# Chapter 6 Artisanal production of ink, recycling the waste applied in the softening process of Amate paper

# Capítulo 6 Elaboración artesanal de tinta, reciclando los desechos aplicados en el proceso de ablandamiento del papel Amate

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**Abstract**

The elaboration of amate paper is a totally handmade process that is carried out in the indigenous communities that inhabit the Sierra Norte of the State of Puebla, within the production process a liquid desire (ink) is obtained, which is discarded in the sewers. and drains contributing to the contamination of rivers and soils of the Otomi indigenous community of San Pablito Pahuatlan. The present work seeks to take advantage of this residue by producing an ink that will be used in the first instance as: a) Input in pens, b) Input in ink injectors for printers, c) Screen printing: Preparation of party cards, thus ending the contamination of stagnant and fluvial rivers, in addition to storing the ink for the decorative painting of amate paper, benefiting the community by not generating excessive expenses in obtaining the same ink, and the environment by not disposing of the residue and providing it with second use. In this way, it seeks to train trained and qualified human capital with the capacity to innovate, adapt and develop new craft methodologies that allow the solution of existing problems in the indigenous community that is dedicated to producing amate paper.

**Ink, Amate Paper, Indigenous Community**

**Resumen**

La elaboración del papel amate es un proceso totalmente artesanal que se lleva a cabo en las comunidades indígenas que habitan la Sierra Norte del Estado de Puebla, dentro del proceso de producción se obtiene un desecho líquido (tinta), el cual es desechado en las cloacas y desagües contribuyendo a la contaminación de ríos y suelos de la comunidad indígena otomí de San Pablito Pahuatlan. El presente trabajo busca aprovechar este residuo produciendo una tinta que será utilizada en primera instancia como: a) Insumo en bolígrafos, b) Insumo en inyectores de tinta para impresoras, c) Serigrafía: Elaboración de tarjetas de fiesta., reduciendo así notablemente la contaminación de ríos y estancamientos fluviales, además de almacenar la tinta para la pintura decorativa de papel amate, beneficiando a la comunidad al no generar gastos innecesarios en la obtención de la misma tinta, y al medio ambiente al no desechar el residuo y brindarle un segundo uso. De esta manera, busca formar capital humano capacitado y calificado con capacidad de innovar, adaptar y desarrollar nuevas metodologías artesanales que permitan la solución de problemas existentes en la comunidad indígena que se dedica a producir papel amate.

**Tinta, Papel Amate, Comunidad Indígena.**

## 1. Introduction

The jonote tree grows in many places in Mexico and other countries. Jonote (Trema micrantha) has straight trunks and a broad crown with sufficient foliage to provide good shade for coffee plants. Its leaves are elongated, small and soft, its flowers are white, small and come out in groups. The fruits are very abundant, they appear as very small drupes that turn red when ripe and the birds like them as food. In the Sierra Norte de Puebla, the bark of these trees is used to make a very popular craft: Amate paper produced by ÑaÑhu-Otomi artisans from the town of San Pablito belonging to the municipality of Pahuatlán. In this activity of obtaining jonote bark, residents of towns belonging to the municipalities of Pahuatlán, Tlacuilotepec and Tlaxco, among others, participate.

The amate paper process is 100% handmade, its production process begins when the bark of the jonote tree is selected, it is boiled, rinsed, dried, worked and decorated with natural dyes. The production of amate paper, obtained from the bark of white and red jonotes, contaminates the environment of the San Pablito de Pahuatlán community, whose main economic activity is focused on the sale of this craft. And it is that, according to the study "Sustainability of the amate paper system in San Pablito, Pahuatlán, Puebla", published this year by Colpos Campus Montecillo, the manufacturing process does not meet some environmental protection requirements.

Amate paper is a type of paper of pre-Hispanic origin from Mesoamerica, it is made in an artisanal way, crushing the bark of the jonote, which is cooked in water with ash, lime and jonote bark, once this bark has been softened on liquid is discarded and dumped into the rivers of the community, causing them to dry up in addition to the loss of marine species found in these rivers, due to the chemical compounds that are being used in the softening process, this being a problem serious in the future for this community and its surroundings.

Faced with this problem, they have considered obtaining an ink that will be used in three main products: a) pens for the educational/school/professional area, b) Printers for the educational/school/professional area, c) Serigraphy (Invitations etc.), reducing the contamination of the rivers, the generation of the ink occurs through the development of two phases which are: Phase 1) Decrease in density by increasing temperature, Phase 2) Decrease in density using filtration, once it is The two mentioned phases were carried out, we proceed to select the phase that yields a density similar to that of commercial inks, for which the corresponding calculations are made to determine the density indices of each of the phases, to finish tests are carried out of writing that validate the quality of the ink made from the waste resulting from the process of making amate paper in the community of San Pablito Pahuatlan.

## 2. Objectives

### 2.1. General objective

Prepare an organic ink from the waste obtained from the processing of amate paper, to reduce the levels of contamination of rivers and fluvial stagnations in indigenous communities that speak the Otomi dialect, through an artisanal production process, to provide the community with productive systems that contribute to environmental improvement and the generation of new modalities of economic subsistence for the communal inhabitants.

### 2.2. Specific objectives

a) Learn about the amate paper production process.

b) Determine the existence of waste from the production of amate paper.

c) Ink production process.

d) ink validation

## 3. Justification

In Mexico and the world, in recent years, transformation processes have caused a growing generation of waste. Which, due to the lack of control and recycling places, are dumped in common areas, causing the contamination of soils, rivers and common spaces, where human beings cohabit. This problem represents a source of improvement, where various public organizations and Municipal, state, national and international private companies seek to propose and apply effective solutions to reduce the effect of this waste and generate awareness among the individuals who are participants. Taking into account the growing need to generate effective solutions, this work is carried out, which focuses on the elaboration of an ink, using the waste that results from the softening of amate paper, considered an artisan process that is carried out in the community. of San Pablito Pahuatlán.

