 2018.

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Analysis of Thermal and Optical Efficiency of Parabolic Concentrating System for Thermal Application

By I.Zakariya'u & B. Bande

Abstract- Solar power generation is the most promising technology to transfer energy consumption reliance from fossil fuel to renewable sources. Concentrated solar power generation is a method to concentrate the sunlight from a bigger area to a smaller area. The collected sunlight is converted more efficiently through two types of technologies: concentrated solar photovoltaic's (CSPV) and concentrated solar thermal power (CSTP) generation.

In this research work, these two technologies would be evaluated in terms of system construction, performance characteristics, design considerations, cost benefit analysis and their field experience. The two concentrated solar power generation systems would be implemented with similar solar concentrators and solar tracking systems but with different energy collecting and conversion components: the CSPV system will use high efficiency multi-junction solar cell modules, while the CSTP system will use a boiler -turbine-generator setup. The performances would be calibrated via the experiments and evaluation analysis.

Keywords: solar energy, solar thermal collectors, linear parabolic collectors, compound parabolic collectors, solar thermal systems.

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I. Introduction

Energy consumption has increasing rate worldwide because of the new trends in lifestyle. With threats of global warming and increased energy cost, the use of renewable and sustainable energy sources is becoming more and more popular. Solar energy is the most abundant and its usage is the more widespread. Solar collectors are heat exchanger devices that capture the incident solar irradiation and transform a part of this to useful heat. This heat is given to a working fluid in order to be transferred to the load or to the storage device. The temperature level of the working fluid determines its energy flow which is also a crucial parameter for high temperature applications. In order to increase the temperature of the working fluid and its energy rate, concentrating collectors are used in many applications. The solar thermal collectors have been widely used to concentrate solar radiation and convert it into useful heat for various thermal processes. Characteristics of solar thermal collectors, especially the concentrating type, are well established in research literature and have many applications in industry and for domestic water heating, and steam generation (CSTE, 2004)The operation principle of solar concentrating collectors is the focusing the incident solar radiation onto a small area known as receiver. Many types of concentrating collectors are available, with various concentrating ratios and different operating temperature levels. Linear parabolic collectors, compound parabolic collectors, Fresnel collectors, and solar dish collectors are the most widespread concentrated collectors. Generally, solar thermal utilization can be separated to low, medium, and high temperature systems. The low temperature solar systems, which operate without sunlight concentration, have low conversion efficiency and they are used in domestic applications. The medium and high temperature solar thermal systems, which require sunlight concentration, have higher conversion efficiency and they can used in great variety of applications [1]

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II. Statement of the Problem

There are still millions of people living in electricity-poverty without enough electricity to support their basic needs, such as food, medicine, home heating, cooling etc. in Nigeria particularly northern part of the country e.g Sokoto state. Many places where these people live have great potential of solar energy resource. Distributed solar power generation could be a quick alternative way to help these poor people to obtain electricity in an economic and environmental friendly way without the high cost centralized power plants and power distribution system [1&2].

With the advancement of the modern technologies, there are more effective solutions to utilize solar energy to improve our quality of life and be beneficial to the environment as well.

III. Significance of the Study

Solar power is compatible for both urban and rural remote areas, as well as good for both residential and utility scale development. Solar energy will become the main energy resource of our planet with advancement in solar technology research to lower cost and improve energy conversion efficiency. Access to affordable energy is one of the basic requirements for development and for poverty reduction. Many areas

have about 80% of the population living out of reach of the electrical grid, and where the main energy source is fire wood as reported by [3&4]. Deforestation is already a severe problem, and increasingly so as the population increases. Therefore, concentrating solar collector for thermal steam generation system can fill the gap or compliment non renewable energy sector for the purpose, of transformation and remediation on the stated problems.

IV. Aim and Objectives

The aim of this research is to develop a parabolic concentrating solar collector for steam thermal application.

The objectives are:

i. Investigate the optical performance of a parabolic concentrating solar collector.
ii. Design an optimal receiver for the air based heat transfer system
iii. Investigate the thermal performance of the collector.

