A COMPREHENSIVE STUDY OF ALLERGENIC POLLEN PLANTS: DISTRIBUTION IN FIVE UNITS OF COCHIN CORPORATION, ERNAKULAM DISTRICT, KERALA.

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DEPARTMENT OF BOTANY AND CENTER FOR RESEARCH
ST.TERESA’S COLLEGE (AUTONOMOUS), ERNAKULAM
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A COMPREHENSIVE STUDY OF ALLERGENIC POLLEN PLANTS: DISTRIBUTION IN FIVE UNITS OF COCHIN CORPORATION, ERNAKULAM DISTRICT, KERALA.

DISSERTATION SUBMITTED TO THE MAHATMA GANDHI UNIVERSITY, KOTTAYAM IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF

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CERTIFICATE

This is to certify that the dissertation entitled "**A STUDY OF ALLERGENIC POLLEN PLANTS: DISTRIBUTION IN FIVE UNITS OF COCHIN CORPORATION, ERNAKULAM DISTRICT, KERALA**" is an authentic record of work carried out by **CATHY SURYA** under my supervision and guidance in the partial fulfilment of the requirement of the M. Sc. Degree of Mahatma Gandhi University, Kottayam. I, further certify that no part of the work embodied in this dissertation work has been submitted for the award of any other degree or diploma.

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ABSTRACT

The study envisages the dynamics of pollen allergies in urban environments through an integrated approach combining plant morphology studies, pollen morphology data, weather parameters and plant diversity matrices. The significant influence of weather parameters such as temperature, precipitation, humidity, wind speed and cloud cover on pollen production and dispersal patterns. Elevated temperatures and increased precipitation stimulate plant growth and flowering, consequently leading to high pollen production and allergen exposure. Moreover, higher humidity levels and wind speeds facilitate pollen dispersion, increasing allergic reactions among susceptible individuals. Several abundant allergenic plant species, trees such as *Mangifera indica*, *Cocos nucifera* and herbs such as *Elusine indica* and *Panicum repens* contribute significantly to pollen allergy prevalence in urban environments. Utilizing Shannon diversity indices, the locations were characterized by higher diversity harbour a wider range of allergenic plant species, thereby elevating pollen allergy risk. Insights gathered from personal interviews shed light on peak allergy periods and common precautionary measures adopted by affected individuals. This information can serve as a valuable resource for healthcare providers and policymakers in devising strategies to support individuals affected by pollen allergies. The study aims to develop a pollen calendar, laying the foundation for future research and providing insights into seasonal pollen allergy prevalence.

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CHAPTER 1

1.0 INTRODUCTION

1.1 BACKGROUND

The rise in allergies and changing climate underlines the importance of understanding how pollen spreads in the air (Demain et al., 2021). Pollen calendars are vital for understanding and managing allergies, providing essential details on the time and manner in which airborne pollen spreads in a particular area.

In recent years, the study of airborne pollen has gained increasing importance because pollen grains impact approximately 40% of the global population and it stands as a significant contributor to chronic respiratory illness on a global scale (Wang et al., 2018). Air pollution, climate change and decreased biodiversity resulting from urbanization lead to more respiratory diseases like allergic rhinitis and asthma affecting human health (Singh et al., 2021). Urbanization is linked to decreased contact with natural surroundings (Haahtela et al., 2015). Monitoring pollen is essential, particularly given the anthropogenic changes that impact the physiology and composition of airborne pollen (Ravindra et al., 2021). Identifying plants that trigger allergies is challenging due to their lack of conspicuous flowers. The widespread growth of weeds and trees, coupled with air pollution from greenhouse gases generated by rising traffic levels and the construction of modern structures and factories, contributes to allergy-inducing environments (Oh, 2022). Pollen calendars are crucial for understanding pollen distribution, facilitating the assessment of allergenic risks and assisting in creating effective strategies to manage them.

This dissertation examines the detailed creation of a pollen calendar, concentrating on 5 Wards in Cochin Corporation, located in Ernakulam district of Kerala. The study covers the late North eastern monsoon and early premonsoon months of December through March, capturing changes in pollen levels and their potential effects on respiratory health. The Cochin Corporation is located centrally in the district and serves as a significant hub for culture, education and commercial centres featuring diverse types of residential and commercial buildings (Bernard-Verdier et al., 2022).

1.2 SIGNIFICANCE

This study aims to offer localised data from five specific units within the Cochin Corporation, to inform evidence-based decision-making for managing allergies at the community level. Cochin Corporation is an urbanized area that has a high population and pollution. Climate change and pollution can have a significant impact on this study. This study investigates pollen-allergic plants and their distribution.

1.3 HISTORY

An allergic response is characterized by an overactive reaction from our immune system when exposed to a specific foreign substance. The notion of allergy was first introduced between 1906 and 1907 by Clements Von Pirquet, a Viennese paediatrician. His observation of heightened sensitivity in some patients to typically harmless elements like dust, pollen or specific foods led him to coin the term “allergy”. The term itself originates from the ancient Greek words “allos” signifying different and “ergon” denoting work or action. “Airborne allergens” are commonly called as “aeroallergens” (Sushama et al., 2018). Ancient medical texts from around the second century BCE noted symptoms associated with pollen allergies. By the mid-20th century, scientists started examining pollen calendars to monitor the seasonal patterns of different types of allergic pollen (Lo et al., 2019).

1.4 RESPIRATORY ALLERGIES AND CLIMATE CHANGE

Conditions like allergic rhinitis, allergic rhinoconjunctivitis and asthma are widespread globally, especially in developed countries. Around 300 million people worldwide have asthma and 500 million experience allergic rhinitis with 200 million having asthma along with it (Suanno et al., 2021). Pollen is a frequent trigger for respiratory diseases, with over 150 pollen proteins confirmed to induce allergic sensitization (Xie et al., 2019).

Exposure to environmental contaminants and climate change has been demonstrated to have dangerous effects on human health. They have been linked to the start and aggravation of allergic rhinitis and asthma, as well as some bouts of exacerbation of the condition (D’Amato et al., 2020). Over the past 50 years, reports from developed countries consistently indicate an increasing incidence of allergic diseases. Clinical observations show that respiratory disorders including asthma and allergic rhinitis are becoming more common and more prevalent (Damialis et al., 2019).

Environmental control has been suggested as a method to lessen the health issues caused by allergic rhinitis (AR) and asthma. This mainly focuses on managing indoor environments since they are more controllable compared to outdoor settings. However, outdoor allergens can still enter indoors through open windows and doors. Although allergic individuals cannot change outdoor factors like pollen, fungi, air pollution etc, they can minimise exposure by staying indoors during high-exposure times and living in areas with lower exposure levels (Geller et al.,2019).

1.5 POLLEN GRAINS

Pollen serves as a male gametophyte in Spermatophyta, which includes both gymnosperms and angiosperms. It develops in the anther or pollen sac, where the tapetum- a transient, sporophytic, apoptotic tissue located between the maternal plant tissues and the gametophytic generation provides nutrition (Pacini et al, 2020). The inner pollen wall is known as intine composed of cellulose and pectin and the outer wall is known to be exine. This outer wall protects pollen grains from disintegration. Pollen tube arises from the apertures seen on exine. The major portion of pollen grains in the air are derived from anemophilous plants *(*Asam et al., 2015). These plants produce a large number of pollens to increase their contact with female flowers. The dimensions of pollen vary, with the largest grains measuring between 5 and 200 micrometres in size. Upon release, the pollen is transported by the wind, ranging from a few hours to several days (Sabo et al., 2015).

Wind carries the pollen grains of anemophilous species, which produce abundant pollen to increase the likelihood of effective fertilization in female flowers. Most species are known to cause allergies are anemophilous (Thibaudon et al., 2017). Pollen grains from anemophilous plants typically small and either spherical or flattened. Examination of exine thickness and surface texture revealed that anemophilous pollen grains generally have thinner exine layers and less intricate surface patterns compared to entomophilous pollen grains (Lu&Liu, 2022).

Global literature consistently reports grass pollen as the predominant air-borne allergen across the world. This is attributed to the widespread presence of various grass species and the elevated allergenic nature of their pollen. The family Poaceae, encompassing a considerable number of plants globally, is particularly notable for its predominantly wind-pollinated species (Damialis, A et al., 2019).

1.6 POLLEN ALLERGY

An allergy is characterised as an extremely sensitive reaction that someone experiences when exposed to a substance that typically poses no threat to healthy individuals. Allergic rhinitis (AR), characterized by type I hypersensitivity reaction, is frequently triggered by airborne allergens such as pollen from plants, dust mites and household dust (Yokoi et al., 2022). AR happens when the allergen triggers mast cells or basophils to release immune mediators like cytokines, which in turn promote the maturation of T helper 2 cells and inflammation in the mucosal lining (Li et al., 2023). Pollinosis, pollen allergy or hay fever are the terms used to describe the symptoms triggered by pollen grains, such as sneezing, runny nose, nasal congestion, nose itching and red irritated eyes. This is mainly caused by having an allergy to specific pollens of grasses and trees. The common symptoms include

- Sneezing along with a runny nose
- Itching in the eye, nose, throat
- Dark circles developing under the eyes (Khandelwal et al., 2019)

Pollen is one of the major components of airborne particles. The study of airborne pollen particles is known as Aeropalynology (Agashe, 2021). Understanding the seasonal variations of pollen types in the atmosphere helps to identify allergens present at specific times and treat patients with allergic disorders. This knowledge also assists in planning travel for individuals suffering from pollen-related allergies. Additionally, pollen grains are being investigated as carriers of COVID-19 infection (Chaurasia, 2021). The size of pollen greatly depends on the type of allergy it causes. Hay fever-causing pollen grains are small and light, easily carried by wind (Khandelwal et al., 2019).

