

# Green Alternatives to Synthetic Acid–Base Indicators: A Quantitative Study of Apocynaceae Floral Extracts

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## Abstract

*This study evaluates floral extracts from the Apocynaceae family as sustainable alternatives to synthetic acid–base indicators. Flowers from Catharanthus roseus, Allamanda cathartica, Cascabela thevetia, Allamanda blanchetii, Catharanthus coriaceus, and Tabernaemontana divaricata were collected from Khairahani Municipality, Nepal, and analyzed for pigment composition. Anthocyanins, flavonoids, carotenoids, and alkaloids were identified, contributing to distinct pH-sensitive color changes. Comparative titration with synthetic indicators showed that Allamanda blanchetii and T. divaricata provided sharp, clear endpoints like phenolphthalein. The findings demonstrate that these plant-based indicators are biodegradable, non-toxic, cost-effective, and consistent with green chemistry principles, offering a viable alternative for analytical and educational applications while reducing environmental impact. This is the first reported study in Nepal assessing Apocynaceae species for analytical purposes.*

**Keywords:** *Allamanda blanchetii, Tabernaemontana divaricata, anthocyanins, Apocynaceae, eco-friendly alternatives.* Bottom of Form

## Introduction

Acid–base indicators play a critical role in analytical chemistry, particularly in volumetric analysis, where accurate endpoint detection is essential for reliable quantitative results. Green chemistry is the practice of a set of principles that decrease the use of hazardous substances in the design, manufacture and applications of chemical products. Green chemistry means the concept of design which were first formulated at the beginning of the 1990s. It inserts novelty, planning and systematic conception. It includes careful planning of molecular design and chemical synthesis. It's means goal to achieve sustainability at the molecular level. It has displayed how chemist can design next generation products and processes thus they are beneficial for human health and the environment(Warner et al., 2004a). Many universities offer the classes on green chemistry and many sectors like as aerospace, automobile, cosmetic pharmaceutical use principle and application of green chemistry. Those use of natural indicator in place of synthetic indicator is one of the practices of green chemistry.

(Warner et al., 2004b)

### **Synthetic Indicators**

Robert Boyle is supposed as the originator of indicator chemistry. A precise definition of a chemical indicator has been given by Kolthoff, "An indicator is a substance which indicates the extent to which a reaction between two or more reactants occurs" (Baker, A. 1964). Indicator is a substance which shows the different color in different medium as an acid base medium. Mostly the indicators are used in laboratory to distinguish the characteristics of acid and base. From the different investigation acid is a substance which gives a proton (to other substance and can dissolve in water having the value less than 7. It has sour taste and may cause damaging the metal. Similarly, the base is an antithesis of acid base is planned to element that have a more than 7. It has bitter taste if the acid and base react with each other than neutralization reaction take place between them to form a salt. The point at which finalized neutralization is executed is called equivalent point.

### **Apocynaceae family as a natural indicator**

3,91,000 plant species recognize to science as of 2021. Among APG identified approximately 416 plant families. Among them Apocynaceae family are endangered due to habitat destruction, climate change and other human activities. It is one of the biggest family in plant kingdom. It includes 424 genera 4600 species well recognized and well gardening genera of Apocynaceae family (Patil et al., 2023). Thus, family plant can be used as a natural indicator because it contains natural pigments such as anthocyanin, flavone, saponin, glycosides, coumarins, and can display distinct color change. Among such natural pigments anthocyanin is a water soluble and flavones are water and alcohol soluble pigments. They are commonly found in flower, leaves, fruits of the plant. They give sharp and passionate color change (Jeeva & Joselin, 2014). Those natural indicators can use as an alternative source of synthetics of indicator. Natural indicators are biodegradable less toxic and cheapest (Nag et al., 2023).

### **Acid – Base Indicators**

Acid – Base indicators are either a weak base or weak acid which is introduced to a solution in small quantity to visually examine the and colour change when the changes. According to Arrhenius model, an indicator is a chemical indicator. (Garg Guru Ramdas Khalsa & Garg Guru Ramdas Khalsa, 2018).