San Pablito Pahuatlan is an Otomi community located in the Sierra Norte of the State of Puebla, with coordinates of longitude ( dec ): -98.161944 and Latitude ( dec ): 20.302222, this town is located at a median altitude of 1180 meters above sea level. sea. The main economic activity of this indigenous community is the manufacture of amate paper, in the experience of Fuentes (2019) the production of amate paper dates back to the 300s AD. C by the Mayans, in the Yucatan Peninsula and later in the years 1100 and 1300 the Aztecs used it for the placement of offerings to the deities of the culture, now in the Otomi culture the artisanal production was initially destined according to of the following two activities: 1) Making ritual objects, 2) Representing divinities through figures. Specifically, in this community the production of amate paper is valued from two perspectives, these are:

1. Market value as a craft product.

2. Sacred value

According to these two evaluations, the production of amate paper in this community is the main economic activity, originating high levels of production that bring with it higher rates of waste, taking into account that the production of amate paper uses a large amount of water, approximately 5 liters per kilo of jonote bark. This liquid waste, which contains chemicals and particles of organic material, is being dumped into rivers, causing a significant source of pollution.

As the community of San Pablito Pahuatlan is notorious, it does not profitably take advantage of the generation of waste resulting from the manufacture of amate paper, for which in the present work a viable solution is proposed through the production of quality ink from this waste, with the sustainability objective of reducing the amount of polluted water that is discharged into stormwater bodies, supporting the preservation of water quality and protecting aquatic ecosystems. In addition to contributing to a circular economy in the town, with the creation of a new product that results from the sustainable use of the waste generated, and the implementation of an artisan production process at low costs and easy to understand.

## 4. Theoretical framework

In order to understand the objective of this research, the theoretical foundations that support the artisan elaboration of organic ink using the waste applied in the softening process of Amate paper are described:

### 4.1. Community of San Pablito Pahuatlan

Considered an indigenous community because 99.70% belong to this cultural regime, while 86.50% speak the Otomi dialect (PueblosAmerica.com, 2023), for this reason it is named by the inhabitants as "Nvite", whose meaning in this same dialect is "At the foot of the hill", this community maintains a deep synergy between pre-Hispanic beliefs and Catholic worship, among the main activities that contribute to economic development are agriculture and the transformation of the bark of the jonote tree on amate paper (Díaz, 1988).

Regarding agriculture, the production of crops such as: sugar cane, peanuts, corn and coffee is observed, but the main activity is the production of amate paper, which is extracted from the jonote tree through an artisanal process inherited from the first inhabitants of the area up to the present.

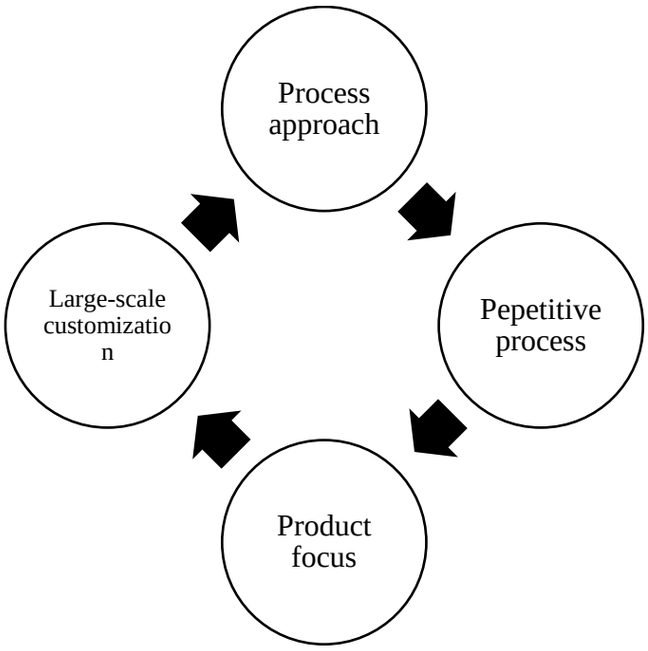
### 4.2. Artisan processes

A production system based on artisanal processes, according to the experience of Bustos (2009) consists of a methodology oriented towards obtaining products/services through manual techniques, with a minimum intervention of machines or tools, this type of process uses materials local raw materials and the production processes are transmitted from generation to generation, the characteristics that identify this process are: a) The artisan/producer intervenes in all stages of the process, b) Techniques based on ancestral knowledge are used, c) The processes imply longer production time, d) Lower amounts of investment are required for the generation of the product, 3) Sophisticated technology is not used, f) Manufacturing takes place in the producer's house or in small workshops.

#### 4.2.1. Types or approaches of craft processes

Heizer and Render (2001) indicate that, according to the continuity of the process, these are classified into (Figure 1 Approaches to artisanal processes):

**Figure 1** Approaches to artisanal processes




*Source of Consultation: Own Elaboration*

Bustos (2009), considers the general characteristics of the approaches according to the following description:

1. Process approach: This type of approach is identified as a production process that manufactures products in small quantities, but with different varieties. It is carried out mainly in workshops and its main characteristic is flexibility; it tends to be an intermittent methodology.

2. Repetitive process: This process is oriented to mass production, the characteristic that identifies it is the manufacture of large volumes of standardized products through a clear division of operations and little flexibility to change.

3. Product approach: This modality is known as a continuous process, dedicated to producing a large quantity of physical goods, but of a controlled variety.

4. Large-scale customization: Approach characterized by presenting high flexibility to new production processes, responsible for producing a wide variety of products, and in larger volumes.