1.7 POLLEN CALENDAR

A pollen calendar serves as a valuable tool to identify the allergenic potential of different pollen types present in the air at specific times of the year (Oh, 2023). Pollen calendars are crucial in understanding and managing allergic diseases caused by airborne pollen (Kumar & Kumar, 2022). By documenting the prevalence and distribution of pollen, the calendar provides crucial insights for diagnosing and treating hypersensitive allergic disorders.

1.8 OBJECTIVES

- To conduct a comprehensive study of the allergic potential of anemophilous plants of Cochin corporation in Ernakulam District.
- To understand the weather patterns and their potential impact on pollen distribution.
- To study their abundance, distribution and the allergic reactions they cause in the local population.
- To identify and characterize pollen morphology and allergenic potential of some of the plants studied using microscopic techniques.
- To develop a Pollen Calendar to raise awareness among the local communities regarding pollen-related issues and their implications.

CHAPTER 2

2.0 REVIEW OF LITERATURE

John Bostock, a physician at Guy's Hospital in London, first identified clinical symptoms of Hay fever in 1819 (Bostock, 1819). Later, Dr. Donald reported that his symptoms of sneezing, itchy eyes and nasal congestion were limited to the summer months. In 1828, "he realized that his symptoms were associated with the cutting of hay and deduced that his problems were somehow related to substances emanating from hay." He so developed the name "hay fever" (Donald, 1995).

Millions of people worldwide were diagnosed with seasonal allergies and asthma during the twentieth century. (Smith, 2014). It is now understood that over 150 allergens found in grasses, trees and weeds can cause allergic responses (Pablos, 2016). Anemophilous plants are common causes of hay fever due to their airborne pollen, while insect-pollinated plants are less likely to induce allergies. Some plants use a combination of both mechanisms, producing pollen that can become airborne (amphiphily) (Oh & Oh, 2018).

Grass pollen from the Poaceae family is a significant airborne biological pollutant that causes pollen allergies. Cross-reactivity among different grass species and urban pollution increases immune responses. The timing and intensity of pollen seasons are genetically determined but influenced by climate change, making them susceptible to changes that can affect airborne pollen concentrations (García-Mozo, 2017)

The study of (Bose et al., 2023) discusses that medicinal herbs also trigger allergic reactions and the overactive immune response involved in allergies. It focuses on plant-based materials like pollens, medicinal plants, fruits, and latex, and their clinical significance in causing airway and skin allergies. (Green et al., 2018) reviews about hay fever and seasonal allergies. It discusses ways to reduce exposure to allergens, like selecting low-allergenic plants and avoiding exposure to other biological hazards. The article of (Taia, 2020) analyzed pollen grains from sixteen wild plants, shrubs, and road trees using SEM to study and photograph their morphology. It also assessed mineral and protein content. The findings suggest allergies are influenced by factors like pollen grain density, air pollution, and humidity, rather than being specific to certain types of flora. (Oh, 2022) discusses the impact of airborne pollens on respiratory allergies in a changing global environment. It highlights the increasing prevalence and challenges of managing allergic diseases caused by pollens. The interactions between pollens, weather, and air pollution in a changing environment remain poorly understood. The article underscores the importance of monitoring and managing pollen allergies in the context of climate change and calls for proactive measures to reduce associated risks to human health.

The study of (Singh et al., 2017) correlated pollen counts with the number of hospital visits by asthmatic and allergic rhinitis patients in Jaipur, India. It revealed two seasonal peaks in pollen counts during March – April and August- October. Grass pollen counts showed a significant correlation with the number of new patients, unlike tree and weed pollen. This study mainly shows the importance of understanding pollen seasons for managing asthma and allergic rhinitis effectively.

The review of (Brake et al., 2023) explores how meteorological and environmental factors affect pollen counts, allergenicity and symptom thresholds in individuals with allergies. It summarises various variables affecting pollen levels and allergen load for symptom induction varied across studies based on pollen type. Symptoms diseases and locations highlight the complex interplay between environmental biological factors influencing power and religious allergic diseases. (Bhawnani et al., 2020) found that various types of plant pollens respond differently to different meteorological conditions. Factors such as temperature, humidity, cloud cover, wind speed, and air pressure can all influence pollen levels in India. (Schramm et al., 2021) analysed 93 studies and discovered that warmer temperatures are associated with earlier and longer pollen seasons, along with increased pollen levels. Precipitation has different effects on pollen concentration and season timing, potentially leading to short-term decreases, followed by long-term variations.

The study of (Raj, 2018) compared intradermal skin test results among 1000 patients at a Respiratory Allergy and Immunology Clinic in Thiruvananthapuram, Kerala, revealing a predominant posture response to *Cocos nucifera* antigen. Male patients, especially those with an asthma history, exhibited significant skin test positivity. According to a study of (Verma et al., 2014) Cassia, Ageratum, Salvadora, Ricinus, *Albizia lebbeck* and *Artemisia scoparia* have been reported as important aeroallergens from South India. (Chaurasia, 2021) reviewed that predominant pollen grains in the Southern region of India were *Peltophorum pterocarpum, Ageratum conyzoides, Tridax procumbens, Cocos nucifera and Pithecolobium dulce.* (García-Mozo, 2017) discussed in this review about grass allergens, sensitization and the dynamics of airborne pollen. He also reviewed that Poaceae pollen is the leading airborne biological pollutant that causes pollen allergy worldwide. (Olowokudejo et al., 2017) conducted a study on aero pollen in Nigeria, which revealed the dominance of Poaceae and Cyperaceae members.

(Gyandeo et al., 2017) conducted a study in Central Maharashtra, India on respiratory allergic diseases. Skin prick tests were performed and results showed the one of the most prevalent allergic plants is Peltophorum. (Butt et al., 2018) studied pollen grains of 12 species from Cyperaceae under a light microscope and scanning electron microscope. (Mosquera et al., 2019) in Colombia Cyperaceae, Poaceae, *Mimosa pudica* L. and *Ricinus communis* L. were identified as highly allergenic types and Psidium guajava was categorized as not very allergenic type. (Sabit et al., 2020) done skin prick tests on some arboreal plants and results show greater pollen allergy in the case of *Mangifera indica*, compared to *Cocos nucifera, Mimosa spp, Terminalia catappa* etc.

The study of (Martínez-Bracero et al., 2015) focuses on creating pollen calendars of cities in Andalusia, Spain, based on a 10-year historical database of airborne pollen counts. The study points out the importance of pollen calendars for preventing hay fever by identifying the timing and intensity of pollen seasons. Variations in pollen spectra and season duration among the cities emphasize the urban landscape's diversity and the impact of green areas on pollen levels. In a study by (Katotomichelaki et al., 2015) the clinical importance of the pollen calendar in Western Thrace, an area with a Mediterranean climate, was investigated. The research revealed that olive, oak, grass, and cypress were the most commonly found pollen grains, with higher concentrations and longer pollination periods. (Park, 2020) introduces a new pollen calendar for South Korea, Highlighting significant regional differences in allergenic pollen distribution and the impact of climate and ecological changes on pollen counts.

CHAPTER 3

3.0 MATERIALS AND METHODOLOGY

3.1 MATERIALS

a. Field survey

- Collection bags: Durable bags with ample space during fieldwork were used for gathering plant specimens.
- Scissors: Sharp cutting tools were used for safely and effectively cutting plant samples.
- Gloves: Disposable gloves were used to prevent contact with allergenic plants and other potential hazards.
- Field notebook: For recording plant species, location and observation details a field book was carried.
- Smartphone with GPS capability: For accurate recording of geographic coordinates of plant locations GPS apps were used.

b. Herbarium Materials

Herbarium sheets or mounting paper: Used for preserving plant specimens.

Plant press: For flattening and drying collected plant specimens, wooden presses with adjustable straps for uniform pressing.

Plant identification guides or keys: For accurate species identification Flora of Presidency of Madras was used.

Labels: For labelling herbarium specimens with collection information.

c. Pollen Collection

- Containers: Clean, airtight containers for preserving pollen samples.
- Forceps: For safely picking up pollen grains during collection.

Sampling materials: Such as glass slides, coverslips, staining solution (Acetocarmine), acetic acid, mounting medium (Glycerin) and light microscope with camera for microscopic analysis.

3.2 METHODOLOGY

3.2.1 RESEARCH DESIGN

The Cochin Corporation lies (76° 14' E to 76° 21' E and 9° 52' to 10° 14' N). The body of Cochin is the municipal body in charge of managing Kochi. The city is split into 74 administrative wards (Phan, 2014). This area faces considerable environmental difficulties, including air pollution. Rapid urbanisation industrial operations automobile emissions all contribute to increased levels of air pollution in the region, putting inhabitants' health in danger.

This study adopts a quantitative research design, aiming to meticulously construct a comprehensive pollen calendar encompassing five distinct units within the expansive Cochin Corporation area. This urban expanse is renowned for its multifaceted socio-economic landscape and diverse geographical features. Spanning a duration of four months, from December 2023 through March 2024, the research strategically encompasses this timeframe to capture the seasonal fluctuations in pollen distribution characteristic of the region. This study endeavours to capture the full spectrum of seasonal variations in pollen abundance and distribution patterns.

