



## FORMULATION, PHYSICOCHEMICAL CHARACTERIZATION AND PERFORMANCE EVALUATION OF DETERGENTS PRODUCED FROM LOCALLY AVAILABLE RAW MATERIALS

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**ABSTRACT:** Detergents are synthetic, water – soluble cleaning agents, designed to emulsify dirt, grease and oil from various surfaces, including clothes, skin, and industrial equipment. Unlike soap, they are highly effective in hard water. They consist primarily of surfactants, which reduce water's surface tension, and may include builders and enzymes. The production processes involved the careful selection, measurement, and systematic mixing of surfactants, builders, stabilizers, and additives following standard laboratory procedures. Both detergent powder and liquid were produced under controlled conditions to ensure consistency and reliability. The formulated products were subjected to quality control tests including pH determination, foaming capacity, cleaning efficiency, density, viscosity (for liquid detergent), bulk density (for detergent powder), solubility, and stability assessment. The results obtained showed that both powder and liquid detergent possessed acceptable physical appearance, good foaming ability, effective cleaning action, and satisfactory stability under normal storage conditions. The detergent powder exhibited suitable alkalinity for laundry applications, while the liquid detergent had a near-neutral to mildly alkaline pH range, making it suitable for general household and hand-washing purposes. The findings of this study indicate that high-quality powder and liquid detergent can be successfully produced using the selected formulations and production methods. The study therefore provides valuable information for small-scale detergent production and contributes to practical knowledge in detergent formulation, characterization and performance evaluation. This will in turn reduce cost of living and improve standard of living via increase employment rate.

**Keywords:** *Cleaning Efficiency, Detergent, Foaming Capacity, pH, Quality Control Surfactants.*

### 1.0 INTRODUCTION

Detergents are essential chemical products that play a central role in maintaining cleanliness, hygiene, and public health in modern society. They are widely used in households, hospitals, laboratories, schools,

hotels, and industrial environments for cleaning fabrics, utensils, equipment, and surfaces. The primary function of detergents is to remove dirt, grease, microorganisms, and other contaminants by reducing surface tension, emulsifying oily substances, and suspending dirt particles in water so that they can be easily removed during rinsing. Because of these properties, detergents contribute significantly to disease prevention, environmental sanitation, and improved quality of life. (Auta & Jimoh, 2013)

The demand for detergents has increased steadily over the years due to rapid population growth, urbanization, rising living standards, and increased awareness of hygiene and sanitation. In both developed and developing countries, detergents are now considered basic household and industrial necessities. The expansion of healthcare services, food processing industries, hospitality businesses, and manufacturing activities has further intensified the consumption of cleaning products. As detergent use continues to grow, so does the volume of detergent residues released into the environment, raising important concerns about sustainability and environmental safety (Hoque et al., 2018).

Traditionally, detergents and soaps were produced from natural fats and oils using simple chemical processes such as saponification. Early forms of soap were made by reacting animal fats or vegetable oils with alkaline substances derived from wood ash. While these products were effective to some extent, they had limitations, particularly in hard water where calcium and magnesium ions reduced their cleaning efficiency. These limitations led to the development of synthetic detergents in the twentieth century, which offered superior cleaning performance, better solubility, and improved stability under various conditions (Ali & Elsamahy, 2016).

Most modern detergents are synthesized from petrochemical raw materials, especially synthetic surfactants such as linear alkylbenzene sulfonates and related compounds. These surfactants are widely used because they are effective, versatile, and relatively inexpensive to produce on a large scale. However, their production relies heavily on petroleum, which is a finite and non-renewable resource. The extraction, refining, and processing of petroleum are associated with environmental degradation, energy consumption, and greenhouse gas emissions. As global petroleum reserves decline and environmental regulations become stricter, the long-term sustainability of petrochemical based detergent production is increasingly questioned. (Hoque et al., 2018)

In addition to resource depletion, synthetic detergents pose significant environmental challenges after use. Many synthetic surfactants are non-biodegradable or degrade slowly, allowing them to persist in the environment for extended periods. When detergents enter wastewater systems, they may pass through treatment plants without complete removal, especially in regions with inadequate treatment facilities. As a result, detergent residues are discharged into rivers, lakes, and coastal waters, where they can cause foaming, reduce oxygen transfer at the water surface, and harm aquatic organisms (Abdel-Raouf et al., 2012).