### **Sources of Synthetic Indicators**

Nowadays we are using different kind of synthetic indicator. Such indicators are extracted by using certain chemical which can be shown in table 1 below.

**Table 1:** Artificial indicator with their source

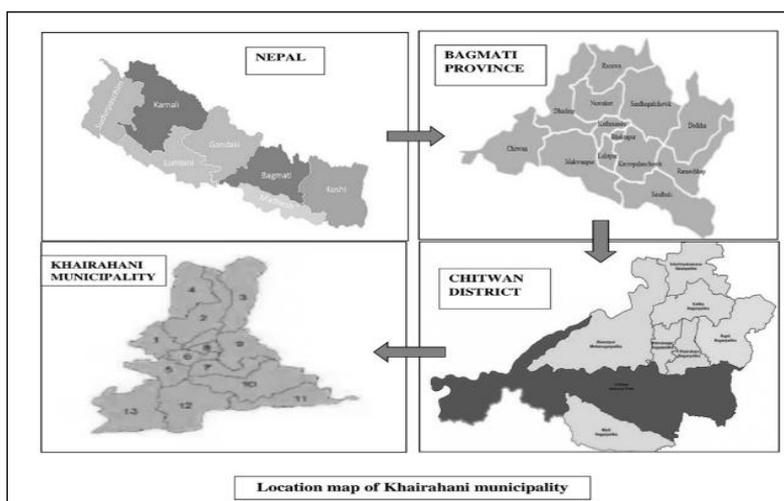
Indicator	Source Type	Source Details
Phenolphthalein	Synthetic	Prepared chemically from phthalic anhydride and phenol in acidic medium
Methyl Orange	Synthetic	A Synthetic azo dye from sulfanilic acid and dimethylaniline
Methyl Red	Synthetic	Prepared from anthranilic acid and dimethylaniline
Bromothymol Blue	Synthetic	Prepared from dibromothymol sulfonphthalein
Thymol Blue	Synthetic	Prepared from thymol and sulfonphthalein derivatives

## Materials and Methods

### Study Area

The study area includes Khairahani Municipality located in Chitwan district in Bagmati province. Previously it lies Narayani zone of southern Nepal, which was established on 8 may 2014 by merging the existing Khairahani, Kumroj and Chainpur under newly introduced federal system in the country. The altitude of Khairahani Municipality ranges from 182m to 673m from the mean sea level. It consists of 97% of gentle and 3% of moderate area.

**Fig 1:** Location Map of Khairahani Municipality



**Size and location:** Khairahani municipality have an area of 85.75 Sq. km. It lies between 27.571°N latitude and 84.571°E longitude. It is 190 km south-west of the Kathmandu valley. The boundary of the Khairahani has been delineated as follow:

**East:** Rapti Municipality

**West:** Ratnanagar Municipality

**North:** Kalika Municipality

**South:** Chitwan National Park and Madi Municipality

## **Materials**

### **Plant Materials**

- Catharanthus roseus (dark pink)
- Allamanda cathartica
- Cascabela thevetia L.
- Catharanthus roseus (light pink)
- Allamanda blanchetii
- Catharanthus coriaceus mark gr.
- Catharanthus roseus (white)
- Tabernaemontana divarticata

For this study, fresh petals of six different flowers—*Catharanthus roseus*, *Allamanda cathartica*, *Cascabela thevetia*, *Allamanda blanchetii*, *Patharanthus coriaceus*, and *Tabernaemontana divaricata*—were collected from Khairahani Municipality, cleaned with distilled water, dried in a hot air oven, and ground into fine powder using mortar and pestle. Extracts were prepared by mixing 20–30 ml of distilled water or ethanol (for carotenoid-rich petals) with the powdered samples, and the resulting slurry was filtered to obtain clear extracts, which were stored in airtight vials under refrigeration to preserve pigment stability. For titration, a standard acid–base system (0.1N HCl vs 0.1N NaOH) was set up, with 25 ml of HCl pipetted into a conical flask and titrated against NaOH from a burette. Synthetic indicators (phenolphthalein, methyl orange, bromothymol blue) and the prepared natural flower extracts were tested by adding 2–3 drops to the acid solution, and the endpoint was determined by observing a stable color change. Each titration was repeated at least three times to ensure accuracy and reliability.