3.2.2 STUDY AREA

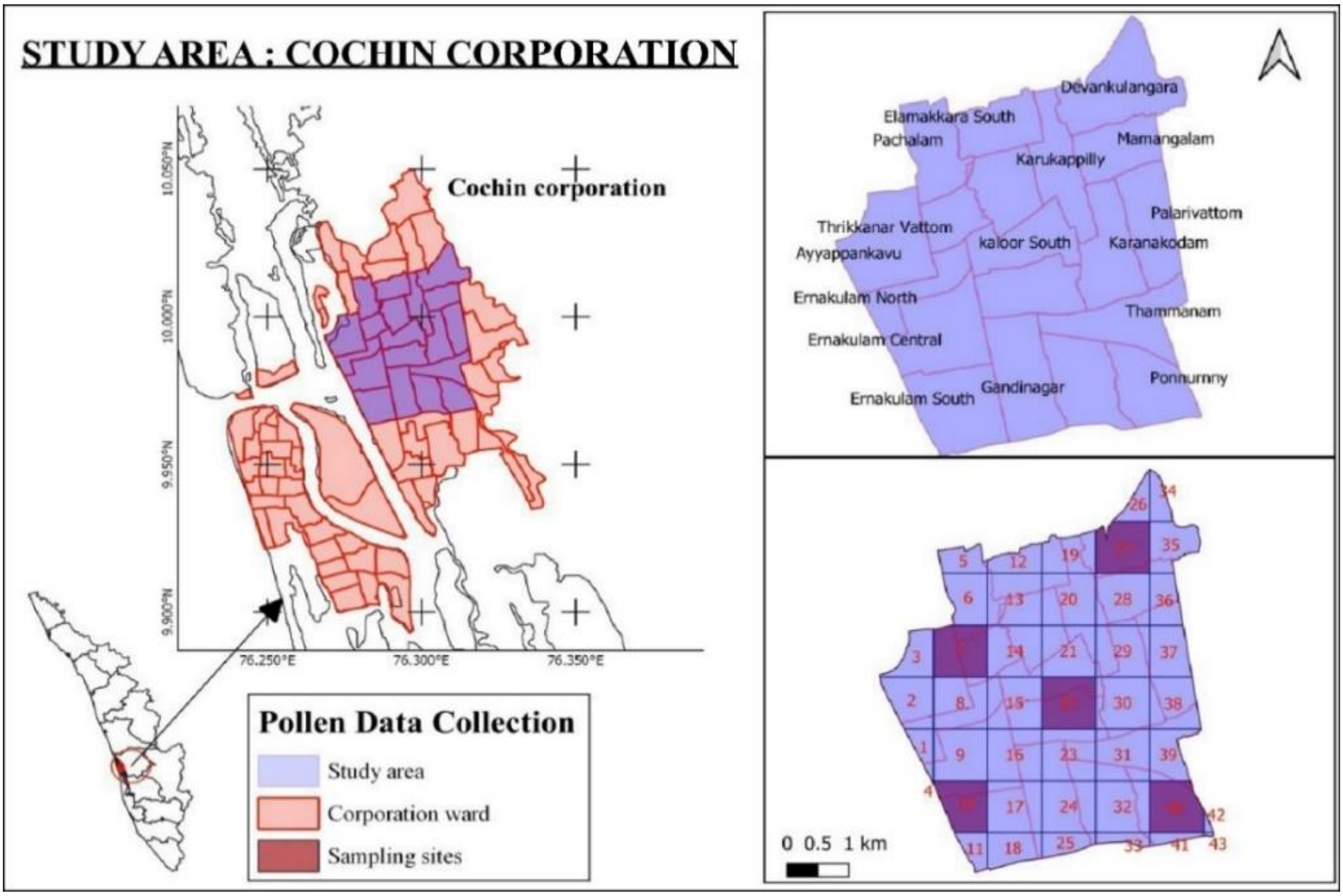

Fig:1 Map of Cochin Corporation showing the study areas

The study area encompasses the Cochin Corporation and extends over an expansive territory measuring a total area of approximately 94 square kilometres. The body of Cochin is the municipal body in charge of managing Kochi. The city is split into 74 administrative wards. Employing advanced Geographic Information Systems (GIS) technology, the area was partitioned into 43 specially defined units, with each unit spanning an area of 3 square kilometres. This methodological approach facilitated a granular and systematic analysis of the study area, allowing for a detailed examination of pollen distribution patterns and associated environmental factors.

3.2.3 SAMPLING DESIGN

A stratified random sampling approach was employed to ensure representation across the study area. The stratification was based on the 43 delineated units, each representing a homogenous geographical region within Cochin Corporation. (Wang et al., 2018 with slight changes).

3.2.4 SAMPLE SELECTION

To ensure representativeness and minimize bias, 5 units were randomly selected from the 43 units formed. This randomly selected process was conducted to facilitate convenience in travel logistics and ensure comprehensive coverage of the study area. The selection of 5 units from the total of 43 ensures a sufficient sample size for meaningful analysis while balancing the constraints of time and resources.

The five units selected are

1. Ponnurunni
2. Devankulangara
3. Pachalam
4. Ernakulam South
5. Kaloor South

3.2.5 DATA COLLECTION

The data collection involves 4 main components: Meteorological data collection, a Survey of residents, and a botanical survey to asses pollen allergy and identify pollen allergy-causing plants in five units of Cochin Corporation and microscopic analysis of pollen samples from selected plant species in the field.

- Meteorological Data Collection: The meteorological data for December 2023 to March 2024 were collected from www.visualcrossing.com. Parameters collected include temperature, humidity, wind speed, cloud cover and precipitation.
- Public survey: The participants were selected using a convenience sampling method, targeting individuals residing in residential areas within the five selected units of Cochin Corporation. A total of 50 participants were surveyed.

- Field Survey: The abundance of pollen allergy-causing plants especially wind-pollinating plants was assessed within each unit, sampling sites were selected based on vegetation, density and accessibility, ensuring representative coverage of each ward.
- Assessment of pollen-allergic plant abundance: Abundance data collected for herbs and trees known to cause pollen allergies. Species diversity was quantified using the Shannon-Wiener index.
- Microscopic analysis: Slides were prepared from pollen samples collected from various plant species. Pollens were done acetolysis and the slides were stained with Acetocarmine to enhance visibility, and pollen grains were examined under a light microscope for morphological characterization.

a. METEOROLOGICAL DATA COLLECTION

For the compilation of the pollen calendar, meteorological data was collected from the website www.visualcrossing.com. The chosen parameters included temperature, wind speed, humidity, cloud cover and rainfall. These factors were selected as they have been shown to influence pollen dispersal and airborne pollen concentrations.

b. PUBLIC SURVEY

The survey was done by directly approaching individuals within the selected wards. The participants were selected using a convenience sampling method.

A structured questionnaire was designed and administered to participants to collect data on pollen allergy symptoms and related factors. In addition to direct surveys, Google Forms was utilized as an online data collection tool, allowing broader participation and convenience for respondents. The questionnaire included four sections: Participant demographics (age, gender and ward number), allergic rhinitis and asthma symptoms (frequency severity and presence of each sneezing rhinorrhea, blocked nose and difficulty breathing), symptoms management, medication and immunotherapy use and often ended question on how symptoms are managed (Medek et al., 2019).

With participant consent, images were captured during the survey process to document the data collection environment and context. However, due to ethical considerations, only images from consenting participants were included in the study. The data collected from the survey responses are stored securely and analysed to identify patients of pollen allergy prevalence and symptom, severity among residents of the five wards. Before participation, respondents were provided with detailed information about the study objectives, procedures, and their rights as participants. Informed consent was obtained from all the participants. Participants were given the option to decline participation or to exclude their images from the study without any repercussions. The data from the Google Form is evaluated and transformed into a graph for further investigation.

Image 1: Images from resident survey

c. FIELD SURVEY

A botanical survey was conducted in each unit to identify and quantify the number and abundance of pollen allergy-causing plants. The survey involves systematic observations of vegetation in each uni. The presence of known allergenic plant species specifically herbs and trees where recorded and estimated their abundance. The plants were identified and authenticated from St. Teresa's College, Ernakulam. The flowering status of pollen allergy causing plants was meticulously observed, documenting the presence of flowers and their flowering timing throughout the study period. These data were collected through regular field visits to ensure comprehensive and accurate data collection. During the field survey, certain plant specimens were gathered and subsequently preserved in an herbarium.

Image 2: Pictures taken during Botanical survey

d. ASSESSMENT OF POLLEN ALLERGIC PLANT ABUNDANCE

Abundance data was collected for both herbaceous and tree species known to elicit pollen allergies. The number of individual plants belonging to each pollen-allergic species was recorded within predetermined sampling plots to quantify their abundance in each ward. Species diversity within each ward was quantified using the Shannon - Wiener index. The abundance was calculated by dividing the number of individuals of species by the total number of individuals observed in the ward.