According to the characteristics of the approaches, it can be deduced that the process applied for the elaboration of the ink is the process approach.

### 4.3. Matte paper (Processing)

To obtain the raw material, the artisans take the bark of the jonote tree, to process it, the following steps are carried out:

a) Boiling process: The bark of the jonote tree is placed in a container with water, lime is deposited on it, and it is boiled.

b) Cooling process: The bark of the jonote tree is allowed to cool at room temperature in a time interval of 12-48 hours.

c) Resting process: Once the bark of the tree has cooled, it is left to rest for a period of 2-3 days.

d) Compaction process: The crust is spread out on a clean surface, placed in thin layers (5-8 mm), and proceeded to flatten with the use of rocks of different sizes (volcanic rocks), this compaction process allows the formation of plates of different dimensions (according to the craft that was manufactured) (Fuentes and Jiménez, 2019).

e) Compaction process: The crust is spread out on a clean surface, placed in thin layers (5-8 mm), and proceeded to flatten with the use of rocks of different sizes (volcanic rocks), this compaction process allows the formation of plates of different dimensions (according to the craft that was manufactured) (Fuentes and Jiménez, 2019).

f) Drying process: The previously formed plates are placed under the sun, so that they dry completely, distributed sequentially.

g) Separation process: Each one of the layers is detached, in thin layers and sent to the transformation process, which follows different treatment methodologies, according to the craft that will be manufactured.

The manufacture of amate paper is considered an artistic technique from Mesoamerican cultures, it is a resource that symbolically represents the spirituality of indigenous communities (Pérez, 2021), and for the municipality of San Pablito Pahuatlan it is the cultural heritage that is inherited from generation to generation and represents a source of employment to support the families that produce it.

### 4.3.1 jonote tree

As previously mentioned, the main material for amate paper is the jonote tree (Trema micrantha ) (Figure 2. Jonote tree), which is considered a tree for artisanal and medicinal use, used as weaving fiber, identified by growing in mostly within coffee plantations, this tree is characterized by:

a) It has a height of 12-14 meters.
b) The foliage shows a dark brown hue.
c) The foliage is composed of alternate ovate leaves up to 16 cm long and 14 cm wide, pointed with regular teeth.
d) Large inflorescence, measuring up to 15 cm long and 14 cm wide.
e) Circular dry fruit 5 mm long and 4 mm wide, and seeds with branched hairs on their surface.

**Figure 2** Jonote tree

*Source of Consultation: Own Elaboration*

### 4.4. Waste

López (2003), indicates that the production of amate paper brings with it the generation of waste, due to the disposal of wastewater and the use of different inputs that are applied to reduce the resistance of the paper, it is convenient to mention that the diversity of The waste comes from the different amate paper production processes, such is the case of the boiling process, where the waste resulting from the cooking of the fibers has effects on the quality of the soil. These wastes, mostly made up of large amounts of fibers, firewood, ashes, water and dyes, are thrown freely into pluvial stagnations, causing a high rate of environmental impact.

#### 4.4.1. Components of the main waste

The waste that is generated by the production of amate paper is the result of the conjunction of the following elements:

1. Caustic soda: This polluting element, made up of sodium hydroxide, is incorporated into the process to soften the bark of the jonote tree, in less time, seeking to reduce plate preparation times.

2. Chlorine: This chemical element is incorporated into the bleaching process, to obtain layers with greater bleaching, to be used in crafts for export.

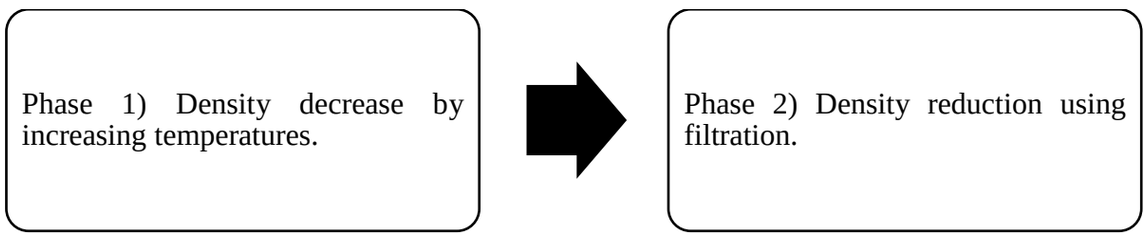
3. Lime: Calcium oxide is placed in the boiling preparation to soften the bark of the jonote tree, it is suggested by artisans that lime works as a softener, speeding up the softening process.

4. Dyes: Chemical elements that are used as a means of decoration for artistic design, are part of the final process, to provide aesthetics and a good presentation to the manufactured crafts.

## 5. Methodology to develop

The present work is developed through the intervention of the following two phases (Figure 3 Phases of intervention), these phases were carried out to select the phase that contributes significantly to the generation of the ink, which must comply with the density indices that identify commercial inks.

**Figure 3** Phases of intervention




*Source of Consultation: Own Elaboration*

#### Phase 1) Density decrease by temperature increase

Bearing in mind that density is known as the relationship between the weight of a substance and the volume it occupies, we proceed to decrease the weight of the sample by increasing the temperature (Figure 4 Density decrease by temperature increase), considering the assumption that the density will decrease.