V. Literature Review

The solar thermal collectors have been widely used to concentrate solar radiation and convert it into useful heat for various thermal processes. Characteristics of solar thermal collectors, especially the concentrating type, are well established in research literature and have many applications in industry and for domestic water heating, and steam generation .[5] . The operation principle of solar concentrating collectors is the focusing the incident solar radiation onto a small area known as receiver. Many types of concentrating collectors are available, with various concentrating ratios and different operating temperature levels. Linear parabolic collectors, compound parabolic collectors, Fresnel collectors, and solar dish collectors are the most widespread concentrated collectors. Generally, solar thermal utilization can be separated to low, medium, and high temperature systems. The low temperature solar systems, which operate without sunlight concentration, have low conversion efficiency and they are used in domestic applications. The medium and high temperature solar thermal systems, which require sunlight concentration, have higher conversion efficiency [6&7], and they can used in great variety of applications.

[8] has presented a study that aims to develop a 3-D static solar concentrator that can be used as low cost and low energy substitute. Their goal was to design solar concentrators for production of portable hot water in rural India.

[9&10] has investigated on the photo-thermal conversion efficiency in order to improve the cost effectiveness of the examined solar system. They used the Monte Carlo ray tracing method for calculating the radiation flux distribution on the receiver and the ANSYS Fluent for calculation of radiation and convection heat transfer mechanisms. Their results proved that the maximum energy efficiency was about 52% when the direct normal irradiation was 800 W/m2.

[11&12] investigated the thermal efficiency of solar a cooker with parabola diameter of 3.56 m and total aperture of 10.53 m2, with a finally thermal efficiency of 60 [13&14]have experimentally investigated a solar parabolic dish collector with 20m2 aperture in order to investigate its performance with the examined modified cavity receiver. The average value of the overall heat loss coefficient was found to be about 356 W/m2.

[15]computed the flux distribution on a cylindrical receiver of parabolic dish concentrator using geometric optics method. Parameters such as concentrator surface errors, pointing offset errors and finite sun shape were taken into consideration in the geometric optics methods.

[16&17] have investigated the possible use of parabolic dish collector in process industries. They presented a mathematical model for heating application using thermal oil.

[18]described optical test for the DS1 (parabolic Stirling dish) prototype, a study that was carried out by CTAER. The aim of this investigation was to characterize the optical parameters of DS1 prototype. The results comparison proved that the dish surface had an average optical error of 2.5m rad and an estimated spillage value of 7%, for the examined geometry.

[19&20] presented the radiation flux distributions of the concentrator-receiver system by Monte Carlo ray tracing. The final radiation flux profiles were subsequently transferred to a CFD code as boundary conditions in order to simulate the fluid flow and the conjugated heat transfer in the receiver cavity by coupling the radiation, natural convection, and heat conduction numerically.

[21] presented an optical design and ray tracing analysis of a solar dish concentrator composed of 12 curvilinear trapezoidal reflective facets made from solar mirror with silvered coating layer.

A more recent study reported that 95% of the insulation reflected from a 500 m2 dish (mirror reflectivity of 93.5%) was focused into a cavity type receiver with an aperture of 500 mm diameter [22&23].

VI. Research Methodology

a) Design Consideration

A dish Stirling system or concentrating solar collector system would comprises of a parabolic dish concentrator, a thermal receiver, and a Stirling engine position would be at the focus of the dish; the whole system would be mounted on a structure that tracks the sun by pivoting on one or two axes [24].

Fig. 3.1; shows a parabola which has a locus of a point that moves so that its distances from a fixed line

and a fixed point are equal, where the fixed line is called the directrix and the fixed point F, the focus. The length FR equals the length RD. The line perpendicular to the directrix and passing through the focus F is called the axis of the parabola. The parabola intersects its axis at a point V called the vertex, which is exactly midway between the focus and the directrix [25].

