# Formulation and Evaluation of Herbal Anti-Pollution Gel

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***Abstract*—Air pollution is one of the major environmental problems that adversely affects human skin, leading to oxidative stress, premature ageing, dryness, irritation and loss of skin elasticity. Continuous exposure to pollutants such as dust, smoke, and harmful gases generates free radicals that damage the skin barrier and accelerate skin disorders. The present study focuses on the formulation and evaluation of a herbal anti-pollution gel using natural ingredients such as hibiscus, neem and aloe vera, which possess antioxidant, antibacterial and moisturising properties.**

**The gel was prepared using Carbopol 940 as a gelling agent and triethanolamine as a neutralising agent. The prepared formulation was evaluated for various physicochemical parameters such as pH, viscosity, spread ability, homogeneity and skin irritation. The results showed that the gel possessed good stability, an acceptable pH, and excellent spread ability, with no signs of irritation.**

**Thus, the developed herbal gel can be considered a safe, effective and economical formulation for protecting the skin against the harmful effects of environmental pollution and maintaining healthy skin.**

***Index Terms*—Herbal anti-pollution gel, Skin protection, Herbal extracts, Antioxidant activity, Environmental pollution, Dermal protection, Cosmeceutical formulation**

## I. INTRODUCTION

❖ Introduction to Skin

The skin is the largest and one of the most important organs of the human body. It forms a protective covering over the entire body and acts as the first line of defence against external environmental factors such as microorganisms, chemicals, ultraviolet (UV) radiation, dust, smoke, and pollution. Healthy skin not only improves appearance but also plays a vital role in maintaining overall body health.

The average adult human skin covers approximately 1.5–2 square meters and performs several important physiological functions. Skin helps in the regulation of body temperature, the prevention of water loss, sensory perception, the excretion of sweat, and protection from harmful environmental agents.

Human skin is mainly divided into three layers:

1. Epidermis

The outermost layer of skin acts as a protective barrier. It protects the body from pollutants, bacteria, and harmful substances. It also contains melanin pigment responsible for skin colour.

2. Dermis

The middle layer contains blood vessels, nerves, sweat glands, sebaceous glands, collagen fibres, and hair follicles. It provides elasticity, nourishment, and strength to the skin.

3. Hypodermis (Subcutaneous Layer)

The innermost fatty layer, which stores energy, provides insulation, and protects internal organs from injury.

❖ Structure of Human Skin

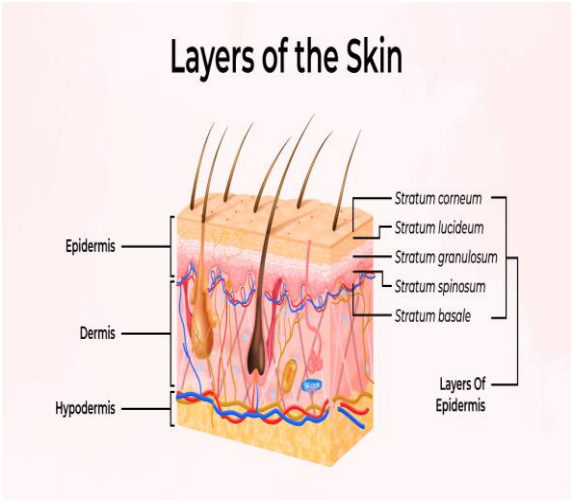



Fig No.1: Anatomy of Skin

Functions of Skin

- The major functions of skin include:
- Protection from external harmful agents
- Prevention of excessive water loss

- Regulation of body temperature
- Sensation of touch, pain, heat, and cold
- Production of vitamin D
- Excretion of sweat and toxins
- Maintenance of skin hydration and elasticity

Pollution and Its Effect on Skin

Pollution is one of the major environmental problems affecting human health and skin condition. Environmental pollution refers to the contamination of the environment by harmful substances such as dust, smoke, toxic gases, chemicals, heavy metals, and particulate matter.

Continuous exposure to pollution damages the natural protective barrier of skin and leads to various skin problems such as dryness, irritation, acne, pigmentation, premature ageing, wrinkles, dullness, allergies, and inflammation.

Nowadays, increasing urbanisation, industrialisation, and vehicle emissions have significantly increased the level of pollution in the environment. Therefore, protection of skin from pollution has become an important part of skincare.

Types of Pollution Affecting Skin

1. Air Pollution

Air pollution is caused by smoke, dust, vehicle exhaust, industrial gases, and particulate matter (PM 2.5 and PM 10). These pollutants clog skin pores and increase oxidative stress, leading to acne, premature ageing, and pigmentation.