## **Result and Discussions**

The flower of Apocyanaceae family were studied for the natural indicators. From the tests performed, it was found that different natural pigments were present in the flowers of Apocynaceae family. Thus, they used as a natural indicator.

## Qualitative analysis of phytochemical in Apocynaceae family

**Table 2:** Results of the phytochemical screening of flower extract of Apocynaceae family

Plant Name	Plant color	Plant Extract Color	Natural Pigment Type
Cantharanthus Roseus	Dark Pink	Pinky – Violet	Anthocyanins
Allamanda Cathartica	Golden Yellow	Redish	Anthocyanins
Cantharanthus Roseus	Light Pink	Yellow	Anthocyanins
Cantharanthus Roseus	White	Yellow	Anthocyanins
Cascabela thevetia	Pale Yellow	Pale Yellow	Carotenoids, Flavonoids
Allamanda Blanchetii	Purple	Deep Violet	Carotenoids, Flavonoids
Catharanthus Coriaceus	White Pink	Pinkish Red	Anthocyanins
Tabernaemontana Divaricata	White	Lightly Kenish	Alkaloids, Flavonoids

In this study, the results of phytochemicals revealed of Anthocyanins, Carotenoids, Flavonoids, Alkaloids in plant extract were reported. The phytochemicals natural pigments in most of the plant extract had diverse biological properties as analgesic, anti – carcinogenic, anti – inflammatory and antioxidant activities. They employed in the treatment of diabetes, piles, for managing itching, hair loss. It also applied in the case of gastrointestinal and skin disorders. Whereas according to the investigation phytochemical screening showed the presence of anthocyanin, carotenoids, flavonoids, Alkaloid, Flavone, saponin, Comorians, glycosides in the plant extract.

The previous literature also supported that the analysis of natural indicators showed. The presence of anthocyanin, carotenoids, flavonoids, Alkaloids, flavone, saponin, coumarins, glycosides. There was also report that Anthocyanin is one of the most found natural pigments in the most of flower of Apocynaceae family plant. Anthocyanin rich flowers like catharanthus roseus and Allamanda blanchetii produce vivid extracts that change color sharply with pH. Carotenoid rich flowers like cascabela thevetia and A. cathartic tend to produce yellowich extracts that change color unclearly with pH. Similarly, Tabernaemontana divaricate is not usually pigmented in flower, but it contains Alkaloid sometimes, so the extract color comes from leaf, and it shows

weak indicator due to change color unclearly.

### **Acid – Base Titration of synthetic indicators**

**Table – 3:** *Titration of synthetic indicators.*

Indicator Name	Color in Acid	Color in Base	pH Range	Endpoint Visibility
Phenolphthalein	Colorless	Pink		Excellent
Methyl Orange	Red	Yellow		Very good
Methyl Red	Red	Yellow		Good
Litmus	Red	Blue		Fair
Bromothymol Blue	Yellow	Blue		Excellent
Thymol Blue	Red – Yellow	Yellow – Blue	1.2 – 2.8 / 8 – 9.6	Good to Excellent

Phenolphthalein and Bromothymol Blue are the synthetic indicators. They are widely used due to its clear and sharp transition, especially for strong base – strong and titration. Methyl orange is usually useful for strong acid – weak base titration due to its low pH transition range. It shows clear contrast litmus is typically not used in precise titration because it shows broader range of pH that reduces sharpness. Thymol Blue shows dual range of pH and color. It is usually used for weak acid and weak base titration.