$H' = -\sum_{i=1}^{s} pi \ln pi$ (Rad et al., 2009).

e. HERBARIUM PREPARATION

To establish the herbarium, samples of anemophilic herbs and trees were carefully collected processed and pressed. The data set for sample collection includes the botanical binomial, date of collection, geographical coordinates of the location and the identity of the individual responsible for collecting each sample.

f. LIGHT MICROSCOPIC ANALYSIS OF POLLEN GRAINS

Fresh flowers of different pollen-allergenic plants were collected early in the morning before anthesis from the study area in the period of December 2023 to March 2024.

Plants such as *Pennisetum polystachion, Panicum repens, Kyllinga brevifolia, Mangifera indica, Peltophorum pterocarpum, Ricinus communis, Tridax procumbens, Terminalia catappa, Mimusops elengi* were collected and pollen morphology was studied by acetolysis method (Basarkar et al., 2017). The anthers were isolated from these flowers and arranged on a glass slide. One drop of acetic acid was poured onto the anthers, and they were crushed with the help of a glass rod. After removing the debris, the slide was stained with acetocarmine and mounted with glycerine (Raees et al., 2017, Amina et al., 2020). Olympus binocular microscope was used to study the characteristics of pollen. Pollen micrographs were taken at 40x resolution. The photographs were taken with the help of Magnus Vision software.

g. FIELD BOOK

A field book was combined to document plant information encompassing botanical binomial, growth habit, botanical family, collection date and a brief portrayal of each plant's characteristics This comprehensive record serves as a valuable resource for further botanical analysis and research works.

CHAPTER 4

4.0 OBSERVATIONS AND RESULTS

The anemophilous plants that have been observed in selected units of Cochin Corporation.

a. Pachalam

Plants	Family	Habit
Kyllinga brevifolia	Cyperaceae	Herb
Panicum repens	Poaceae	Herb
Panicum maximum	Poaceae	Herb
Elusine indica	Poaceae	Herb
Pennisetum polystachion	Poaceae	Herb
Bambusa vulgaris	Poaceae	Herb
Cyanthillium cinereum	Asteraceae	Herb
Tridax procumbens	Asteraceae	Herb
Psidium guajava	Myrtaceae	Tree
Mangifera indica	Anacardiaceae	Tree
Tectona grandis	Lamiaceae	Tree
Cassia fistula	Fabaceae	Tree
Cocos nucifera	Arecaceae	Tree
Dypsis lutescens	Arecaceae	Tree
Roystonea regia	Arecaceae	Tree
Crystostachys renda	Arecaceae	Tree
Areca catechu	Arecaceae	Tree
Artocarpus heterophyllus	Moraceae	Tree
Azadiracta indica	Meliaceae	Tree
Samanea saman	Fabaceae	Tree
Casuarina equisetifolia	Casuarinaceae	Tree
Peltophorum pterocarpum	Fabaceae	Tree
Ricinus communis	Euphorbiaceae	Herb
Terminalia catappa	Combretaceae	Tree

b. Devankulangara

Plant	Family	Habit
Elusine indica	Poaceae	Herb
Panicum repens	Poaceae	Herb
Panicum maximum	Poaceae	Herb
Bambusa vulgaris	Poaceae	Herb
Dendrocalamus strictus	Poaceace	Herb
Eragostis amabilis	Poaceae	Herb
Eragostis tenella	Poaceae	Herb
Dactyloctenium aegyptium	Astereaceae	Herb
Cyanthillium cinereum	Astereaceae	Herb
Mikania micrantha	Asteraceae	Herb
Mangifera indica	Anacardiaceae	Tree
Psidium guajava	Myrtaceae	Tree
Syzigium cumini	Myrtaceae	Tree
Tectona grandis	Lamiaceae	Tree
Cassia fistula	Fabaceae	Tree
Samanea saman	Fabaceae	Tree
Terminalia catappa	Combretaceae	Tree
Dypsis lutescens	Arecaceae	Tree
Cocos nucifera	Arecaceae	Tree
Areca catechu	Arecaceae	Tree
Mimusopus elengi	Sapotaceae	Tree
Artocarpus heterophyllus	Moraceae	Tree

c. Ponnurunni

Plant	Family	Plant type
Mikania micrantha	Asteraceae	Herb
Cyanthilium cinereum	Asteraceae	Herb
Panicum repens	Poaceae	Herb
Panicum maximum	Poaceae	Herb
Tridax procumbens	Asteraceae	Herb

Elusine indica	Poaceae	Herb
Mimosa pudica	Fabaceae	Herb
Kyllinga brevifolia	Cyperaceae	Herb
Pennisetum polystachion	Poaceae	Herb
Amaranthus dubius	Amaranthaceae	Herb
Amaranthus spinosus	Amaranthaceae	Herb
Begonia grandis	Begoniaceae	Herb
Mangifera indica	Anacardiaceae	Tree
Artocarpus heterophyllus	Moraceae	Tree
Artocarpus atilis	Moraceae	Tree
Roystonea regia	Arecaceae	Tree
Cocos nucifera	Arecaceae	Tree
Areca catechu	Arecaceae	Tree
Terminalia catappa	Combretaceae	Tree
Crystostachys renda	Arecaceae	Tree
Samanea saman	Fabaceae	Tree
Cassia fistula	Fabaceae	Tree
Peltophorum pterocarpum	Fabaceae	Tree
Tectona grandis	Lamiaceae	Tree
Psidium guajava	Myrtaceae	Tree
Azadiracta indica	Meliacaeae	Tree

d. Kaloor South

Plant	Fabaceae	Habit
Mikania micrantha	Asteraceae	Herb
Cyanthillium cinereum	Asteraceae	Herb
Panicum repens	Poaceae	Herb
Panicum maximum	Poaceae	Herb
Megathyrsus maximus	Poaceae	Herb
Elusine indica	Poaceae	Herb
Pennisetum polystachion	Poaceae	Herb
Bambusa vulgaris	Poaceae	Herb
Argostis gigantea	Poaceae	Herb
Chloris barbata	Poaceae	Herb

Mimosa pudica	Fabaceae	Herb
Peltophorum pterocarpum	Fabaceae	Tree
Samanea saman	Fabaceae	Tree
Cassia fistula	Fabaceae	Tree
Mimusops elengi	Fabaceae	Tree
Dypsis lutescens	Arecaceae	Tree
Cocos nucifera	Arecaceae	Tree
Crystostachys renda	Arecaceae	Tree
Roystonea regia	Arecaceae	Tree
Tectona grandis	Lamiaceae	Tree
Terminalia catappa	Combretaceae	Tree
Mangifera indica	Anacardiaceae	Tree
Artocarpus heterophyllus	Moraceae	Tree

e. Ernakulam South

Plant	Family	Habit
Mikania micrantha	Asteraceae	Herb
Cyanthillium cinereum	Asteraceae	Herb
Tridax procumbens	Asteraceae	Herb
Amaranthus spinosus	Amaranthaceae	Herb
Cynodon dactylon	Poaceae	Herb
Kyllinga brevifolia	Poaceae	Herb
Megathyrsus maximus	Poaceae	Herb
Pennisetum polystachion	Poaceae	Herb
Panicum repens	Poaceae	Herb
Elusine indica	Poaceae	Herb
Eragostis amabilis	Poaceae	Herb
Bambusa vulgaris	Poaceae	Herb
Crystostachys renda	Arecaceae	Tree
Roystonea regia	Arecaceae	Tree
Cocos nucifera	Arecaceae	Tree
Dypsis lutescens	Arecaceae	Tree
Terminalia catappa	Combretaceae	Tree
Mangifera indica	Anacardiaceae	Tree
Psidium guajava	Myrtaceae	Tree

Syzigium cumini	Myrtaceae	Tree
Artocarpus heterophyllus	Moraceae	Tree
Cassia fistula	Fabaceae	Tree
Samanea saman	Fabaceae	Tree
Peltophorum pterocarpum	Fabaceae	Tree
Azadiracta indica	Meliaceae	Tree

4.1 Morphological Characters of Plants Studied

1. *Kyllinga brevifolia Rottb.* (Image 3:1)

Erect perennial herb, leaves are acuminate, leathery. The stem is triangular and erect. The inflorescence is whitish globose, spike and bracteate. The spikes are solitary and globose. The spikelets are numerous.

2. *Panicum repens* L. (Image 3:2)

Perennial, rhizomatous, creeping. Stems are erect and tall. Leaves are simple, alternate, and vertically erect. Leaf sheaths are glabrous, and striate. The inflorescence is a panicle with obliquely erect branches with small groups of spikelets. The spikelets are oval and slightly purple.

3. *Panicum maximum* (Image 3: 3)

Perennial tufted grass with short rhizomes. The stem has a height of 2 metres. Leaf sheaths are present at the base, it is covered with hairs. The leaves are blade-shaped, glabrous to pubescent. The inflorescence is a large multibranched, open panicle. Spikelets are green to purple.

4. *Eleusine indica* L. (Image 3:4)

It is a perennial plant. They grow as tufts or mats. The culms are slender and compressed. The leaves are alternate in arrangement and the leaf blade is flat and linear, they have prominent midrib and have a rough texture. The culms have spike-like raceme inflorescences that arise from the centre of the tuft. It consists of small spikelets arranged along the central axis.

5. *Pennisetum polystachion* (Image 3: 5)

It is a perennial grass species that typically grows in clumps. The leaves are linear, elongated and lanceolate. Leaf blades are flat and slightly folded. The inflorescence is a terminal spike. The spikelets are yellowish-brown to purple. The stems are erect and usually stout.