2. UV Radiation Pollution

Continuous exposure to sunlight and ultraviolet radiation damages collagen fibres and causes tanning, sunburn, wrinkles, and early ageing.

3. Chemical Pollution

Harmful chemicals present in cosmetics, detergents, and industrial waste may cause irritation, allergies, and skin sensitivity.

4. Smoke and Dust Pollution

Dust particles and smoke accumulate on the skin surface, making skin dull, dehydrated, and prone to infection.

Pollution Affecting Skin


Fig No.2

Need for Anti-Pollution Gel

Due to increasing environmental pollution, skin requires special protection to maintain its health and appearance. Ordinary skincare products may not effectively protect skin from pollutants and oxidative stress. Therefore, anti-pollution skincare products are developed to provide a protective barrier against harmful environmental agents.

Anti-pollution gel helps to:

- Remove dirt and pollutants from skin
- Protect skin from oxidative damage
- Reduce acne and irritation
- Maintain hydration and moisture
- Soothe and refresh the skin
- Improve skin texture and glow
- Herbal anti-pollution gels are more preferred because they contain natural ingredients

The present study focuses on the formulation and evaluation of A herbal anti-pollution gel incorporating natural extracts, aiming to provide effective protection against pollution-induced skin damage while maintaining skin health and hydration.

## II. LITERATURE REVIEW

1. Kulveer Singh Ahlawat and Bhupender Singh Khatkar reported that Aloe vera is one of the most important medicinal plants used in herbal cosmetics due to its moisturising, anti-inflammatory and antioxidant properties. The authors explained that Aloe vera helps in protecting the skin from environmental damage, improves skin hydration and promotes skin healing. It also reduces irritation and dryness caused by pollution exposure.

Journal of Food Science and Technology, 2011, pp. 525–533.

2. Claudia Juliano and Giovanni Antonio Magrini explained that environmental pollutants generate free radicals, which damage skin cells and accelerate premature ageing. The authors stated that herbal antioxidants present in botanical extracts help neutralise these harmful free radicals and protect the skin barrier from pollution-induced stress.
Cosmetics (MDPI), 2018, pp. 1–24.

3. Niraj Mistry described that anti-pollution cosmetic formulations are specially developed to protect the skin against harmful environmental pollutants such as dust, smoke and particulate matter. The study highlighted that herbal ingredients and antioxidants help in reducing pigmentation, inflammation and oxidative skin damage.
Cosmetics (MDPI), 2017, pp. 1–16.

4. Varinder Singh et al. studied the dermatological importance of Neem and reported that Neem possesses antimicrobial, antioxidant and anti-inflammatory activities. The authors concluded that Neem extract is beneficial in protecting the skin from microbial infections, irritation and acne caused by environmental pollution.
Current Traditional Medicine, 2021, pp. 94–121.

5. Chitrarekha A. Jadhav, Priya Rao and R.S. Jadhav reported that Aloe vera-based herbal formulations are highly effective for skincare applications because of their soothing, moisturising, and protective actions. The authors observed that Aloe vera forms a protective layer on the skin and helps in reducing the harmful effects of pollutants on skin health.
World Journal of Pharmaceutical Sciences, 2020, pp. 19–23.

6. Diki Prayugo Wibowo et al. explained that herbal cosmetic products containing natural antioxidants help protect the skin against oxidative stress caused by environmental pollution. The study showed that herbal extracts improve skin regeneration, hydration and overall skin appearance.
Science Midwifery, 2023, pp. 785–793.

7. Bissett Donald L. reported that antioxidants present in herbal skincare formulations play an important role in protecting the skin from oxidative stress caused by pollution and ultraviolet radiation. The author explained that antioxidant-based cosmetic products help in reducing premature aging, wrinkles and skin damage caused by environmental exposure.
American Journal of Clinical Dermatology, 2002, pp. 445–449.

8. Pandey Shivanand and Meshya Nilam explained that herbal cosmetics are safer and more compatible with skin compared to synthetic products because they contain natural bioactive compounds. The authors highlighted that herbal gels prepared using plant extracts provide cooling, moisturizing and protective effects against environmental pollutants.
Asian Journal of Pharmaceutical and Clinical Research, 2010, pp. 1–7.