**Figure 4** Density decrease by temperature increase

*Source of Consultation: Own Elaboration*

The aforementioned experiment is carried out for three replicates which are described below (Table 1 Replicate 1, Table 2 Replicate 2, Table 3 Replicate 3):

**Table 1** Replicate 1

| Operation | Activity description |
|---|---|
| 1 | Measure 100 milliliters of waste from the softening of the amate paper in a test tube, this measurement is called test 1. |
| 2 | Place test 1 in direct exposure to fire, with a maximum temperature range of 80° Celsius. |
| 3 | Weigh the material resulting from test 1. |

*Source of Consultation: Own Elaboration*

**Table 2** Replicate 2

| Operation | Description of activity |
|---|---|
| 1 | Measure 100 milliliters of waste from the softening of the amate paper in a test tube, this measurement is called test 2. |
| 2 | Place test 1 in direct exposure to fire, with a maximum temperature range of 100° Celsius. |
| 3 | Weigh the material resulting from test 2. |

*Source of Consultation: Own Elaboration*

**Table 3** Replicate 3

| Operation | Activity Description |
|---|---|
| 1 | Measure 100 milliliters of waste from the softening of the amate paper in a test tube, this measurement is called test 3. |
| 2 | Place test 1 in direct exposure to fire, with a maximum temperature range of 200° Celsius. |
| 3 | Weigh the material resulting from test 3. |

*Source of Consultation: Own Elaboration*

When carrying out the previous replicas, we noticed that the loss of material is considerable, recording the following values for each replica (Table 4 Record of material decrease in replicas Phase 1):

**Table 4** Record of material decrease in replicas Phase 1

| Replica | Temperature (ºC) | Volume (ml) | % Decreasing | Weight (g) | % Decreasing |
|---|---|---|---|---|---|
| 0 | Room temperature | 100 | ------ | 523 | ------ |
| 1 | 80 | 90 | 10% | 451 | 13.76% |
| 2 | 100 | 85 | 15% | 446 | 14.72% |
| 3 | 200 | 70 | 30% | 420 | 19.63% |
| Average | | | | | |

*Source of Consultation: Own Elaboration*

As is notorious, this method causes a minimum decrease in volume of 10% (Replica 1) and weight of 13.76% (Replica 1) with respect to the initial sample, for which the next phase is carried out, seeking to preserve a greater quantity of ink with the ideal characteristics for its usability.

**Phase 2) Density reduction using filtration**

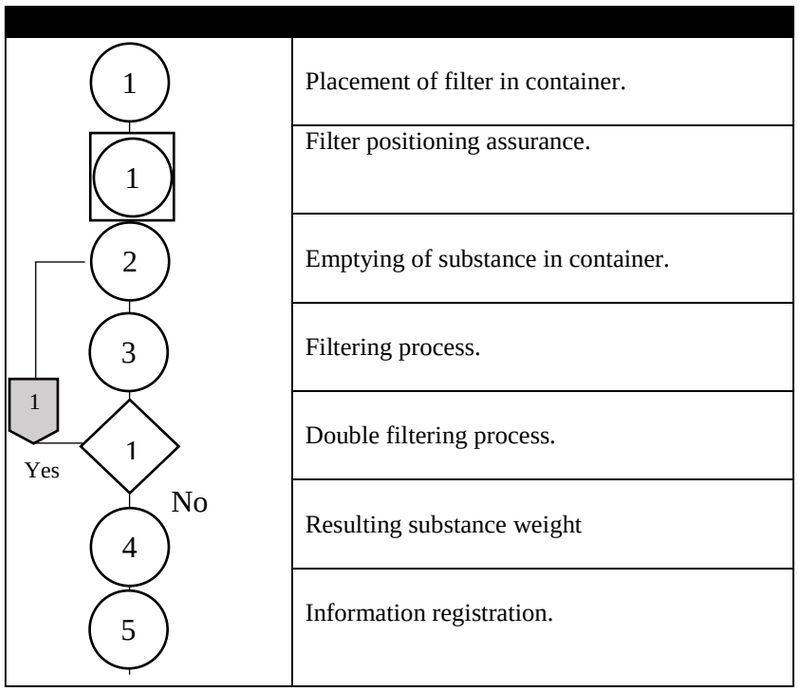
Filtration is a process that is responsible for separating the solid particles present in a liquid through a porous material called filter paper. This process (Figure 5 Density reduction using filtration) allowed within the present work to obtain ink free of impurities or external agents that contaminate the safety of the product.

**Figure 5** Density reduction using filtration

Source of Consultation: Own Elaboration

Taking into account the aforementioned, a sequence of 3 replicas was carried out through the following operational process (Figure 6 Process diagram for carrying out phase 2 replicas):

**Figure 6** Process diagram for carrying out phase 2 replicas




*Source of Consultation: Own Elaboration*

The general observations of each replicate are explained below:

Replication 1) For this first replica, the type of filter used is the one commercially known as Superabsorbent Polymer (SAP), which is used for its excellent capacity to retain moisture, the filtering process is carried out correctly following the indicated operational sequence. , but at the end of the weighing process, the loss of liquid substance was observed by 40% (Table 5 Record of decremental material from replicas Phase 2).

Replication 2) For this second replica, filter paper was used, observing a high degree of effectiveness when carrying out the filtering process only once, at the end of the weighing process (Figure 7 Phase 2 weighing process) a loss of material was recorded of 6 %.

**Figure 7** Phase 2 weighing process

*Source of Consultation: Own Elaboration*

Replication 3) This third replica was carried out by means of a double filtration, obtaining a 12% decrease in the liquid substance (Table 5 Record of decremental material from replicas Phase 2).

**Table 5** Record of decremental material from replicas Phase 2

| Filtration | Volume (ml) | % Decreasing | Weight (g) | % Decreasing |
|---|---|---|---|---|
| **0** | **100** | ------ | **523** | ------ |
| 1 | 60 | 40% | 300 | 42.63% |
| 2 | 94 | 6% | 456 | 12.87% |
| 3 | 88 | 12% | 354 | 32.31% |
| Average | | 19.33% | Average | 29.27% |

*Source of Consultation: Own Elaboration*

The results obtained indicate a minimum volume decrease of 6% for replicate 2, while the minimum decrease in weight is 12.87% for replicate 2.