Scientific studies have shown that prolonged exposure to detergent pollutants can disrupt aquatic ecosystems by affecting algae growth, fish reproduction, and the survival of invertebrates. Some surfactants exhibit toxic effects even at low concentrations, while others interfere with the natural balance of aquatic food chains. The presence of detergent residues in water bodies also degrades water quality, making it unsuitable for drinking, irrigation, and recreational purposes. The United Nations Environment Programme has identified detergent related pollution as a growing concern in urban waterways, particularly in developing countries where regulatory enforcement and wastewater management are often weak (UNEP, 2020).

This study therefore focuses on the production of detergent from locally available materials and the evaluation of its physicochemical characteristics. By conducting laboratory analyses and comparing the results with those of commercial detergents, the research seeks to provide scientific evidence on the viability of locally available material-based detergents for domestic and industrial applications. In addition to contributing to scientific knowledge, the study supports sustainable development objectives, particularly those related to responsible consumption and production, climate action, and protection of aquatic ecosystems (UNEP, 2020).

Detergents have remained essential cleaning agents for domestic, industrial, medical, and institutional use for several decades. Since the mid-20th century, particularly from the 1950s onward, the detergent industry has relied heavily on synthetic surfactants derived from petrochemical sources due to their strong cleaning efficiency and low production cost. Over the years, the demand for detergents has increased steadily as a result of population growth, urbanization, industrial expansion, and heightened awareness of hygiene and sanitation, especially following global public health concerns in the last two decades.

Despite their effectiveness, conventional synthetic detergents have been associated with significant environmental challenges. Studies conducted from the early 2000s to recent years have shown that many synthetic surfactants are either non-biodegradable or degrade slowly in the environment,

leading to their accumulation in water bodies. This has resulted in ecological problems such as excessive foaming, reduced dissolved oxygen levels, and toxicity to aquatic organisms. By the 2010s, international environmental agencies and researchers had increasingly emphasized the need to reduce the environmental footprint of household and industrial chemicals, including detergents (Abdel-Raouf et al., 2012).

Therefore, the background of this study is anchored in the growing need, especially in the 21st century, to develop environmentally friendly detergent alternatives while ensuring adequate product quality. By focusing on both production and quality control analysis, this research contributes to sustainable industrial practices, effective waste management, and the development of safe and efficient detergent products from locally available materials (UNEP, 2020).

The statement of the problem is that, since the early 2000s, the widespread use of synthetic detergents has increasingly contributed to environmental pollution, particularly in aquatic environments. Large quantities of detergent residues are discharged daily into water bodies through domestic and industrial wastewater. Many of these residues contain surfactants and additives that persist in the environment, leading to long-term ecological damage. By the 2010s, environmental studies had linked synthetic detergent pollution to reduced water quality, disruption of aquatic ecosystems, and harmful effects on fish and other aquatic organisms.

Although research conducted in recent years has demonstrated the potential of using locally available materials for detergent production, the practical adoption of such detergents remains limited. One major challenge is the lack of comprehensive quality control analysis to verify the performance and safety of detergents produced from those materials. Many studies focus primarily on production methods without thoroughly evaluating key quality parameters or comparing the products with conventional commercial detergents.

## 2.0 MATERIALS AND METHODOLOGY

### 2.1 MATERIALS

#### 2.1.1 Sample

The samples used in this study consisted of chemical raw materials required for Powder and Liquid detergent production and water as the reaction medium. All chemicals were sourced from local chemical suppliers and were of commercial grade, suitable for detergent formulation. Water used throughout the production process was clean tap water and served as the solvent for dissolving the chemicals and controlling the final consistency of the powder and liquid detergent.

#### 2.1.2 Reagents

The major chemical samples included nitrosol, caustic soda, Carboxymethyl Cellulose, sulphonic acid, texapon, foam booster, soda ash, sodium lauryl sulphate, sodium tripolyphosphate, colourant, and perfume. These materials were selected because of their established roles in powder and liquid detergent production, including cleaning action, foaming ability, thickening, and stabilization. Proper handling and preparation of each sample were ensured to maintain product quality and safety.

#### 2.1.3 Equipment

The equipment used includes: Plastic Bowls, Measuring Cylinders, Digital Weighing Balance, Thermometer, Stirring Rods, Hand Gloves, Face Mask, and Clean Plastic Containers for Storage.