9. Dureja Harvinder, Kaushik Diksha and Gupta Mona reported that herbal formulations containing Neem, Aloe vera and Tulsi possess excellent antimicrobial and antioxidant activities. The study concluded that these herbs are effective in maintaining healthy skin and preventing skin irritation caused by pollutants and microorganisms.
International Journal of Pharmaceutical Sciences Review and Research, 2011, pp. 27–32.

10. Arora Pooja, Nanda Arun and Karan M. stated that herbal gels are widely used in cosmetic preparations because of their non-greasy nature, easy spreadability and soothing effect on skin. The authors explained that herbal ingredients help in maintaining skin hydration and protecting the skin from external environmental stress.
International Journal of Pharmaceutical Sciences and Drug Research, 2012, pp. 383–387.

11. Korac Radava and Khambholja Kapil explained that exposure to air pollution leads to increased production of reactive oxygen species, which damage the skin barrier. The authors suggested that herbal antioxidants and polyphenols present in cosmetic formulations help in minimising pollution-induced skin ageing and inflammation.
Indian Dermatology Online Journal, 2011, pp. 2–6.

## III. AIM AND OBJECTIVES

Aim

To formulate and evaluate a herbal anti-pollution gel incorporating bioactive plant extracts.

Objectives

1. To prepare and optimise aqueous extracts of hibiscus and neem using suitable extraction techniques.
2. To formulate a stable and non-greasy gel base using Carbopol 940 and suitable neutralising agents.
3. To incorporate herbal extracts into the gel base in appropriate concentrations for maximum efficacy.
4. To evaluate the formulated gel for physicochemical parameters such as pH, viscosity, spreadability, homogeneity and appearance.
5. To assess the safety of the formulation by performing a skin irritation test.
6. To study the potential anti-pollution activity of the gel based on the antioxidant and protective properties of herbal ingredients.
7. To develop an economical, safe and effective herbal formulation suitable for topical application.

Plan Of Work

Collection of Raw Materials
↓
Cleaning and Drying of Plant Material
↓
Powder Preparation (Hibiscus & Neem)
↓
Aqueous Extraction (Heating at 50–60°C)
↓
Filtration of Extract
↓
Concentration of Extract (if required)
↓
Preparation of Carbopol Gel Base
↓
Addition of Glycerin
↓
Incorporation of Herbal Extracts
↓
Addition of Aloe Vera & Rose Water
↓
Neutralisation with TEA (Gel Formation)
↓
Addition of Fragrance (Essential Oil)
↓
Evaluation of Gel (pH, viscosity, spreadability)
↓
Final Product (Anti-Pollution Gel)

## IV. DRUG PROFILE

Neem (Azadirachta indica)

Synonyms: Neem, Indian Lilac, Margosa Tree, Nimba (Sanskrit)

Biological source: Neem consists of the fresh and dried leaves, bark and seeds of Azadirachta indica belonging to the family Meliaceae.

Family: Meliaceae

Fig No.3: Neem (Azadirachta indica)

Chemical constituents: Neem contains a wide range of biologically active compounds, such as:

- Azadirachtin
- Nimbin
- Nimbidin
- Quercetin(flavonoid)
- Limonoids

Uses:

- Antibacterial
- Antifungal
- Anti-inflammatory
- Treatment of acne and infections

Role in Anti-Pollution Gel: Neem acts as a natural purifying and protective agent.

It helps in:

- Removing microbial contaminants from skin
- Preventing infections caused by pollutants

Aloe vera (Aloe barbadensis)
Synonyms: Aloevera, Barbados aloe
Biological source: Aloe vera consists of the fresh mucilaginous gel obtained from the leaves of Aloe barbadensis belonging to the family Asphodelaceae.
Family: Asphodelaceae

Fig No.4: Aloe vera (Aloe barbadenesis)

Chemical constituents: Aloe vera contains various bioactive compounds, such as:

- Vitamins (A, C, E)
- Enzymes(amylase,lipase)
- Polysaccharides (acemannan)
- Amino acids
- anthraquinones

Uses:

- Moisturizing agent
- Soothing and cooling
- Wound healing
- Anti-inflammatory
- Skin hydration and repair

Role in Anti-Pollution Gel: Aloe vera acts as a hydrating and soothing agent.
It helps in:

- Maintaining skin moisture
- Reducing irritation caused by pollutants
- Enhancing skin barrier function

Hibiscus (Hibiscus rosa-sinensis)
Synonyms: Hibiscus, China rose, Shoe flower, Jaswand (Marathi)
Biological source: Hibiscus consists of the fresh and dried petals of Hibiscus rosa-sinensis, belonging to the family Malvaceae.
Family: Malvaceae