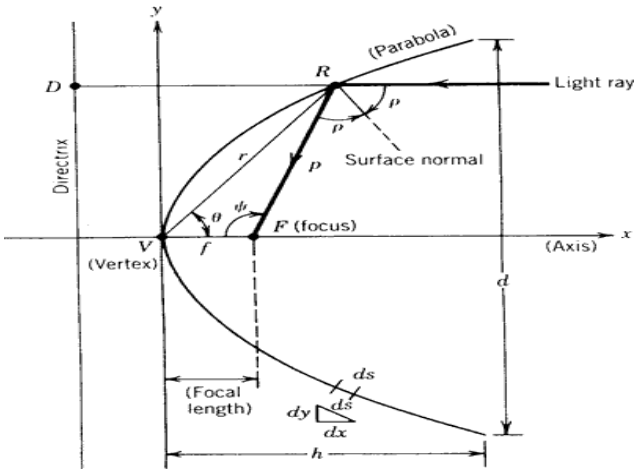

Fig. 3.1: The Parabola

If the origin is taken at the vertex V and the x-axis along the axis of the parabola, the equation of the parabola is given by:

$$y2 = 4fx \quad (1)$$

where x = h i.e. the dept while f is the focal length between the vertex and focus, when the origin is shifted to the focus F as is often done in optical studies, with the vertex to the left of the origin, the equation becomes;

$$y2 = 4f(x-f) \quad (2)$$

In polar coordinates, using the usual definition of r as the distance from the origin and θ the angle from the x-axis to r, we have for a parabola with its vertex at the origin and symmetrical about the x-axis;

$$\frac{\sin^2\theta}{\cos\theta} = \frac{4f}{r} \quad (3)$$

Usually, in solar studies, it is more useful to define the parabolic curve with the origin at F and in terms of the angle (ψ) in polar coordinates with the origin at F. The angle ψ is measured from the line VF and the parabolic radius p, is the distance from the focus F to the curve. Shifting the origin to the focus F, [26&27] describe it as:

$$p = \frac{2f}{1+\cos\omega} \quad (4)$$

The parabolic shape is widely used as the reflecting surface for concentrating solar collectors because it has the property that, for any line parallel to the axis of the parabola, the angle p between it and the surface normal is equal to the angle between the normal and a line to the focal point. Since solar radiation arrives at the earth in essentially parallel rays and by Snell's law the angle of reflection equals the angle of incidence, all radiation parallel to the axis of the parabola will be reflected to a single point F, which is the focus and then the following is true:

$$\psi = 2p \quad (5)$$

ψ is the angle of reflection and P is distance RF. The general expressions given so far for the parabola define a curve infinite in extent. Solar concentrators use a truncated portion of this curve. The extent of this truncation is usually defined in terms of the rim angle (ψrim) or f/d which represents the ratio of the focal length (f) to diameter of dish (d). The scale (size) of the curve is then specified in terms of a linear dimension such as the aperture diameter d or the focal length f. This is readily apparent in fig 3.2 below which shows various finite parabola having a common focus and the same aperture diameter:

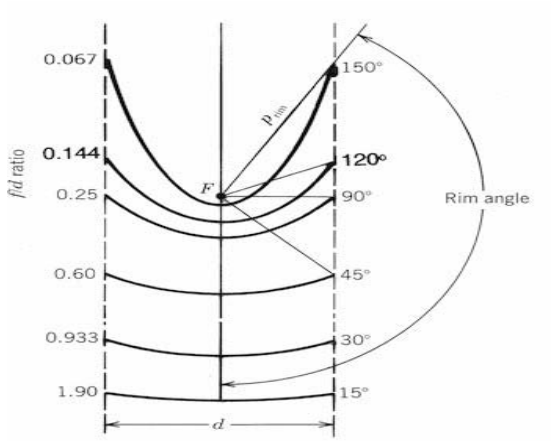

Fig. 3.2: Segments of a parabola having a common focus F and the same aperture diameter.

$$h = \frac{d^2}{16f} \quad (6)$$

In a like manner, the rim angle (ψ_{rim}) may be found in terms of the parabola dimensions

$$\tan\psi_{rim} = \frac{1}{(d/8h) - 2h/d} \quad (7)$$

Another property of the parabola that may be of use in understanding solar concentrator design is the arc lengths. This may be found for a particular parabola. From Equation (7) by integrating a differential segment of this curve and applying the limits x = h and y = d/2.