#### 2.1.4 Sample Preparation

Before production, all chemical samples were properly prepared and treated to ensure safety, uniform mixing, and high-quality detergent products. The following preparation steps were carried out:

- All raw materials were weighed accurately using a digital weighing balance according to the required formulation.
- Solid chemicals such as soda ash, sodium sulphate, STPP, and CMC were sieved to remove lumps and impurities.
- Liquid chemicals such as LABSA, texapon, sulphonic acid, and foam booster were filtered where necessary to remove dirt particles.
- Caustic soda was dissolved separately in water before mixing to avoid excessive heat and ensure safe handling.
- Nitrosol and CMC were dissolved gradually in water with continuous stirring to prevent lump formation.
- Colourants were dissolved in a small amount of water before addition to achieve uniform colour distribution.
- Perfume was added only after cooling or stabilization to prevent loss of fragrance.
- Clean plastic bowls and containers were washed and dried before use to prevent contamination.
- Safety measures such as wearing hand gloves and face masks were observed throughout the preparation process.

These preparation procedures ensured proper chemical reaction, uniform mixing, product stability, and accurate evaluation of detergent quality.

##### 2.1.4.1 Chemical Composition for Powder Detergent Formulated

The materials used in the production of powder detergent were carefully selected based on their cleaning efficiency, availability, and suitability for detergent formulation. Each material performs a specific function in the final product.

**Table 1: Chemical Materials and their Function**

| Chemical Reagents                                      | Function                                                                           |
|--------------------------------------------------------|------------------------------------------------------------------------------------|
| 1. <b>Linear Alkyl Benzene Sulphonic Acid (LABSA):</b> | Acts as the primary surfactant responsible for dirt and grease removal.            |
| 2. <b>Soda Ash (Sodium Carbonate):</b>                 | Serves as a builder that increases alkalinity and improves cleaning efficiency.    |
| 3. <b>Sodium Tripolyphosphate (STPP):</b>              | Functions as a water softener by binding calcium and magnesium ions in hard water. |
| 4. <b>Sodium Sulphate:</b>                             | Used as a filler to improve bulk density and ensure uniform mixing.                |
| 5. <b>Carboxymethyl Cellulose (CMC):</b>               | Acts as an anti-redeposition agent to prevent dirt from settling back on fabrics.  |
| 6. <b>Foam Booster:</b>                                | Enhances foaming ability during washing.                                           |
| 7. <b>Colour:</b>                                      | Improves product appearance.                                                       |
| 8. <b>Perfume:</b>                                     | Provides a pleasant fragrance to the detergent powder.                             |
| 9. <b>Water:</b>                                       | Used in small quantity for proper mixing and neutralization during formulation.    |

#### 2.1.4.2 Chemical Composition of Liquid Detergent Formulated

The materials used for the production of liquid detergent were selected based on their effectiveness, availability, safety, and suitability for soap making. Accurate measurement of all chemicals was carried out to ensure proper chemical reactions and good product quality.

The chemicals and materials required include: Nitrosol, Caustic Soda, Sulphonic Acid, Texapon, Foaming booster, Soda Ash, SLS (Sodium Lauryl Sulphate), STPP (Sodium Tripolyphosphate), Color, Perfume, and Water.

**Table 2: Chemical Materials and Their Function**

| Chemical Reagents                 | Function                                                                                                         |
|-----------------------------------|------------------------------------------------------------------------------------------------------------------|
| 1. Nitrosol                       | This serve as a thickener in the production of liquid detergent                                                  |
| 2. Caustic Soda                   |                                                                                                                  |
| 3. Sulphonic acid                 | It is a foaming and cleaning agent which neutralizes the basic effect of caustic soda<br>This is a foaming agent |
| 4. Texapon                        |                                                                                                                  |
| 5. Foam boaster:                  | This is a cleaning agent that produces foam                                                                      |
| 6. Soda Ash                       | It enhances the washing performance of the soup and also a thickening agent                                      |
| 7. Soduim Lauryl Sulphate (SLS)   | This is also foaming agent                                                                                       |
| 8. Soduim Tripolyphosphate (STTP) | This is a cleaning and thickening agent                                                                          |

## 2.2 Methodology

### 2.2.1 Formulation for Powder Detergent

Accurate measurement of all raw materials was carried out to ensure proper formulation and product consistency. Measurements were performed using a digital weighing balance.