Fig No.5: Hibiscus (Hibiscus rosa-sinensis)

Chemical constituents: Hibiscus contains various bioactive compounds, such as:

- Flavonoids
- Anthocyanins
- Vitamin C
- Organic acids

Uses:

- Antioxidant
- Anti-aging
- Skin brightening
- Improves skin elasticity
- Protects against environmental stress

Role in Anti-Pollution Gel: Hibiscus acts as a natural antioxidant agent.
It helps in:

- Neutralising free radicals
- Preventing pollution-induced skin damage
- Enhancing skin glow and elasticity

Carbopol 940
Synonyms: Carbomer, Carboxypolymethylene
Category: Synthetic polymer (Gelling agent)
Chemical nature: Cross-linked polyacrylic acid polymer
Properties:

- High viscosity
- Forms a clear gel
- Non-greasy
- Stable over a wide pH range

Uses:

- Thickening agent
- Stabilizer
- Suspending agent

Role in Anti-Pollution Gel: Forms the gel base and provides the required consistency and texture

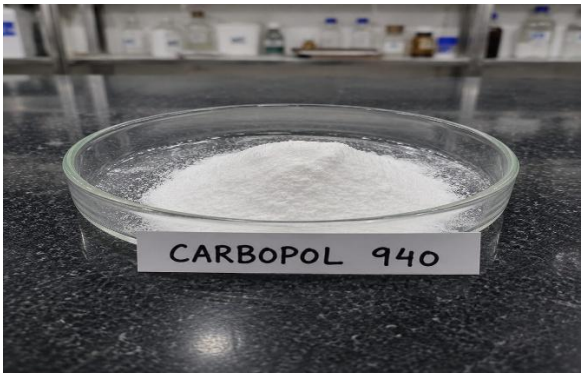



Fig No.6: Carbopol 940

Triethanolamine (TEA)
Synonyms: TEA, Trolamine
Category: Neutralising agent
Chemical nature: Organic amine compound
Properties:

- Colourless
- Viscous liquid
- Water-soluble

Uses:

- pH adjustment
- Emulsifier
- Neutralization

Role in Anti-Pollution Gel:

- Converts carbopol dispersion into a gel structure and maintains the pH.


Fig No.7: Triethanolamine (TEA)

Glycerin
Synonyms: Glycerol, Propanetriol
Category: Humectant
Chemical Nature: Trihydric alcohol
Properties:

- Colourless, odourless liquid
- Hygroscopic (absorbs moisture)
- Sweet taste

Uses:

- Moisturizer
- Skin softening
- Solvent

Role in Anti-Pollution Gel:

- Maintains skin hydration and prevents dryness


Fig No.8: Glycerine

Rose water
Synonyms: Gulab Jal, Rose hydrosol
Category: Natural aromatic water

Fig No.9: Rose Water

Properties:
- Pleasant fragrance
- Mild astringent
- Cooling effect

Uses:
- Skin refreshing
- Toning agent
- Fragrance

Role in Anti-Pollution Gel:
- Provides fragrance and soothing effect

Lavender oil (Lavandula angustifolia)
Synonyms: Lavender oil, oil of lavender
Biological source: Lavender oil is obtained by steam distillation of the flowering tops of Lavandula angustifolia.
Family: Lamiaceae

Fig No.10:Lavender oil

Chemical constituents: Lavender oil contains various active components such as:
- Linalool
- Linalyl acetate
- Camphor
- Terpinen-4-ol
- Cineole

Properties:
- Pale yellow liquid
- Volatile and aromatic
- Characteristics pleasant odour

Uses:
- Antimicrobial
- Anti-inflammatory
- Aromatherapy(relaxing effect)
- Mild antiseptic

Role in Anti-Pollution Gel: Lavender oil acts as a fragrance and therapeutic agent.
It helps in :
- Providing a pleasant aroma
- Reducing skin irritation
- Offering mild antimicrobial protection

## V. MATERIALS AND METHODS

Materials
The following materials were used for the formulation of the herbal anti-pollution gel:

| Sr.no. | Materials | Function |
|---|---|---|
| 1. | Aloe vera gel | Moisturizer |
| 2. | Hibiscus extract | Antioxidant |
| 3. | Neem extract | Antibacterial |
| 4. | Carbopol 940 | Gelling agent |
| 5. | Triethanolamine (TEA) | Neutralizer |
| 6. | Glycerin | Humectant |
| 7. | Rose water | Fragrance/soothing |
| 8. | Lavender oil (essential oil) | Fragrance |
| 9. | Distilled water | Vehicle |

Methods
Preparation of Herbal Extracts
Hibiscus Extraction
Fresh hibiscus petals were collected, washed, and shade-dried. The dried petals were powdered and subjected to aqueous extraction by heating with distilled water at 50–60°C for 15–20 minutes. The extract was then filtered and concentrated to obtain a suitable extract.