VII. Locating The Focal Point Of The Dish

In locating the focal point of the dish, two methods are often used: Manual construction which entails finding the focal point by placing the receiver on the approximate or assumption point till the right point of

receiving the highest reflected sunlight is gotten or through the calculations (equation) method. In this work, the calculation (equation) method which entails using the parabola equation to calculate the required parameter was adopted. Referring to fig 3.1, the focal point would be calculated using equation (8) below:

$$f = \frac{D^2}{4d} \quad (8)$$

where D is the longest width [28]. The steps are as follows

Step 1: The longest diameter (width) of the parabola up to its rim was measured to be 252m

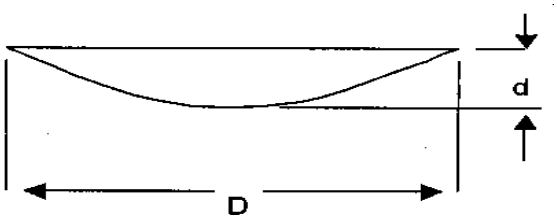

Fig.3.3: Schematic diagram for determining the focal point

Step 2: Divide the diameter by two i.e. to determine the radius y, we have y = 126m

Step 3: Square the radius i.e. $y^2 = (126)^2 = 15,876$

Step 3: Measure the depth of the parabola (d) from its vertex .i.e. (42m) and multiply it by 4. i.e. = 4d (4*42) =168m

Step 4: substituting into equation 23 gives the focal point i.e. $\frac{15,876}{168} = 94.5m$

a) Construction Procedure

The main components of a Parabolic Dish Solar Concentrator (PDSC) are: The Parabolic dish, the Support and the Receiver,

b) Solar Dish Concentrator Design

The parabolic dish concentrator has six segmental parts for easier transportation to be assembled using bolts and nuts to tight them together. Each part would be made up of light steel material; the upper surface would be coated with an aluminium foil reflector sheet or thin foil reflective aluminum sheet in order to have a high efficiency of reflecting sun energy onto the receiver. After finishing the coating, the segmented part of the parabolic dish would be connected together to be fixed into the parabolic dish shape. The whole system would be mounted on a rigid sand- rooted support. Alternatively, Stainless steel sheet would be use as reflecting surface. The collector would be design using simple parabolic equations. From geometrical relations of the parabolic section, equations (1), the cross section for the parabolic concentrator would be trace as shown by figures. 3.1. The sheet would be curve to form a parabolic dish module of reasonable length and aperture width with effective aperture area. The simple parabolic equation as stated by [28] in line with equation (8) above

c) The Receiver/Heat exchanger Design

The receiver is the part of the system that converts solar radiation to heat energy in a working fluid. The receiver consists of an absorber, heat exchanger and possibly heat storage.

Therefore, in this research work the heat exchanger would be inform of an improvise receiver in the form of a kettle-like form with an internal coil made from a good conducting material e.g. copper. It shall be used in conducting the steam generation test.

The absorber would be in form of impinging surface for reflected solar radiation to strike. Radiation would be absorbed into the absorber material as heat. The heat exchanger transfers the energy to a working fluid that carries the energy out of the receiver. Equation (9) shows an energy balance for a receiver.

$$Q_{out} = Q_{abs} - Q_{loss} \quad (9)$$

Where

Q_{out} = useful energy transfer to working fluid

Q_{abs} = Energy received by the absorber

Q_{loss}= Receiver energy lost

The receiver design for this research work would act as an absorber, boiler, and heat storage unit. A cavity type absorber (receiver type) is selected due to its high absorption efficiency and low heat loss. Surrounding the absorber inside the receiver would contain 10 kg of sodium nitrate. This salt will acts as a heat transfer and storage media and 0.6 cm diameter copper tubing would be coiled through it. The working fluid is pumped through the tubing where heat is transferred to the fluid.

d) Collector supporting structure (Adjustable mechanism)

For collectors' stability and accuracy, a rigid supporting structure would be designed, to structure the frame that would be supported for the rotation axis of the parabolic reflecting surface. It's used for the rotation of the horizontal axis for daily tracking of the sun. For test purpose and cost reduction, the unit would be designed for easy manual tracking system as shown Fig 3.4