### **Acid – Base Titration of Natural indicator**

**Table – 4:** *Titration of natural indicators*

Plant Name	Color in Acid	Color in Base	Endpoint Sharpness
Dark pink – Catharanthus roseus	Wine red	Pink	Moderate
Light pink – Catharanthus roseus	Light pink	Pale purple	Moderate
White Catharanthus roseus	Faint Yellow	Colorless	Moderate
Catharanthus Coriaceus	Yellow	Greenish	Faint
Allamanda Cathartica	Pale Yellow	Orange	Sharp
Cascabela thevetia	Light orange	Red	Moderate
Allamanda blanchetii	Lavender	Blue	Sharp
Tabernaemontana divaricata	White	Purple	Very sharp

The experiment shows how different plant extracts behave as natural indicators during acid–base titration. Each plant contains its own natural pigments, which make the colour change unique.

*Catharanthus roseus*, whether dark pink, light pink, or white, produces only a moderate colour shift. The change can be noticed, but it is not very strong or sharp. For example, the dark pink variety turns from wine red to pink, and the light pink one shifts from light pink to pale purple. These changes are visible but not striking enough for quick judgment. Similarly, the white variety moves from faint yellow to colourless, which is quite subtle.

*Catharanthus coriaceus* is even less effective. Its change from yellow to greenish is weak and not clear enough to be useful, as the shades are too close and can easily confuse the observer.

On the other hand, *Allamanda cathartica* shows a very clear and strong transition from pale yellow to orange. The colour is bright and obvious, making it easy to recognize the endpoint. *Cascabela thevetia* also shows a clear but slightly softer shift from light orange to red, which makes it moderately good but not as strong as *Allamanda cathartica*.

*Allamanda blanchetii* stands out because it produces a distinct and sharp transition from lavender to blue. This clear change makes it highly effective and reliable, very much like the commonly used laboratory indicators.

The strongest performance is seen with *Tabernaemontana divaricata*. Its transformation from white to purple is fast, sharp, and extremely easy to spot. The high contrast between the two colors makes it an excellent choice among all the tested plants.

In short, plants like *Allamanda cathartica*, *Allamanda blanchetii*, and *Tabernaemontana divaricata* provide sharp and striking color changes, making them very effective as natural indicators, while *Catharanthus* species and *Catharanthus coriaceus* are less reliable due to their weaker or less visible shifts.

## **Conclusion**

In this thesis work, by the help of Acid – base titration of indicator in the lab, color change was determined in acidic and basic medium. This method is safe, easy and reliable. The analysis showed that the sample was collected from the Khairahani Municipality i.e. flower of Apocynaceae family, contains natural pigment which help to show sharp and fast color change. In my study, I compared the natural indicators with synthetic indicators.

Synthetic indicators are toxic, hazardous, expensive thus many people attract on natural indicators. Natural indicator contains natural pigments such as anthocyanin,

flavonoids, carotenoids, glycosides, saponin, tannins etc. so, they can be used as an alternative of synthetic indicator. It shows sharp and distinct colour change in Acid base titration. It is non-toxic, non-hazardous, cheaper, eco-friendly based on the concept of green chemistry and sustainable. This study also suggested that the natural plants, specially Apocynaceae family plant extracts possess antibacterial, analgesic, anti-carcinogenic, anti-inflammatory, antioxidant activity, which might be helpful in preventing or slowing the process of bacterial and fungal related disease as well as hair loss problem.

### **Limitation of The Work**

The pigment concentration in natural indicators can vary due to plant age, soil, climate and season which causes inconsistent color intensity and pH sensitivity that making it different to standardize.

Natural extracts are biodegradable and may lose their indicators properties over time due to oxidation, microbial growth.

It takes more time thus it is called time consuming procedures.

### **Recommendation**

following points can note as recommendation.

Only natural extract of the plant has been used in this study. Further trials should be done by using acid and base.

Both qualitative and quantitative analysis should be conducted.

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