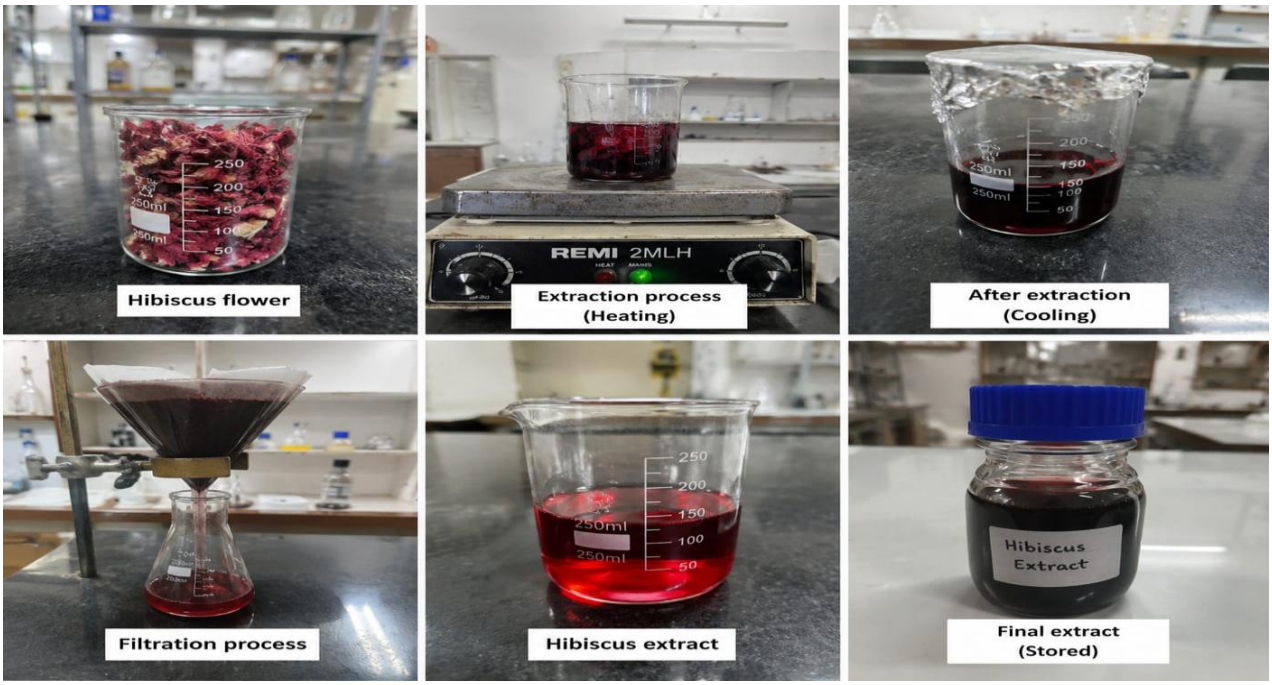
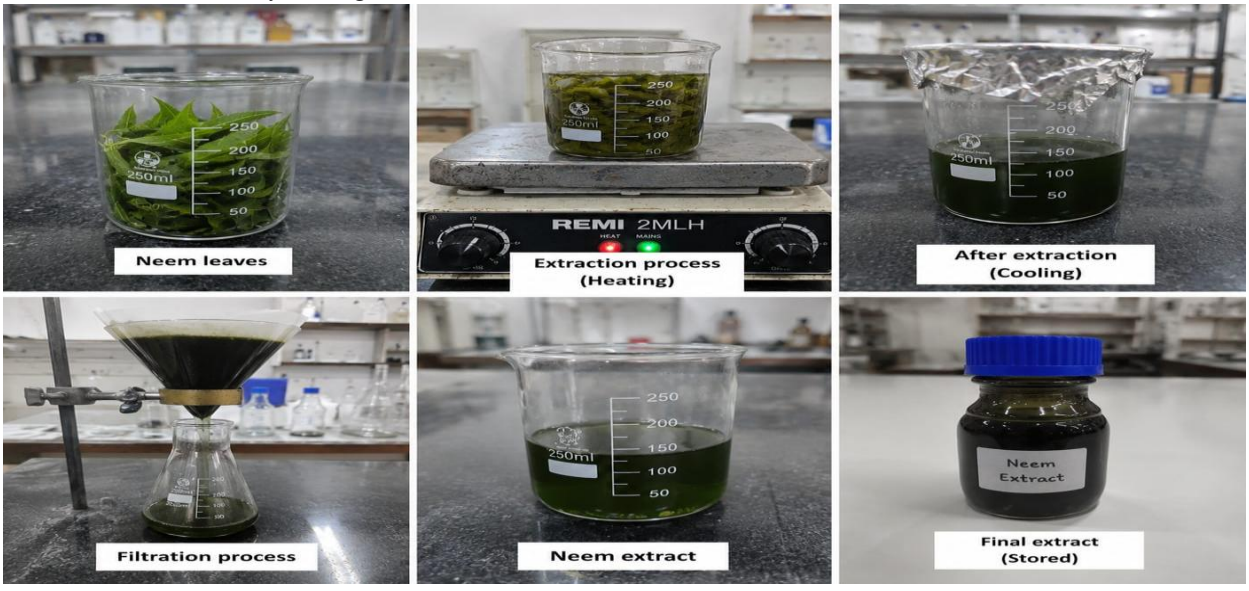