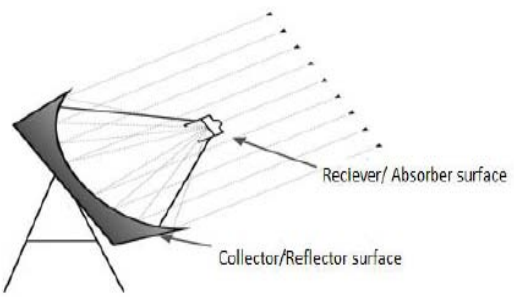

Fig. 3.4: Adjustable Tracking System

e) Evaluation of Thermal Efficiency of the Collectors (η_{th})

The thermal efficiency of the collector (dish) (η_{th}) can be defined as the ratio of the useful energy delivered Q_u to the energy incident on the concentrator aperture Q_S [29].

$$\eta_{th} = Qu/Qs \quad (10)$$

Assuming that the concentrator has an aperture area A_{ap} and receives solar radiation at the rate Q_S from the sun, the net solar heat transfer Qs is proportional to A_{ap} and the direct normal insulation per unit of collector area I_b is given[30&31];

$$Q_S = I_b A_{ap} \quad (11)$$

Under steady state condition, the useful heat delivered by a solar collector system is equal to the energy absorbed by the heat transfer fluid Q_a, which is determined by the radiant solar energy falling on the absorber minus the direct or indirect heat losses Q_l from the absorber to the surrounding .i.e.

$$Q_u = Q_a - Q_l \quad (12)$$

f) Determination of Optical Efficiency of the Collector (Ho)

The optical efficiency depends on the optical properties of the materials involved, the geometry of the collector and the various imperfections arising from the construction of the collector. The equation to be used in deducing the optical efficiency given by [32&33] is:

$$\eta_o = \lambda\rho\tau\alpha\gamma\cos(\theta) \quad (13)$$

where λ is the un-shaded factor, ρ is the dish reflectance, τα is the transmittance-absorptance product, γ is the intercept factor of the absorber i.e. obstacle e.g, dust, birds e.t.c. θ is the angle of incidence.

The total heat lost by the absorber can be through the three basic heat transfers i.e. conductive heat loss (Q_{lk}), convection heat loss (Q_{lc}) and radiation heat loss (Q_{lr}) therefore;

$$Q_l = Q_{lk} + Q_{lc} \quad Q_{lr}$$

g) Evaluation of Instantaneous Efficiency of the Collector

Instantaneous thermal efficiency of a solar concentrator may be calculated from the energy balance on the absorber. If the useful thermal energy delivered by a concentrator is given by [34&35]

$$q_u = \eta_o I_b A_{ap} - u_L (T_{abs} - T_a) A_{abs} \quad (14)$$

then, the instantaneous thermal efficiency may be written as:

$$\eta = \frac{q_u}{I_b A_{ap}} = \eta_o - \frac{U_L (T_{abs} - T_a)}{I_b C} \quad (15)$$

where A_{ap} is the aperture area, q_u is useful thermal energy delivered, I_b is the beam radiation, T_{abs} is the absorber temperature, T_a is the ambient temperature, C is the concentrator ratio respectively η_0, is optical efficiency and U_L is then overall heat loss coefficient.

At higher operating temperatures, the radiation loss term dominates the convection losses and the energy balance equations become [36]

$$q_u = \eta_o I_b A_{ap} - U_L (T^4 - T_a^4) A_{abs} \quad (16)$$

where T is the temperature of heat transfer fluid entering/leaving the collector, while the U_L takes into account the accompanying convection and conduction losses, therefore, the instantaneous thermal efficiency η is given as [37&38]:

$$\eta = \eta_o - \frac{U_L (T_{abs}^4 - T_a^4)}{I_b C} \quad (17)$$

Since the absorber surface temperature is difficult to determine, it is convenient to express the efficiency in terms of the inlet fluid temperature by means of heat removal factor FR defined by Ibrahim, (2012), as:

$$\eta = F_R \{\eta_o - \frac{U_L (T_L - T_a)}{I_b C}\} \quad (18)$$

where T_L is the overall temperature of the system.