## 6. Results

The quantitative results observed for each of the samples are subjected to mathematical calculations to determine the density index, using the formula Density=mass/volume, for Phase 1 the results are shown below (Table 6 Results of Phase 1) Decrease in density by increasing temperature):

### Result 1

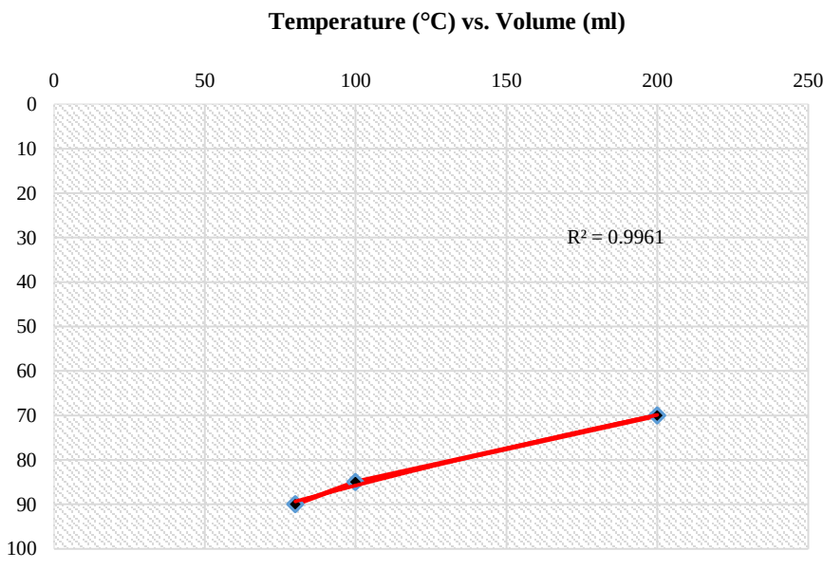
**Table 6** Results of Phase 1) Decrease in density by increasing temperature

| Replica | Temperature (º C) | Volume (ml) | Weight (g) | calculations d=mass/volume | Density (g/ml) | % Increase |
|---|---|---|---|---|---|---|
| 1 | 80 | 90 | 451 | 451/90 | 5.01g/ml | 0% |
| 2 | 100 | 85 | 446 | 446/85 | 5.24g/ml | 4.59% |
| 3 | 200 | 70 | 420 | 420/70 | 6.0g/ ml | 14.50% |

*Source of Consultation: Own Elaboration*

Once the density has been calculated, a statistical analysis is carried out to verify which of the three replicas for this phase is the one that would contribute to a greater generation of ink with optimal density characteristics, which meet the writing requirements of the main consumers. In the first instance, the existing correlation between the supplied temperature (80°, 100°, 200°) with the resulting volume is analyzed (Graph 1 Correlation Temperature (°C) vs. Volume (ml)).

**Graph 1** Correlation Temperature (°C) vs. Volume (ml)

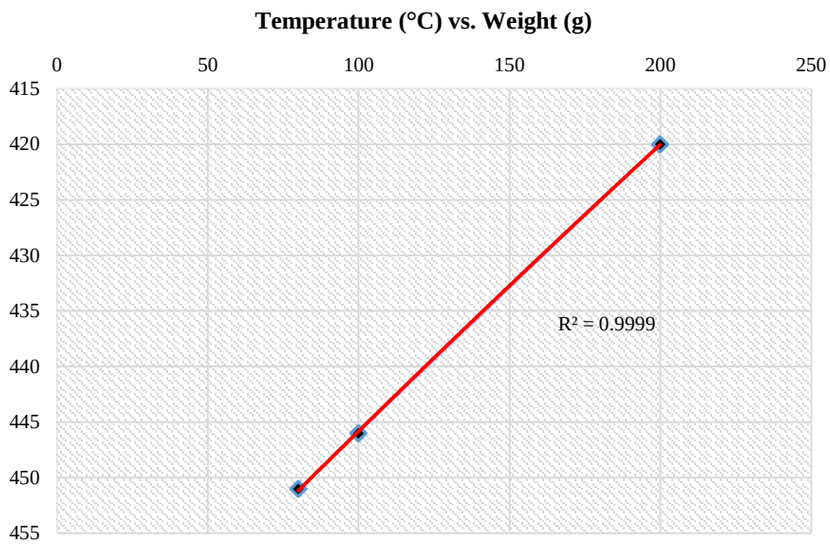



*Source of Consultation: Own Elaboration*

The existing correlation between the temperature and the volume indicates that the higher the temperature, the lower the resulting ink volume will be, with an R $^{2}$ of 0.9961, confirming that this type of experiment generates considerable losses for the final product.

Continuing with the analysis, we proceed to carry out the study that evaluates the action of temperature with the total weight (g) recorded at the end of the experiment (Graph 2 Correlation Temperature (°C) vs. Weight (g)).