The following quantities were used for the production of one kilogram of powder detergent:

- |                                               |              |
|-----------------------------------------------|--------------|
| • Linear Alkyl Benzene Sulphonic Acid (LABSA) | <b>120 g</b> |
| • Soda Ash (Sodium Carbonate):                | <b>150 g</b> |
| • Sodium Tripolyphosphate (STPP):             | <b>100 g</b> |
| • Sodium Sulphate:                            | <b>500 g</b> |
| • Carboxymethyl Cellulose (CMC):              | <b>10 g</b>  |
| • Foam Booster:                               | <b>20 g</b>  |
| • Colour:                                     | <b>5 g</b>   |
| • Perfume:                                    | <b>5 g</b>   |
| • Water:                                      | <b>90 m</b>  |

#### DIAGRAM



Fig 1: Showing the Addition of Labsa Into the Mixing Container During Powder Detergent Production.

### 2.2.2 Powder Detergent Production Processes

Sodium sulphate was first poured into a clean plastic bowl and served as the base material. Soda ash and STPP were added gradually and mixed thoroughly to ensure uniform distribution. LABSA was slowly added while stirring continuously, followed by the gradual addition of water to neutralize the mixture and prevent lump formation. CMC was dissolved separately in a small amount of water and added to the mixture to improve washing performance. Foam booster, colour, and perfume were added last and mixed thoroughly until a homogeneous detergent powder was obtained. The final product was air-dried and packaged in clean, labeled containers for further evaluation.

### 2.2.3 Formulation for Liquid Detergent

|                    |                                      |
|--------------------|--------------------------------------|
| Nitrosol           | ¼ kg                                 |
| Caustic Soda       | 2-3 full spoon                       |
| Sulphonic Acid     | 75cl                                 |
| Texapon            | ¼ kg/ 250g                           |
| Foaming booster    | ¼ litre                              |
| Soda Ash           | ½ kg/ 500g                           |
| SLS                | ¼ kg/ 250g (Sodium Lauryl Sulphate)  |
| STPP               | ¼ kg/ 250g (Sodium Tripolyphosphate) |
| Color              | as desired                           |
| Perfume as desired |                                      |
| Water              | 25 liters                            |



Fig 2: A, B, C & D Showing Foam Booster, Sulphonic Acid (Labsa), Caustic Soda, And Nitrosol Used in Liquid Detergent Production



## 2.2.4 Liquid Detergent Production Processes

The liquid detergent was produced using a sequential mixing method, following standard detergent formulation procedures. The process began with the preparation of individual chemical solutions to ensure proper dissolution and uniform reaction.

Firstly, caustic soda was dissolved in one litre of water and stirred thoroughly until a clear solution was obtained. Soda ash was separately dissolved in two litres of water and stirred properly. Sulphonic acid was poured into an empty plastic bowl, after which texapon was added and stirred continuously. A foam booster was then introduced into the mixture, followed by the addition of one to two litres of water to form a combined three-in-one solution.

Sodium lauryl sulphate was dissolved in two litres of water and stirred until fully dissolved. Sodium tripolyphosphate was also dissolved separately in two litres of water with proper stirring. These solutions were set aside for later use.

Nitrosol was gradually added into the remaining water, approximately seventeen litres, with continuous stirring to prevent lump formation and to achieve a smooth thickened solution. The

previously prepared caustic soda solution was then added slowly to the nitrosol solution and stirred thoroughly to ensure uniform mixing.

Thereafter, the dissolved sulphonic acid, texapon, and foam booster mixture was added to the nitrosol solution and stirred continuously. The dissolved soda ash was then introduced into the mixture and stirred properly, followed by the addition of the dissolved sodium lauryl sulphate and sodium tripolyphosphate, each added gradually with thorough stirring after every addition.

Colourant was dissolved in a small quantity of water to ensure complete dissolution and then added to the mixture with continuous stirring to achieve uniform colour distribution. Additional water was added gradually to the mixture depending on the desired thickness of the liquid soap.

Finally, the mixture was allowed to stand for several hours, preferably overnight, to allow proper stabilization. Perfume was added before packaging to enhance fragrance. The finished liquid detergent was then transferred into clean, labeled containers and stored for further evaluation.