6. *Bambusa vulgaris* (Image 3: 7)

It is a large perennial and woody plant. It is seen as dense clumps. The culms are cylindrical and upright. The culms are green to yellowish. The internodes are hollow. The leaves are long, narrow and lanceolate. They are arranged in an alternative manner. Branches are present and usually in whorls or clusters. These branches *have smaller leaves.*

7. *Cyanthillium cinereum* L. (Image 3: 8)

It is a small, herbaceous perennial plant. The stems are usually erect, slender, branched and small hairs are present. Leaves are simple, pubescent, lanceolate to ovate with serrated margins. Leaves are arranged in opposite manner and sessile. The plant produces small flower heads arranged in clusters at the end of branches. Numerous tiny purple disc florets are present surrounded by bracts.

8. *Tridax procumbens* L. (Image 3: 9)

It is a low-growing herbaceous, perennial plant. They grow as tufts or mats. Stems are prostrate, green, hairy and branching seen from the base. The leaves are simple, opposite and sessile. The leaf is lanceolate to ovate with a serrated margin. The plant produces small head flowers arranged in clusters at the end of the branch. The inflorescence has yellow ray florets surrounding with tiny yellow disc florets. The ray florets are strap-shaped and the disc florets are tubular and bisexual.

9. *Eragostis amabilis* L. (Image 3: 10)

It is a perennial plant that is tufted forming clumps. The stems are slender, erect and smooth. The leaves are linear with pointed tips. Leaf blades are usually flat. The plant produces open, spreading panicles at the tip of the stems. The panicles are composed of numerous spikelets. The spikelets are small, narrow and compressed.

10. *Eragostis tenella* L. (Image 3: 39)

It is an annual plant species with tufted growth. The leaves are linear and narrow, with green to bluish green. They are shorter than the flowering stem. The plant consists of an open panicle, and it bears numerous spikelets. The spikelets are small and have three florets.

11. *Dactyloctenium aegyptium* L. (Image 3:11)

It is a perennial grass that typically forms mats. Stems are prostrate, often rooting occurring at the nodes that touch the ground. The leaves are arranged in an alternate manner, simple and linear in shape. The leaf sheath is split open along one side. The inflorescence produces compact, spike-like inflorescence at the tips of the stem. The inflorescence is composed of small, closely packed spikelets. Each spikelets contain many florets.

12. *Megathyrsus maximus* (Image 3:14)

It is a tall robust grass, that grows in large clumps. The leaves are long, and narrow and are arranged alternately. The inflorescence is a large open panicle. Each spikelet contains multiple small flowers.

13. *Mimosa pudica* L. (Image 3: 13)

It is a sensitive plant having multiple leaflets. When touched the leaves fold inward. The stems are prickly with branching. The flowers are pink with head inflorescence.

14. *Chloris barbata* Sw. (Image 3: 12)

The plant is a perennial herb, with narrow, linear leaves. The inflorescence is cylindrical spike like structure known as panicle. The panicle consist of numerous spikelets.

15. *Argostis gigantea* Roth. (Image 3: 6)

It is a perennial grass species forming dense clumps. The leaves are narrow and linear, with smooth texture. The inflorescence is open panicle, which bear small flowers.

16. *Mikania micrantha* Kunth. (Image 3: 15)

It is a fast-growing perennial vine that can climb over other vegetation and form a dense mat. The stems are slender and wiry. They have small hooked hairs present. The leaves are heart-shaped, with serrated edges and prominent veins. They are arranged alternately.

17. *Begonia grandis* Dryand. (Image 4: 16)

It is a herbaceous perennial plant. The stems are erect and reddish. The leaves are large and heart or kidney-shaped with serrated margins. The colour changes from green to reddish green. The plant produces delicate flowers.

18. *Amaranthus dubius* Mart. ex Thell. (Image 4:17)

It is an annual herbaceous plant that reaches a height of 50-100 cm. It has erect, branching branches and leaves that range from lanceolate to ovate. The leaves range in colour from green to reddish-purple and have a smooth or slightly serrated border. The plant has small, inconspicuous green blooms grouped in dense, terminal spikes. The seeds are tiny, glossy, black, and wrapped in a papery capsule.

19. *Amaranthus spinosus* L. (Image 4: 18)

It is an annual herbaceous plant. It grows erect, with a branching stem coated in sharp spines. The leaves are alternating, oval to lanceolate in form, and frequently show a reddish colour. Green to reddish-brown blooms grow in thick, spiky clusters at the terminals of the stems. The seeds are tiny, glossy, and black.

20. *Psidium guajava* L. (Image 4: 19)

It is a medium-sized evergreen tree. The bark of guava is smooth, thin and copper coloured. It produces white latex when cut. The leaves are simple, opposite and elliptical. Leaf margins are smooth and aromatic. White flowers with numerous stamens and a pistil. The flowers are solitary or arranged in small clusters in leaf axils.

21. *Mangifera indica* L. (Image 4: 20)

It is a large evergreen tree. It has a spreading canopy with a rounded to oval shape. The bark is smooth in younger ones and rough in older ones. The leaves are simple, alternate, and lanceolate in shape with entire margins. They are typically dark green and it is glossy on the upper surface and light green on the underside. The flowers are small and fragrant, inflorescence is a panicle. The flowers have five sepals and petals and are white to yellow. The fruit is observed and is drupe with single large seed surrounded with fibrous flesh.

22. *Tectona grandis* L.f. (Image 4: 22)

The plant is a large typically straight tree. It has a cylindrical trunk. The bark is greyish-brown with longitudinal fissures and ridges. The leaves are simple, opposite and elliptic to ovate-oblong in shape. The leaves are dark green, glossy on the upper surface and pale green on the underside. It has an entire margin. The flowers are small, white to light pink and arranged in panicles. Each flower has five petals and numerous stamens.

23. *Cassia fistula* L. (Image 4: 25)

It is a medium-sized deciduous tree. The leaves are paripinnately compound, arranged alternately on the branches. The flowers are bright yellow and fragrant, arranged in pendulous clusters called racemes. Each flower has five petals and numerous stamens. The fruits are long pods with a hard shell.

24. *Cocos nucifera* L. (Image 4: 21)

It is a tall tree. The trunk is slender, and greyish brown. The leaves are pinnate and spirally arranged at the top of the trunk and form a dense canopy. The plant produces clusters of flowers in spadix inflorescence.

25. *Dypsis lutescens* (Image 4:23)

The plant produces multiple stems from the base. The stems are slender, upright and smooth. The stem is golden yellow when young. The leaves are pinnate and are arranged in a spiral manner. Leaflets are lanceolate to linear in shape with pointed tip.

26. *Roystonea regia* (Kunth) O.F.Cook (Image 4: 24)

It is a tall, single-stemmed straight plant with a smooth trunk having a small bulge at the base. The trunk is greyish and cylindrical. The leaves are large, pinnate and arranged in a spiral manner at the top of the trunk.

Each leaf possesses numerous leaflets that are arranged on either side of the trunk. Leaflets are lanceolate to oblong.

27. *Crystostachys renda* (Image 4: 26)

The plant produces multiple stems from the base. The stems are slender, upright and smooth, typically green or brownish. The leaves are pinnate and arranged in a spiral pattern along the stems. Each leaf possesses numerous leaflets arranged on either side of the rachis. The leaflets are narrow and elongated with pointed ends and they are green in colour.

28. *Dendrocalamus strictus* (Roxb.) Nees (Image 4:27)

The plant is a large, clumping bamboo species with thick-walled culms, straight and cylindrical. The internodes are short. The leaves are large and elongated with lanceolate leaf blades. They are alternately arranged along the culm. They may produce branches at the nodes.

29. *Areca catechu* L. (Image 4: 28)

Areca catechu is a medium-sized palm tree. It has slender, straight stems with greyish to brownish bark and huge, green, glossy pinnate leaves. The leaves are arranged spirally at the top of the trunk. Leaflets are arranged on either side of the central axis. The leaflets are lanceolate to oblong with pointed tips.

30. *Artocarpus heterophyllus* Lam. (Image 5: 29)

The plant is a large, evergreen tree. It has a dense spreading canopy. The leaves are alternate, simple, elliptical and have entire margins. The leaves are glossy, dark green upper surface and light green underside. The fruit of this plant is oblong to oval shape, with a spiky surface. The skin turns green to yellow and ripes.

31. *Artocarpus atilis* (Image 5: 30)

The plant is a large evergreen tree with a dense canopy. The leaves are simple, alternate and large. The leaf shape is ovate to elliptic with a pointed tip and entire margin. Leaves have a glossy, dark green upper surface and light gree-underside. Large stipules are present at the base of petioles. The fruit is large and ovoid. The skin turns yellow from green when ripe. The flesh is white creamy to pale yellow.

32. *Azadiracta indica* (Image 5: 31)

The plant is a medium-sized evergreen tree with a spreading canopy with a dense and round shape. The stem is smooth and greyish-brown. The leaves are compound, alternate and pinnate. The leaflet is lanceolate to ovate with serrated margins. The leaves are having a bitter taste.

33. *Samanea saman* (Image 5: 32)

The plant is a large-sized tree with a broad, spreading canopy. The trunk is typically short. The bark is grey to dark brown. The leaves are bipinnate, which is composed of multiple leaflets. Leaflets are small, oval to elliptical. The inflorescence is a large, spherical cluster of small fragrant flowers.