Fig No.11: Extraction of Hibiscus

Neem Extraction

Fresh neem leaves were collected, washed, and shade-dried. The dried leaves were powdered and extracted using distilled water by heating at 50–60°C for 15–20 minutes. The extract was filtered and concentrated.

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Aloe Vera Gel Preparation

Fresh aloe vera leaves were collected and washed thoroughly. The outer green layer was removed, and the inner gel was scooped out. The gel was homogenised and filtered to obtain a clear gel.

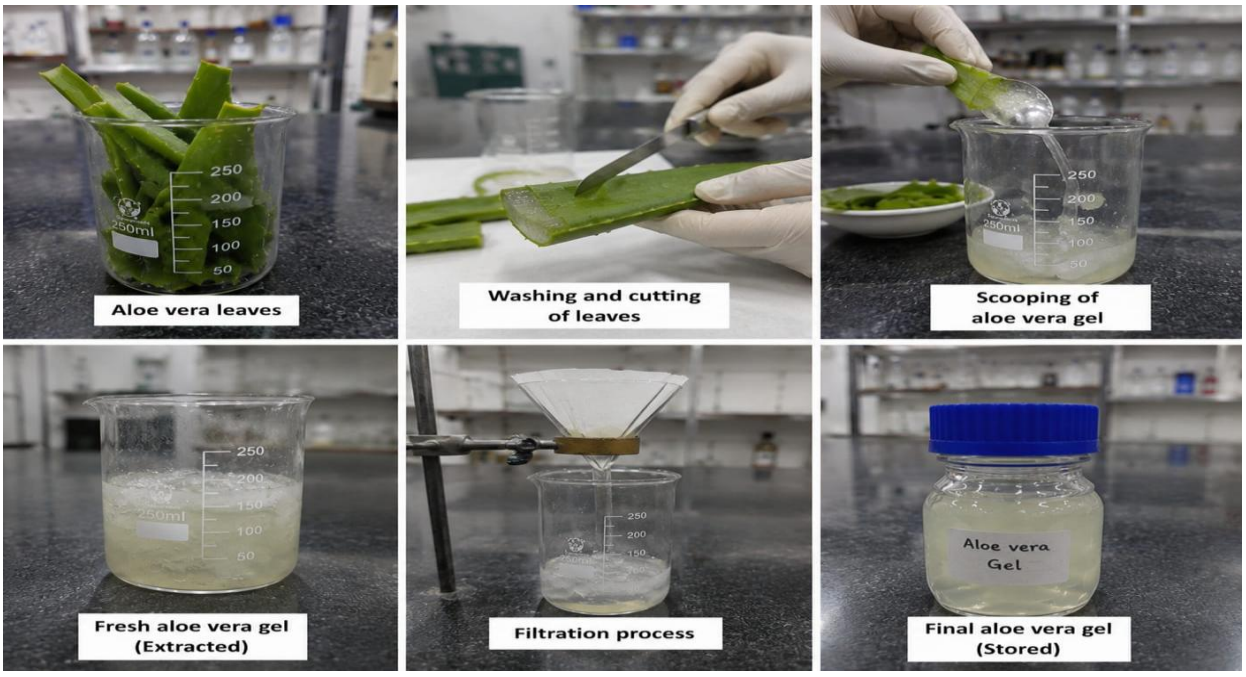


Fig No.13: Extraction of Aloe Vera

Formulation of Herbal Anti-Pollution Gel (50g batch)