## 2.2.5 Experimental Analysis

### 2.2.5.1 Powder Detergent

Different parametric analysis was observed accordingly.

### 2.2.5.2 Powder Detergent

For powdered detergent the following parameters were observed: Physical Appearance and Texture; Percentage Composition; Moisture Content; Solubility; Bulk Density; Foaming Capacity; Cleaning Efficiency; and pH

### 2.2.5.3 Liquid Detergent

While, for liquid detergent the following parameter were observed: Physical appearance; volume yield; viscosity; foaming ability; cleaning efficiency; and P<sup>H</sup>.

### 3.0 RESULTS AND DISCUSSION

#### 3.1 Results

This chapter presents the results obtained from the production of powder and liquid detergent as described earlier. It includes quantitative calculations, physical observations, and performance evaluations of the produced detergents. The results were discussed based on standard detergent quality parameters such as appearance, solubility, foaming ability, cleaning efficiency, viscosity (for liquid detergent), moisture content (for powder detergent), and pH value. These analyses were carried out to assess the effectiveness, stability, and suitability of the detergents for domestic cleaning applications.



Fig 3: Showing Powder Detergent Sample Produced

##### 3.1.1 Powder Detergent

###### ➤ Physical Appearance and Texture

The produced detergent powder was observed to be:

- Free-flowing
- Fine in texture
- Uniformly coloured
- Free from visible lumps after air-drying

This indicates proper formulation, effective mixing, and adequate neutralization of LABSA during production.

###### ➤ Percentage Composition

The detergent powder was produced using a total mass of **1 kg (1000 g)**. The percentage composition of each ingredient was given in the table 3 below.

**Table 3: Showing Percentage Composition of the Product**

| Component       | Mass (g)      | Percentage (%) |
|-----------------|---------------|----------------|
| LABSA           | 120           | 12.0           |
| Soda Ash        | 150           | 15.0           |
| STPP            | 100           | 10.0           |
| Sodium Sulphate | 500           | 50.0           |
| CMC             | 10            | 1.0            |
| Foam Booster    | 20            | 2.0            |
| Colour          | 5             | 0.5            |
| Perfume         | 5             | 0.5            |
| Water           | 90            | 9.0            |
| <b>Total</b>    | <b>1000 g</b> | <b>100%</b>    |

This balanced composition supports effective cleaning, water softening, foaming, and product stability.

➤ **Moisture Content**

Moisture content was determined by air-drying a known mass of detergent powder, and was observed to be **6%** which fall within acceptable value and indicates good storage stability.

➤ **Solubility Test**

The detergent powder dissolved readily in warm and cold water without leaving insoluble residues. This confirms: Proper particle size distribution; Effective formulation; and Absence of excessive fillers.

➤ **Bulk Density**

Bulk density is an important quality parameter for detergent powder as it affects packaging, handling, solubility, and consumer acceptability. Hence, the bulk density of powder detergent was **0.50 g/ml**.

➤ **Foaming Capacity**

Foaming capacity measures the ability of a detergent to produce foam, which is an important consumer quality attribute. Obtained as **60%**. Observed: High foam formation; and Foam stability lasted for several minutes. This performance is attributed to LABSA and foam booster presence.

➤ **Cleaning Efficiency**

Grease-stained fabric samples were washed using the detergent solution. It was observed: Effective stain removal; and No redeposition of dirt. This confirms the effectiveness of STPP (builder) and CMC (anti-redeposition agent).

➤ **pH**

Observed pH value was 9.8. This alkaline pH is suitable for laundry detergents and enhances grease removal which is within acceptable safety limits.

#### 4.1.2 Liquid Detergent

##### DIAGRAM



**Fig 4: Showing The Produced Liquid Detergent Sample.**

➤ **Physical Appearance**

The produced liquid detergent was observed to be: Smooth; Viscous; Homogeneous; and Free from lumps or phase separation. This indicates successful thickening by nitrosol and proper neutralization of sulphonic acid.

➤ **Volume Yield**

With total water used = **25 litres**, and Additional volume from chemicals  $\approx$  **3 litres**, amount to a total of 28 litres, shows a high production yield suitable for small-scale commercial application.