34. *Casuarina equisetifolia* (Image 5: 33)

It is a medium to large-sized tree, which has a conical crown. The bark is rough and reddish brown to greyish brown. The branches are thin and bear numerous branchlets that resemble pine needles. The leaves are reduced to scale-like leaves that are arranged in whorls around the nodes of branchlets.

35. *Peltophorum pterocarpum* (Image 5: 35)

It is a big deciduous tree with a spreading, umbrella-shaped canopy, a short, crooked trunk, and rough, greyish-brown bark. The leaves are bipinnate, alternating and include several tiny leaflets. The tree bears bright yellow flowers in dense, terminal clusters. The fruits are flat, woody pods that turn brown when mature and contain numerous seeds.

36. *Ricinus communis* (Image 5: 36)

It is a tall upright shrub with a woody stem which is usually reddish brown to purplish. The leaves are large, palmately lobed and arranged alternately. Leaves are lanceolate to ovate with a bright green colour and glossy appearance. The plant produces terminal clusters of yellow flowers.

37. *Terminalia catappa* (Image 5: 37)

The plant is a big, deciduous tree. It has a spreading canopy, a straight trunk and smooth greyish-brown bark. The leaves are simple, alternate and widely elliptic in shape.

38. *Mimusops elengi* (Image 5: 34)

It is a medium-sized evergreen tree. The tree has a dense, rounded canopy, a straight, slender trunk, and smooth, greyish-brown bark. The leaves are simple, alternating, and elliptic to oblong in form, with glossy green upper surfaces and pale undersides. The tree has small, white, fragrant blooms that grow singly or in clusters in the leaf axils. The fruits are oval, meaty drupes that turn green to yellow-orange when mature.

39. *Syzigium cumini* (Image 5: 38)

It is a medium-sized evergreen tree. The bark is smooth and grey. The leaves are simple, opposite and elliptical to oblong in shape, with a glossy dark green upper surface and light green lower surface. The flowers are small, fragrant, white to cream coloured.

Image 3: Habit of wind pollinating plants. 1. *Kyllinga brevifolia,* 2. *Panicum repens* 3. *Panicum maximum* 4. *Elusine indica* 5. *Pennisetum polystachion* 6. *Argostis gigantea* 7. *Bambusa vulgaris* 8. *Cyanthillium cinereum* 9. *Tridax procumbens* 10. *Eragostis amabilis* 11. *Dactyloctenium aegyptium* 12. *Chloris barbata* 13. *Mimosa pudica* 14. *Megathyrsus maximus* 15. *Mikania micrantha*

Image 4: Habit of wind pollinating plants. 16. *Begonia grandis* 17. *Amaranthus dubius* 18. *Amaranthus spinosus* 19. *Psidium guajava* 20. *Mangifera indica* 21. *Cocos nucifera* 22. *Tectona grandis* 23. *Dypsis lutescens* 24. *Roystonea regia* 25. *Cassia fistula* 26. *Crystostachys renda* 27. *Dendrocalamus strictus* 28. *Areca catechu*

Image 5: Habit of wind pollinating plants. 29. *Artocarpus heterophyllus* 30. *Artocarpus atilis* 31. *Azadiracta indica* 32. *Samanea saman* 33. *Casuarina equisetifolia 34. Mimusops elengi* 35. *Peltophorum pterocarpum* 36. *Ricinus communis* 37. *Terminalia catappa* 38. *Syzigium cumini* 39. *Eragostis tenella.*

4.2 Microscopic analysis of Pollen grains of some pollen-allergic plants

a. Peltophorum pterocarpum: Peltophorum p. has medium sized (26 to 50µm) pollen units, Known as monads, which are dispersed during pollination. They possess three colporate apertures and exhibit a spheroidal shape with a circular outline in a polar view. (Fig 2: f, Fig 3: a). (Halbritter & Weis, 2016).

b. *Tridax procumbens: Tridax procumbens* is a medium-sized (26 to 50µm) plant. They are monads and they possess colporate structure with four sunken apertures, indicating tetracolporate aperture type. They are characterized by a spheroidal shape with a circular outline in a polar view. (Fig 2: c, Fig 3: b). (Halbritter, 2019)

c. *Ricinus communis: Ricinus communis* has a medium size (26-50µm) and is spheroidal with a circular outline in polar view. But in hydrated form, the pollen's size decreases to 21 to 25µm. The orientation is oblique and the pollen is colporate, with three sunken colporus apertures (Diamantino et al., 2016) (Fig 2: a)

d. *Mimusops elengi: Mimusops e.* pollen is medium-sized ranging from 26 to 50µm. Upon hydration, the pollen size narrows to 26 to 30 µm. In equatorial or polar views, the pollen exhibits a quadrangular outline, indicative of its corporate class and polarity. The pollen's aperture structure consists of four colporus apertures, reflecting its tetracolporate (Heigl, 2021) (Fig 2: e)

e. *Syzigium cumini*: *Syzigium c.* has a small size ranging from 10 to 25µm. When hydrated the pollen size and polar axis length vary. They belong to the synaperturate class with isopolar polarity. In the polar view, they exhibit an oblique dominant orientation. The dry pollen shows an aperture number of 3 with colporus-type aperture (Heigl, 2021).

f. Amaranthus spinosus : Amaranthus spinosus, typically observed as monads, have a size range of 10 to 25µm. Upon hydration, they exhibit sizes ranging from 16 to 21µm. They belong to the synaperture class, the polarity is isopolar. The dominant orientation is oblique. They are colporus type (Franssen et al., 2001). (Fig 2: b, Fig 3: c).

g. Kyllinga brevifolia : Pollen of *Kyllinga brevifolia* is heteropolar, the medium size is 10 to 25µm and has four apertures with one distal ulceroid aperture. Pollen grains are subspheroidal and triangular in outline. They shows oblique orientation (Selamoğlu & Vural, 2022). (Fig 2: c, Fig 3: d).

h. *Mangifera indica :* Pollen grains of *Mangifera indica are* observed as monads, they are relatively large with a size range of 25 to 40µm. They belong to syncolpate class, the polarity is isopolar and the outline is rounded or elliptical (Muniraja et al., 2020). (Fig 2: f, Fig 3: e)

i. *Panicum repens:*They are observed as monads, they are relatively small, within the range of 20 to 30 µm. The pollen is monoporate (El-Amier, 2015) (Fig 2: h).

j: *Terminalia catappa* : The pollen units are monads, they are small in size, measuring between 10-25µm, having hydrated size of 16-20µm. They are from the class colporate, with isopolar polarity. The outline is circular, with oblique orientation. They posess three apertures of colporus type (Heigl, 2021).

k. *Cocos nucifera:* They are typically small to medium size, 28 to 32µm. they are frequently elongated, mainly asymmetric. They possess smooth to finely granular surfaces (Rasheed, 2016) (Fig 3: f).