The optical efficiency, heat loss coefficient and heat removal factor are dependent on the design parameters while the solar flux, inlet fluid temperature and the ambient temperature define the operating conditions. Therefore, the instantaneous thermal efficiency is dependent on two types of quantities, namely the concentrator design parameters and the parameters characterizing the operating conditions as shown in the equation.

h) Evaluation of Efficiency of the Receiver (Absorber)

Cooking occurs faster or at higher temperature, therefore, the heat lost is simply described by [39&40] as;

$$Q_{loss} = \frac{V \Delta T}{R} \quad (19)$$

where, is the difference between the initial and final temperature T Δ

R is the thermal resistance of the receiver,

V is the volume of the receiver, thus;

$$Q_{loss} = \mu A \Delta T \quad (20)$$

Note that, the thicker the walls of the receiver, the greater the value of the R, since

$$\mu = \frac{conductivity}{thickness} \text{ i.e. the conductance } (W/m^2) \quad (21)$$

Therefore, the solar energy reflected upon the receiver per unit area can be calculated [41];

$$\text{Energy} = IVT \quad (22)$$

Where I is the Solar Insolation and V is the volume of the receiver and T is the time taken.

Therefore, the efficiency of the receiver can be deduced from specific heat capacity i.e.

$IVT = MC\theta$ (heat exchange) equations as:

$$\eta = \frac{E_o}{E_i} = \frac{Q}{VIT} = \frac{M_{ca}C_{ca} + M_w \times C_w(T_{wf} - T_{wi}}{VIT} \quad (23)$$

i) Determination of Water Boiling Test (Wbt)

The PDSC performance can be analyzed using water boiling test method recommended by the Provisional International Standard for Comparison [42] The methods include:

Water Boiling Test (WBT): it is a laboratory test that allows the researcher to be able to know the magnitude of heat utilized, thus:

$$H = \frac{\textit{Total heat utilized}}{\textit{Heat net supplied}} \times 100 \quad (24)$$

$$H = \frac{M_p C_p \times M_w C_w (T_i - T_o) M_v L_v}{A_c Q_c t} \times 100 \quad (25)$$

where,
M_W is the mass of the water,
M_P is the mass of the pot,
T_f and To is the change in temperature,
M_V is the mass of water evaporated,
L_V latent heat of vaporization of water,
C_W is specific heat capacity of water;
C_P is specific heat capacity of pot,
A is the area of the collector,
Q is the radiation intensity,
T is the duration.

j) Evaluation of Steam Generation Test

The performance of solar steam generating system can be evaluated by installing the necessary instrument to measure the required process parameters [43&44] suggested that, the collector field efficiency η field can be computed using the equation below;

$$\eta_{field} = \frac{mC_p(T_o - T_i)}{IA_c} \quad (26)$$

Where,
m is the collector fluid flow rate (kg/s),
C_p is the collector fluid specific heat capacity (kJ/kg/^{0}C),
T_o-T_i is the outlet and the inlet temperature (^{0}C),
I is the direct solar insulation,
Ac is the effective area of collector field (m^2)

k) Experimental procedure or Test

The components; the parabolic dish, receiver/heat exchanger and the support would be coupled together to form the Parabolic Dish Solar Concentrator System (PDSC). the performance evaluation of the PDSC system, experiments would be conducted for a given period of time on the performance of the receiver for steam generation and as well as for thermal applications (cooking application).

The following parameters would be taken into account for the performance evaluation. First the availability of solar irradiation: this is measured using pyranometer instrument. Also ambient condition information like ambient temperature, ambient pressure/relative humidity, wind speed and its direction are essential for the performance calculation of PDSC. Table 4.1 indicates the various parameters measured using the different relevant instruments. Below is a table showing the list of the apparatus used in recording the measurements taken during the experiment.

S/N	PARAMETER MEASURED	INSTRUMENT USED
01	Solar insolation	Pyranometer
02	Wind speed	Anemometer
03	Relative density	Maximum and minimum
04	Ambient & content temp	Digital Data logger
05	Weight of water and other food substance	Electronic Weighing balance

VIII. Conclusions and Suggestion

To analyse the potential of the parabolic solar concentrating system, the following experimental test facilities would be developed, as schematically presented in Fig.4. Therefore, through these testing facilities, experimental tests would be carried out in order to evaluate the response and the efficiency of the system.

IX. Expected Results and Analysis

The main expected results from this research work is to come up with improved and efficient system that can produce a higher temperature that is required for power steam generation use for domestic consumption.

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5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.

- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

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Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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