| Sr.No. | Ingredients | F1(gm) | F2(gm) | F3(gm) |
|---|---|---|---|---|
| 1. | Carbopol 940 | 0.5 | 0.5 | 0.5 |
| 2. | Aloe vera gel | 5 | 6 | 7 |
| 3. | Hibiscus extract | 3 | 3 | 3 |
| 4. | Neem extract | 2 | 2 | 2 |
| 5. | Glyserin | 2 | 2 | 2 |
| 6. | Rose water | 2ml | 2ml | 2ml |
| 7. | Triethanolamine | q.s | q.s | q.s |
| 8. | Lavender oil | 2drops | 2drops | 2drops |
| 9. | Distilled water | q.s to 50gm | q.s to 50gm | q.s to 50gm |

"The formulation was prepared in three batches (F1, F2 and F3) by varying the concentration of aloe vera to optimise the formulation".

Procedure for Preparation of Herbal Anti-Pollution Gel

1. Carbopol 940 was accurately weighed and dispersed in distilled water with continuous stirring and allowed to swell for 30 minutes.
2. Glycerin was added to the swollen Carbopol and mixed thoroughly to obtain a uniform base.
3. The prepared hibiscus and neem extracts were added slowly with continuous stirring to ensure uniform distribution.
4. Aloe vera gel and rose water were incorporated into the mixture and mixed properly.
5. Triethanolamine was added dropwise with continuous stirring until a clear gel was formed.
6. Lavender oil was added at the final stage and mixed gently to impart fragrance.
7. The prepared gel was transferred into a clean, airtight container and stored at room temperature.

## VI. EVALUATION PARAMETERS OF HERBAL ANTI-POLLUTION GEL

Physical Appearance

The prepared gel was visually inspected for its colour, clarity, texture and overall appearance. A good gel should be free of grittiness and have a smooth, uniform consistency. The formulated gel was found to be light green in colour, with a smooth, elegant appearance, indicating good formulation characteristics.

pH Determination

The pH of the gel was determined using pH paper/digital pH meter by dissolving a small quantity of gel in distilled water. The pH is an important parameter to ensure compatibility with the skin. The pH of all batches was found to be within the range of 5.5–6.5, which is suitable for topical application and does not cause irritation.

Viscosity

Viscosity of the gel was evaluated to determine its thickness and consistency. It plays an important role in the application and stability of the formulation. The viscosity was found to increase with an increase in aloe vera concentration. The gel exhibited good consistency without being too thick or too thin.

Spreadability

Spreadability of the gel was measured by applying a small quantity of gel between two glass slides and observing the ease with which the gel spreads. Good spreadability indicates better patient compliance and ease of application. Among the batches, F2 showed excellent spreadability compared to F1 and F3.

Homogeneity

The homogeneity of the gel was evaluated by visual inspection after preparation. The gel was checked for the presence of lumps or phase separation. All the formulations were found to be homogeneous, smooth and free from any aggregates.

Skin Irritation Test

The skin irritation test was carried out by applying a small amount of gel on the skin and observing for redness, itching or irritation. The formulation showed no signs of irritation, indicating that it is safe for topical application.