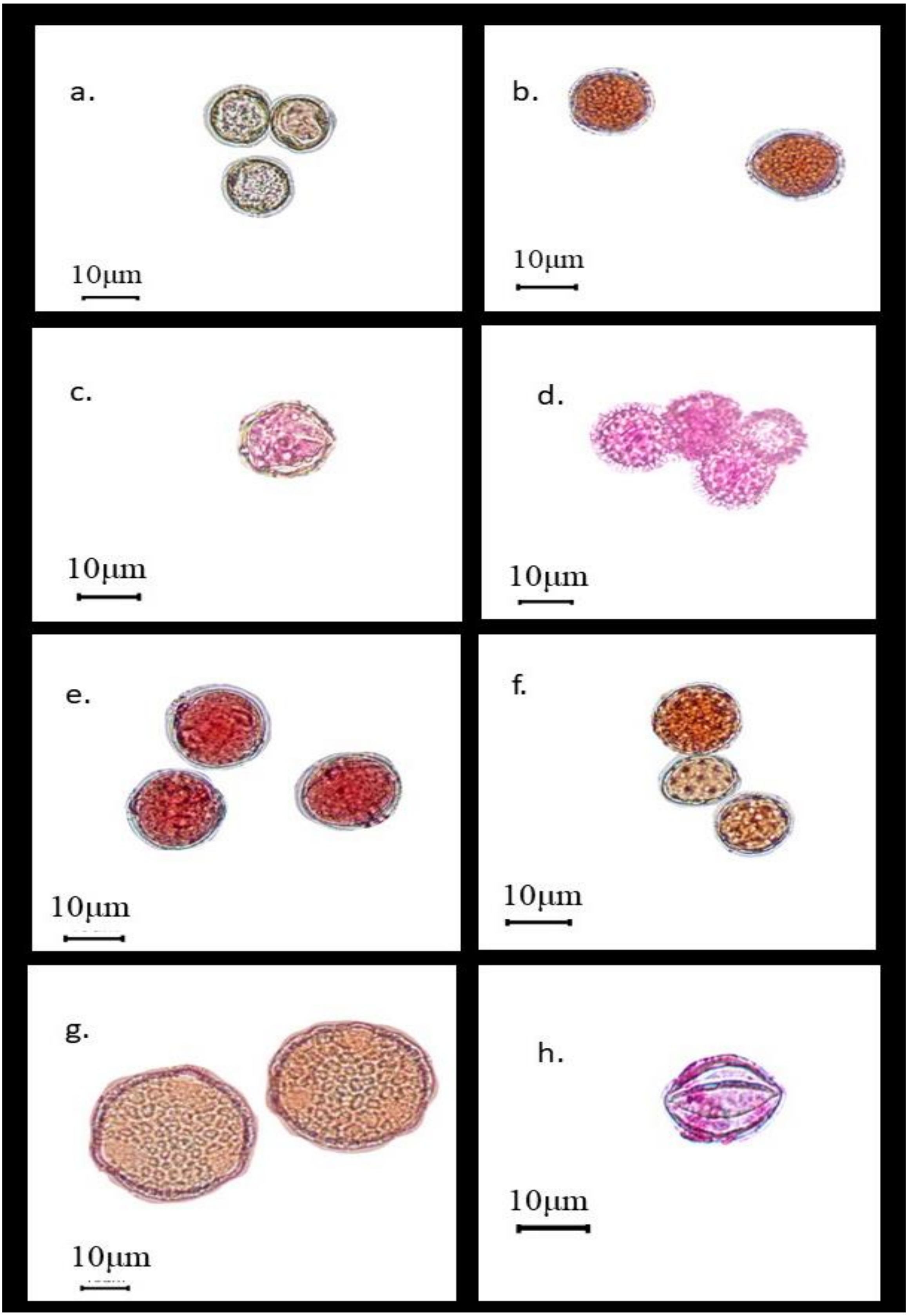

Fig 2: Light microscopic images of Pollen allergic plants. a. *Ricinus c.,* b. *Amaranthus s., c. Kyllinga b.,* d. *Tridax p.*, e. *Mimusops e.*, f. *Mangifera i.,* g. *Peltophorum p., h. Panicum r.*

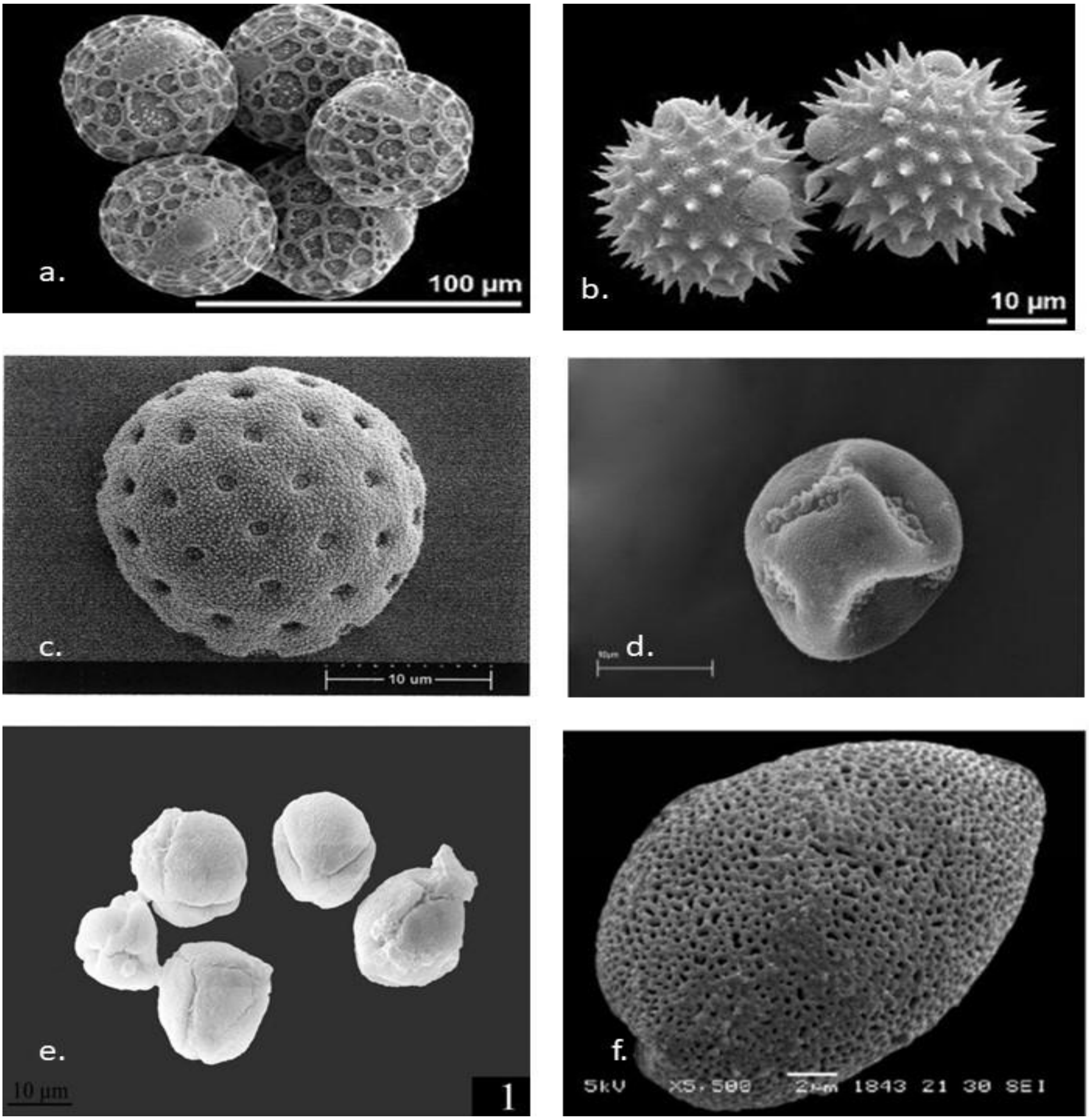

Fig 3: SEM images of Pollen allergic plants. a. *Peltophorum p.* (Halbritter &Weis, 2016), b.*Tridax p.* (Halbritter, 2019), c. *Amaranthus s.*(Franssen et al., 2001), d. *Kyllinga b*. (Selamoğlu & Vurul, 2022), e. *Mangifera i.,* (Muniraja et al., 2020), f. *Cocos n.* (Rasheed, 2016).

4.3 RESULT

4.3.1 Physicochemical parameters

During the four-month study period (late northeast monsoon and early premonsoon) from December to March, varying weather conditions were observed across the five wards of Cochin Corporation. Meteorological data, including temperature, humidity, wind speed and cloud cover were collected from these areas.

a. Temperature, Precipitation

The plotted graphs of temperature and precipitation data across the five wards in Cochin Corporation revealed minimal fluctuations over the four months from December to March. Mean temperatures remained relatively stable, ranging from 28°C in December to 30°C in March. Precipitation levels exhibited similarly low variability across the study area (Fig:4).

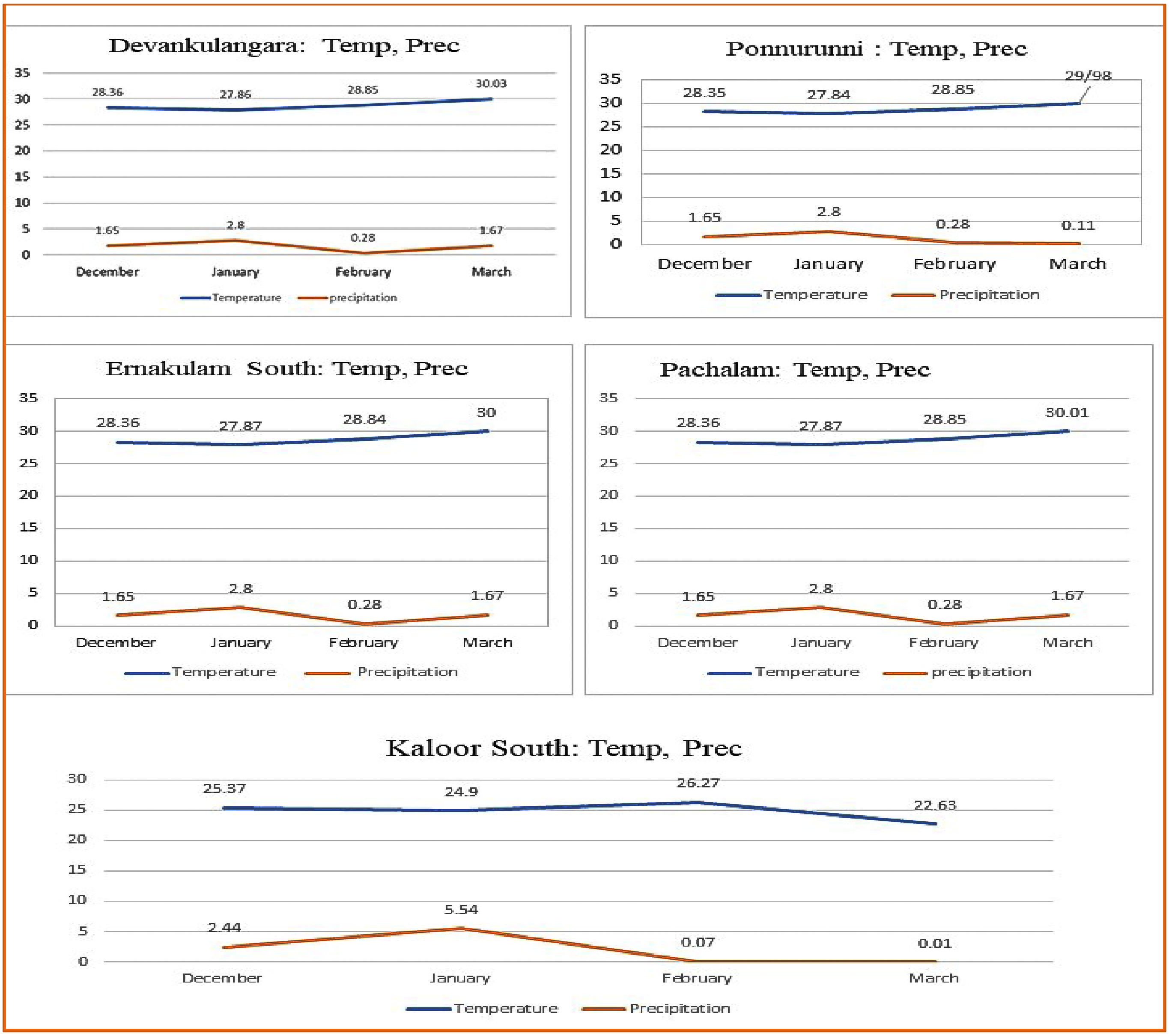

Fig 4: Temperature and Precipitation graphs of five wards in months of December to March

b.Windspeed

Windspeed data exhibited limited variability across the wards, with mean wind speeds ranging from 13km/h to 17 km/h over the study period in Ponnurunni and 13 km/h to 21km/hr in other wards (Fig:5).