**Graph 2** Correlation Temperature (°C) vs. Weight (g)

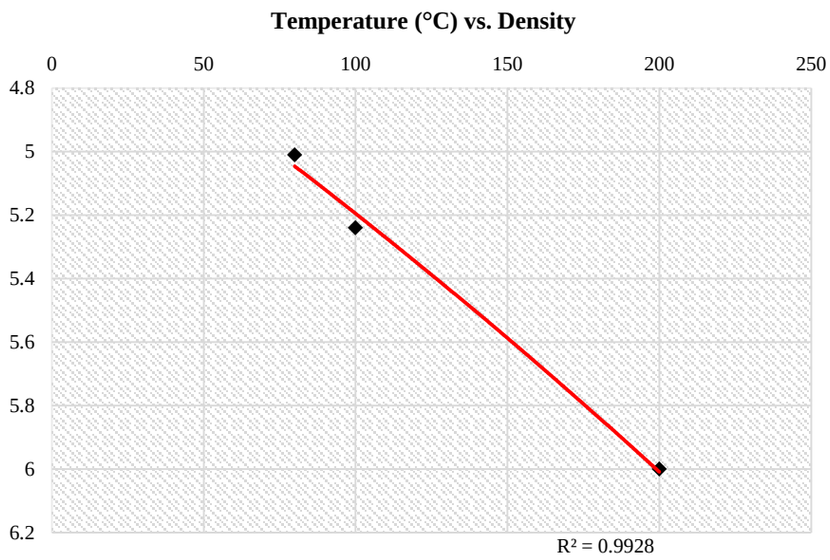



*Source of Consultation: Own Elaboration*

The existing correlation between the temperature and the weight (g) indicates that the higher the temperature, the lower the total weight of the resulting ink will be, with an R 2 of 0.9999, $^{\text{confirming}}$ that this type of experiment generates considerable losses for the final product.

To finish this correlational analysis, the action of the heat input to the samples with respect to the resulting density is studied (Graph 3 Correlation Temperature (°C) vs. Density).

**Graph 3** Correlation Temperature (°C) vs. Density




*Source of Consultation: Own Elaboration*

As we can see, the correlation indicates that the higher the temperature, the greater the density shown by the ink. However, in general and taking into account the statistical analysis carried out, it is concluded for this phase that:

1. The process of supplying heat causes volume loss of the ink.
2. The process of supplying heat brings with it quantifiable losses in the weight of the ink.
3. The process of supplying heat brings about a gradual rate of increase in the density factor, causing the ink to become less fluid.

**Result 2**

The results of Phase 2) Density reduction using filtration, shown below (Table 7 Results of Phase 2) Density reduction using filtration:

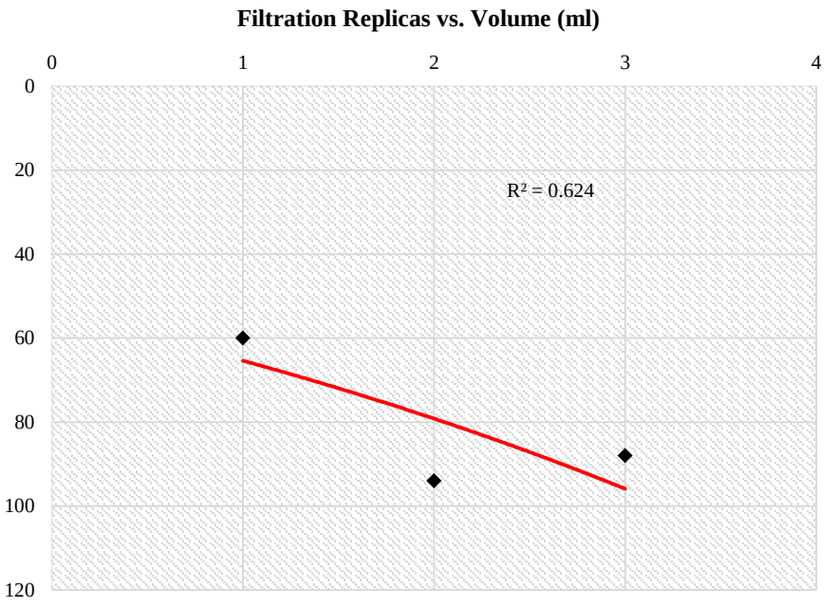
**Table 7** Results of Phase 2) Density reduction using filtration

| Filtration | Volume (ml) | Weight (g) | Calculations Density=mass/volume | Density (g/ml) |
|---|---|---|---|---|
| 1 | 60 | 300 | 300/60 | 5.0g/ml |
| 2 | 94 | 456 | 456/94 | 4.85g/ml |
| 3 | 88 | 354 | 354/93 | 3.80g/ml |

*Source of Consultation: Own Elaboration*

Once the density has been calculated using the filtration method, a statistical analysis is carried out to verify which of the three replicates for this phase is the one that would contribute to a greater generation of ink with optimal density characteristics, which meet the writing requirements of primary consumers. In the first instance, the existing correlation between the filtration replicas with the resulting volume is analyzed (Graph 4 Filtration Replicas vs. Volume (ml)).

**Graph 4** Filtration Replicas vs. Volume (ml)

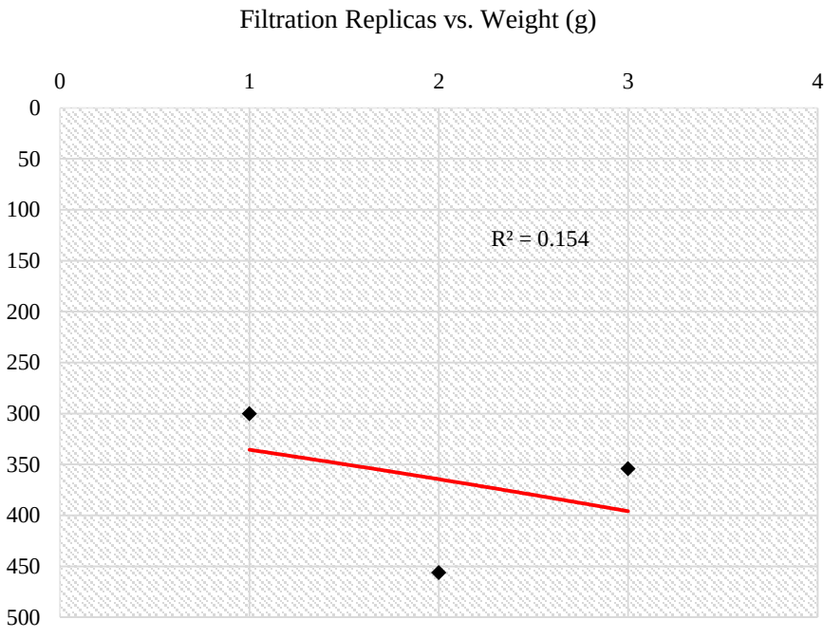



*Source of Consultation: Own Elaboration*

The existing correlation between the s replicates and the volume indicates that they are independent samples, confirming that each of the replicates used a similar method, but different filters, this is confirmed with $R^2 = 0.624$, for this reason the volume is affected independently. for each replica

Continuing with the analysis, we proceed to carry out the study that evaluates the action of each replica with the total weight (g) recorded at the end of the experiment (Graph 5 Filtration Replicas vs. Weight (g)).