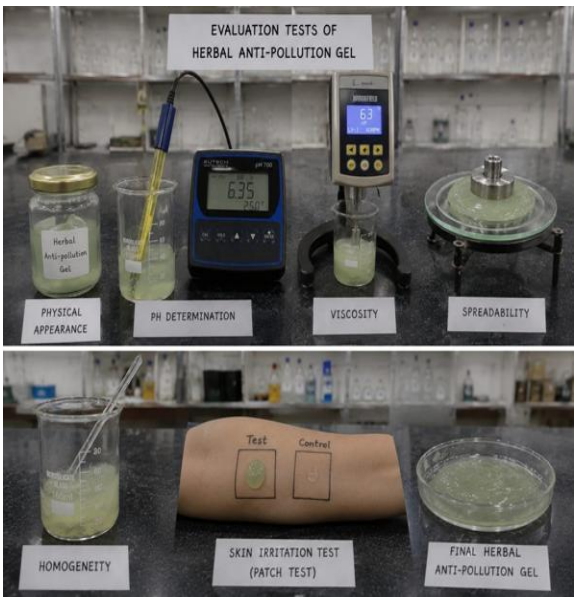


Fig No:14: Evaluation tests of the herbal Anti-Pollution Gel

VII. RESULT

| Sr.No | Parameter | F1 | F2 | F3 |
|---|---|---|---|---|
| 1. | Colour | Light green | Light green | Light green |
| 2. | Appearance | Smooth | Smooth | Smooth |
| 3. | Ph | 6.2 | 6.2 | 6.5 |
| 4. | Viscocity | Good | Good | High |
| 5. | Spreadability | Excellent | Excellent | Moderate |
| 6. | Homogeneity | Excellent | Excellent | Good |
| 7. | Skin irritation test | No irritation | No irritation | No irritation |

"From the above evaluation results, the F2 batch was found to be the optimised formulation due to its balanced properties


Fig No.15: Anti- Pollution Gel

VIII. DISCUSSION

The prepared herbal anti-pollution gel was formulated with the aim of protecting the skin from harmful environmental pollutants such as dust, smoke, and toxic particles. Pollution is one of the major causes of skin damage, leading to dryness, irritation, premature aging, acne, and dullness. Therefore, the formulation of an herbal anti-pollution gel using natural ingredients was considered a safe and effective approach for skin protection.

In the present study, herbal ingredients such as aloe vera, neem, turmeric, green tea extract, glycerin, and rose water were selected because of their antioxidant, moisturizing, antimicrobial, and soothing properties.

Aloe vera provided hydration and cooling effects to the skin, while neem and turmeric helped in reducing microbial growth and inflammation. Green tea extract acted as a strong antioxidant that may help in neutralizing free radicals produced due to pollution exposure.

The prepared gel showed good appearance, smooth texture, and pleasant consistency. The gel was non-greasy, easily spreadable, and quickly absorbed into the skin without leaving any sticky residue. The pH of the formulation was found to be near the skin pH range, indicating that the gel is suitable for topical application and less likely to cause irritation. The spreadability and washability of the gel were also satisfactory, which improves user acceptability.

The stability of the gel was observed under normal storage conditions, and no significant changes in color, odor, or texture were noticed during the observation period. This indicates that the formulation possesses good physical stability. The herbal ingredients used in the formulation also enhanced the safety profile of the product compared to synthetic chemical-based skincare products.

Overall, the formulated herbal anti-pollution gel demonstrated promising protective and skincare properties. The study suggests that herbal formulations can be effectively used in cosmetic and skincare preparations to minimize the harmful effects of environmental pollution on the skin. Hence, the developed gel can be considered a beneficial, economical, and skin-friendly product for daily use.

## IX. SUMMARY

The present project was focused on the formulation and evaluation of a herbal anti-pollution gel for skin protection. Due to increasing environmental pollution, the skin is continuously exposed to harmful pollutants such as dust, smoke, and toxic chemicals, which may cause dryness, irritation, acne, premature aging, and dullness. To overcome these effects, a herbal gel containing natural ingredients was prepared.

The formulation included herbal ingredients such as aloe vera, neem, turmeric, green tea extract, glycerin, and rose water. These ingredients were selected because of their antioxidant, antimicrobial, moisturizing, and soothing properties. The gel was prepared using a suitable gelling agent and evaluated for various parameters such as appearance, color, odor, pH, consistency, spreadability, washability, and stability.

The prepared gel showed good physical characteristics with smooth texture, non-greasy nature, and easy spreadability. The pH was found to be compatible with skin, indicating safe topical application. Stability studies also showed that the formulation remained stable without significant changes in appearance or texture. The herbal anti-pollution gel was found to be effective, economical, and suitable for daily skincare use.

## X. CONCLUSION

From the present study, it can be concluded that the herbal anti-pollution gel was successfully formulated and evaluated. The prepared gel exhibited satisfactory physical properties such as good appearance, smooth consistency, easy spreadability, and skin-friendly pH. The herbal ingredients used in the formulation provided antioxidant, antimicrobial, moisturizing, and protective effects against environmental pollutants.

The formulation was found to be stable and safe for topical application. The use of natural herbal ingredients makes the gel safer and more beneficial compared to synthetic chemical-based products. Therefore, the developed herbal anti-pollution gel can be considered an effective skincare formulation for protecting the skin from harmful effects of pollution and maintaining healthy skin.

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