➤ **Viscosity Test**

The liquid detergent exhibited: Moderate to high viscosity; and Good flow property. which is attributed to the combined thickening action of **nitrosol, soda ash, and STPP**.

➤ **Foaming Ability**

Foaming Capacity was observed to be 90%. Indicating rich foam formation and Stable foam retention. The foaming performance is due to **sulphonic acid, texapon, and SLS**.

➤ **Cleaning Efficiency**

Oil-stained plates and fabrics were washed using the liquid detergent. Effective removal of grease and stains with Minimal rinsing required were observed. This confirms the synergy between surfactants and builders.

➤ **pH**

pH value of 7.5 was observed. Which was near-neutral to mildly alkaline making it: Safe for hand washing; Suitable for domestic use; and Non-irritating to skin when properly rinsed.

**Table 4: Comparative Analysis of Detergent Powder and Liquid Detergents**

| Parameter           | Detergent Powder | Liquid Detergent |
|---------------------|------------------|------------------|
| Physical State      | Solid            | Liquid           |
| pH Range            | 9.5 – 10.0       | 7.5 – 8.0        |
| Foaming Ability     | High             | Very High        |
| Cleaning Efficiency | Very Good        | Excellent        |
| Ease of Dissolution | Good             | Excellent        |
| Skin Friendliness   | Moderate         | High             |

### 3.2 Discussion of the Findings

The results obtained demonstrate that both detergent powder and liquid detergent were successfully produced following standard formulation procedures. The powder detergent showed strong “alkalinity” suitable for laundry applications, while the liquid detergent exhibited a milder “pH”, making it safer for hand washing. The high foaming ability, good solubility, and effective stain removal confirm the functionality of the selected raw materials and production methods. This is in concordance with the work of Meyer, U., & Meyer, T. (2016). Detergents and soaps. In *Ullmann's encyclopedia of industrial chemistry*. Wiley-VCH.

The calculated compositions and yield values (powder =200ml, liquid =28 liter) indicate efficient material utilization. The absence of phase separation and lump formation further confirms product stability and quality. Overall, the detergents

produced meet acceptable performance standards for domestic cleaning purposes. In accordance with the work of Hill, K. (2015). Industrial development of surfactants. *Journal of Surfactants and Detergents*, 18(2), 135–

## 4.0 CONCLUSION AND RECOMMENDATIONS

### 4.1 Conclusion

This study successfully demonstrated the production of both powder and liquid detergents using standard chemical formulations and laboratory procedures. The methodologies adopted for both products were effective in producing stable and functional detergents with acceptable quality characteristics. The results obtained from the evaluation tests indicate that the produced detergent powder and liquid detergent met basic performance requirements expected of household cleaning products.

For the powder detergent, the product was free flowing and stable, with effective foaming and cleaning performance. The measured pH value of the powder detergent solution was within an alkaline range suitable for laundry applications, confirming its effectiveness in removing grease and stains from fabrics. The absence of caking or moisture absorption during storage indicates good product stability.

The liquid detergent produced showed acceptable physical appearance, moderate viscosity, and good stability. The pH value of the liquid detergent was within an appropriate mildly alkaline range, making it suitable for general household cleaning. Adequate foaming ability and effective cleaning performance were also observed, indicating that the selected surfactants and additives performed their intended functions.

Overall, the findings of this research confirm that both powder detergent and liquid detergent can be successfully produced using the selected materials and formulation methods. The study achieved its stated objectives by producing and evaluating the quality control parameters of both products.

## 4.2 Recommendations

Based on the findings of this study, the following recommendations are made:

- ✓ Further studies should be conducted to evaluate additional quality parameters such as biodegradability, skin irritation potential, and long-term shelf life of both detergent powder and liquid soap.
- ✓ The formulations of both products can be optimized by adjusting the concentrations of surfactants, builders, and thickening agents to further improve cleaning efficiency and product stability.
- ✓ The use of standard laboratory equipment such as viscometers and calibrated digital pH meters is recommended for more precise quality control measurements in future studies.
- ✓ Large-scale production trials should be carried out to assess the feasibility of commercial production and cost effectiveness of both detergent powder and liquid soap.
- ✓ Compliance with relevant national and international detergent quality standards should be considered in future work to improve product safety and market acceptability.
- ✓ Training and skill acquisition programs are recommended to encourage small-scale detergent production for entrepreneurship and economic empowerment.

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