**Graph 5** Filtration Replicas vs. Weight (g)

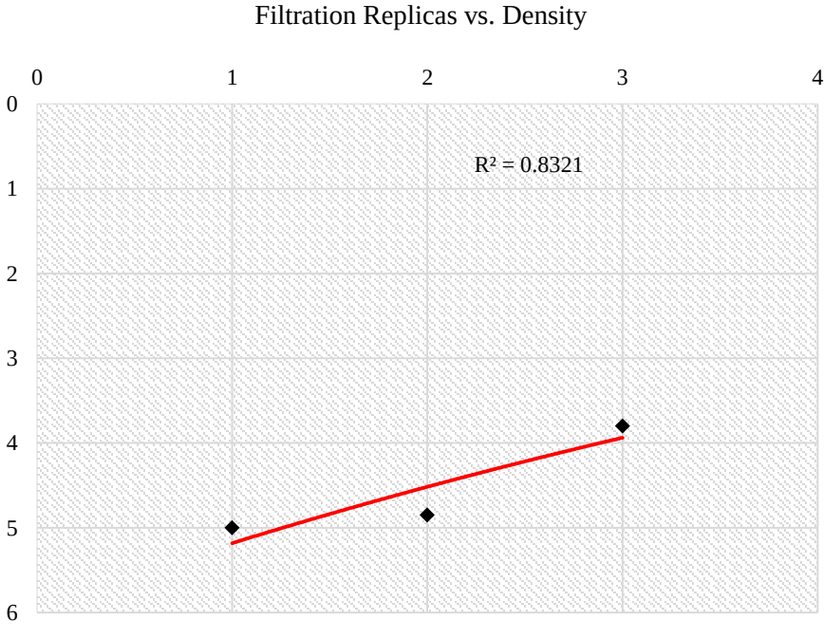



*Source of Consultation: Own Elaboration*

The existing correlation between the replicates and the weight indicates that they are independent samples, confirming that each of the replicates used a similar method, but different filters, this is confirmed with R 2 = 0.154, for this reason the weight is affected independently for each replica.

To finish this correlational analysis, the action of the filtering process on the samples is studied with respect to the resulting density (Graph 6 Filtration Replicas vs. Density).

**Graph 6** Filtration Replicas vs. Density)




*Source of Consultation: Own Elaboration*

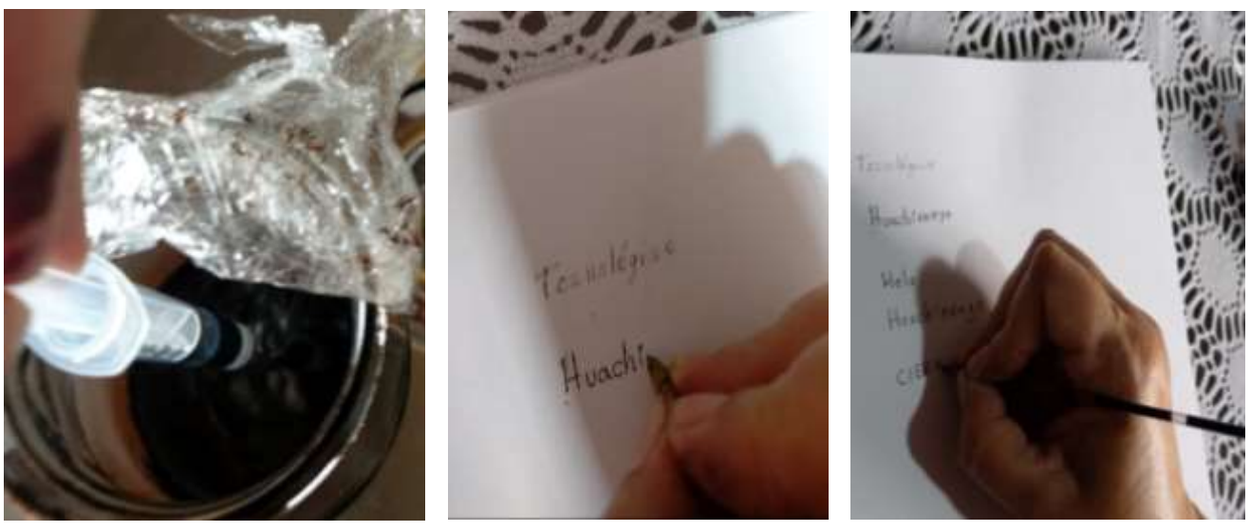
As we can see, the correlation indicates that the filtering process is independent for each replica, this in response to the fact that different filter materials were used, so the third test also underwent a double filtering process, for which the operating method is the same, evidencing an $R^2 = 0.8321$, but the means and decisions were made independently. The conclusion of the results obtained for this phase infers that with the process carried out a gradual decrease in the density index between each replica is reached, bringing with it ink with greater fluidity, in the same way it is notorious that there is less weight loss (12.87%). , volume (6%) (Table 5 Record of decremental material from replicas Phase 2).

**Result 3 Obtaining ink**

As stated in this paper, the use of ink is oriented to three main products: a) pens for the educational/school/professional area, b) Printers for the educational/school/professional area, c) Screen printing (Invitations etc. ), for which we proceed to select the ink that will be useful, specifically the density for this type of products in dark tones (black) is established in an interval that goes from 1.40-2.80 (Grupohdflexo, 2023), therefore which ink that most closely matches this density value is the one obtained by the filtering process with replica model 3, which shows a density index of 3.80, this replica is characterized by having a double filter, considering this action, the possibility of performing 1 to 2 more filters to obtain the indicated index should be assessed.

Once the appropriate replica has been detected, the usability tests are carried out, which consisted of filling a pen, adding 2 milliliters of the selected ink, later writing was captured on a sheet of paper, obtaining positive results (optimal visibility of the characters written with the ink produced), as well as a good fluidity of the liquid inside the polypropylene tube (Ink replacement) was also observed (Figure 8 Ink use tests).

**Figure 8** Ink use tests



*Source of Consultation: Own Elaboration*

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## 7. Conclusions

With the generation of this work, we direct our efforts to support the community of San Pablito located in the State of Puebla, which is characterized by developing the artisan productive activity oriented to the treatment of amate paper for the elaboration of handicrafts, considering during this process the detachment of organic waste that is thrown into the river flows, causing severe water pollution, for which the valuable utility of this waste has been detected for the creation of an ink, which is used in the educational, school and professional, either by the communal inhabitants or by external agents, taking into account this entrepreneurial idea, the generation of the ink was carried out, through two methodologies, the first artisan methodology is based on providing heat (Different temperatures) to the waste, in order to reduce the water content and promote an adequate density index, it is important to consider that this process was carried out through 3 replicates, whose results were submitted to a statistical analysis, indicating that by supplying heat, the following average losses: Volume 18.33%, weight 16.03%, in the same way a minimum density of 5.01 is obtained.

With respect to the second methodology, a filtering process is applied, making use of different materials such as filters, it should be noted that this method exposed an independent correlation with the following average losses: Volume 19.33%, weight 29.27%, in the same way a minimum density of 3.80 is obtained, as we can see in this second process the weight loss is greater, this in response to the fact that It is subjected to a second filtering, but it is also convenient to mention that this second filtering more assertively eliminates impurities and generates optimal fluidity of the ink. Prior to this analysis, it is concluded that the artisanal system that provides the greatest benefits is the filtration, with the replica 2 or replica 3 model, taking into account the level of density to be achieved (According to the product for which the ink is oriented).

Finally, it is concluded that an artisanal methodology has been created for the use of waste that currently causes pollution of rivers and fluvial slopes, this methodology is easily accessible and generates a sustainable product (Ink) that will bring with it: a) New sources of employment , for the producers of the exposed ink, b) Improvement and sanitation of rivers, and a continuous contribution of the community to the sustainable development of its inhabitants.

## 8. References

Fuentes C, M. J., y Jiménez V, M. A. (2019). Papel amate: Tradición y desarrollo. Colección: Desarrollo, disputas socio-territoriales y violencia en México. Facultad de Economía. URL: http://www.eco.buap.mx/publicaciones/libros/dinamicas_productivas_alimentacion_y_politicas.pdf#page=16

Díaz M, A. (1988). Sistema de creencias mágico-religioso de los otomíes de San Pablito, Pahuatlán. URL: https://cdigital.uv.mx/bitstream/handle/123456789/2078/198868P38.pdf?seque

Bustos F, C (2009). La producción artesanal. Visión gerencial. Universidad de los Andes Mérida, Venezuela. Núm. 1.pp. 37-52. URL: https://www.redalyc.org/pdf/4655/465545880009.pdf

Fuentes C, M. J. (2019). Situación actual y perspectivas del papel amate: Hacía una producción sustentable. Colegio de Postgraduados. Institución de Enseñanza e Investigación en Ciencias Agrícolas. Campus Montecillo. Programa de Postgrado en Socioeconomía, Estadística e Informática. Montecillo Texcoco. Estado de México. URL: http://colposdigital.colpos.mx:8080/xmlui/bitstream/handle/10521/3904/Fuentes_Castillo_MJ_DC_ISEI_Desarrollo_Rural_2019.pdf?sequence=1&isAllowed=y

Grupohdflexo. (2023). Midiendo la Densidad de Tinta. Documentación Técnica. URL: www.grupohdflexo.com

Heizer, J. y Render, B. (2007). Dirección de la Producción. Decisiones estratégicas. Madrid, España: Pearson Educación. URL: https://apuntesutnpilar.files.wordpress.com/2014/03/direccic3b3n-de-la-produccic3b3n-y-de-operaciones-d-e-8va-ed-heizer-render-pearson.pdf

López B, C. (2003). The endurance of mexican amate paper: Exploring additional dimensions to the sustainable development concept. University of Twente. URL: https://ris.utwente.nl/ws/portalfiles/portal/279526376/thesis_Lopez_Binnquist.pdf

Pérez R, M. V. (2021). Dinámicas socioeconómicas y problemas socioambientales: la producción de papel amate en la sierra norte de Puebla, México (Doctoral dissertation, Universidad Autónoma Chapingo). URL: https://repositorio.chapingo.edu.mx/server/api/core/bitstreams/06040f43-70dc-41e2-ba20-73f009a976ad/content

PueblosAmerica.com. (2023). PueblosAmerica.com. Obtenido de URL: https://mexico.pueblosamerica.com/i/san-pablito/#:~:text=La%20poblaci%C3%B3n%20de%20San%20Pablito%20(Puebla)%20es%203%2C386%20habitantes