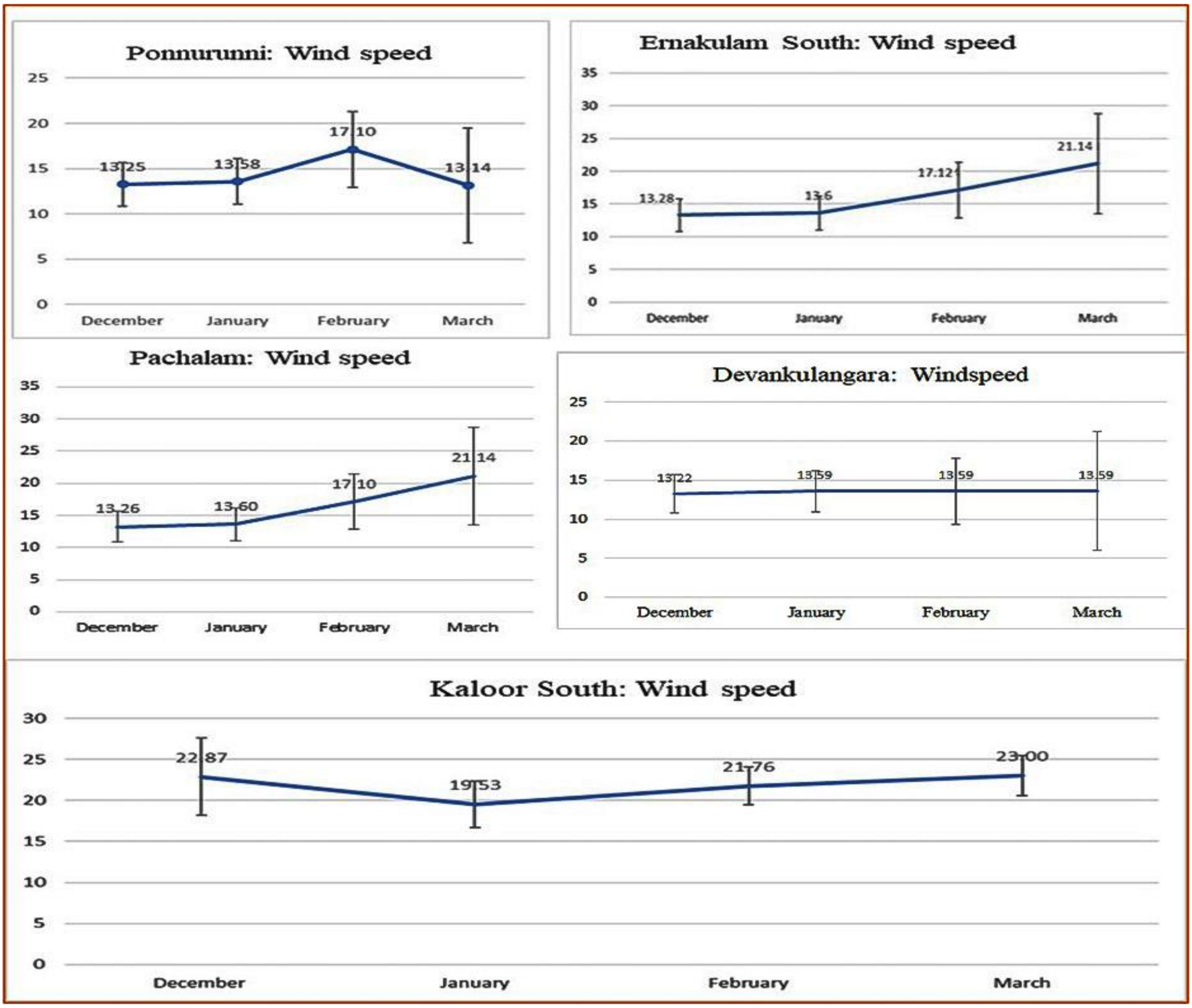

Fig 5: Windspeed data of Five wards from December to March

b. Humidity

Humidity levels remained relatively constant across the five wards, with mean relative humidity percentages ranging from 69% 76% throughout the four months (Fig:6).

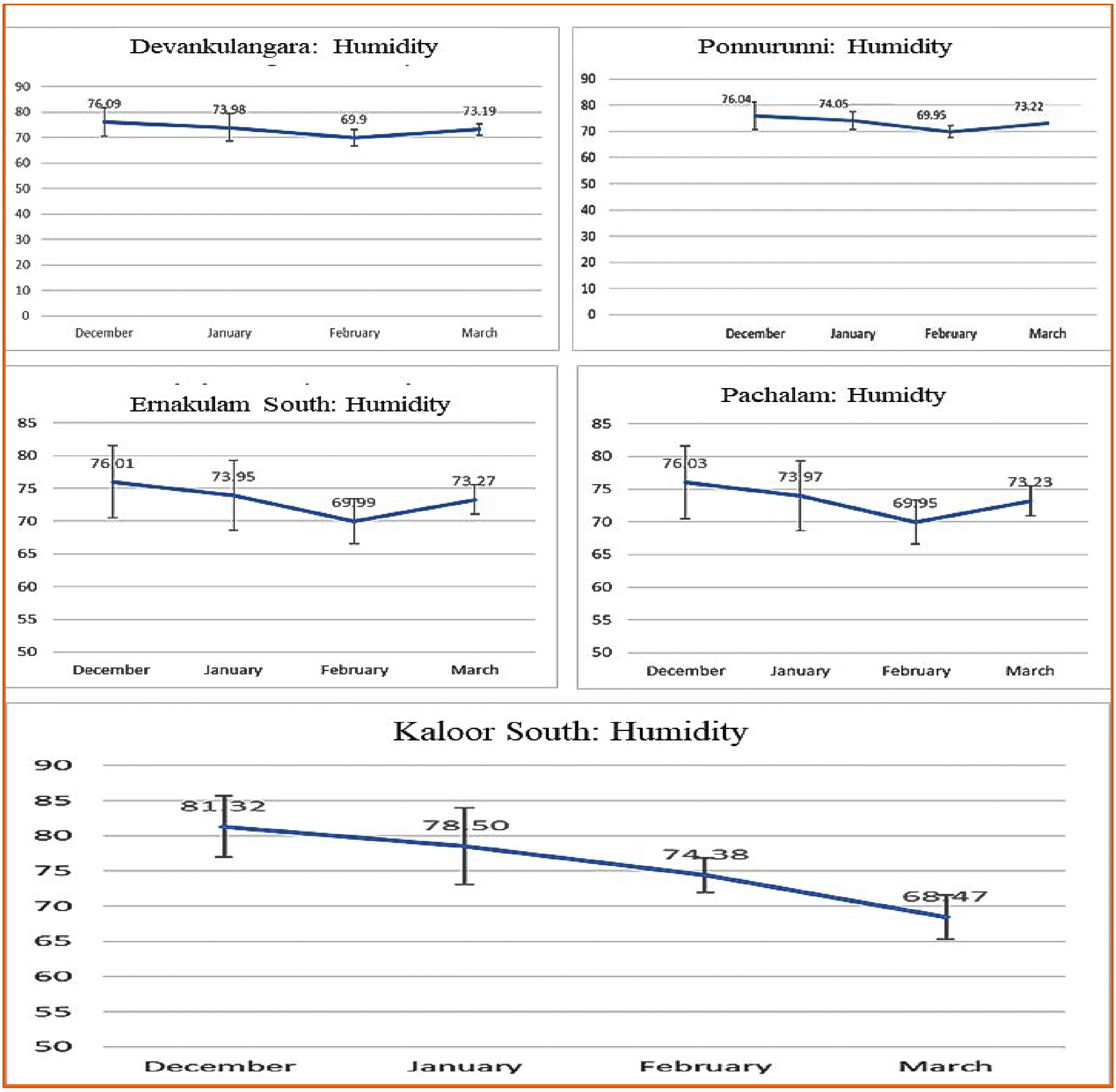

Fig 6: Humidity graphs of five wards from December to March

c. Cloud Cover:

Cloud cover data displayed minimal fluctuations, with mean cloud cover percentages ranging from 32% to 53% in Ponnurunni,19% to 53% in Devankulangara. Pachalam, Ernakulam South, Kaloor South shows similar range with Ponnurunni (Fig:7).

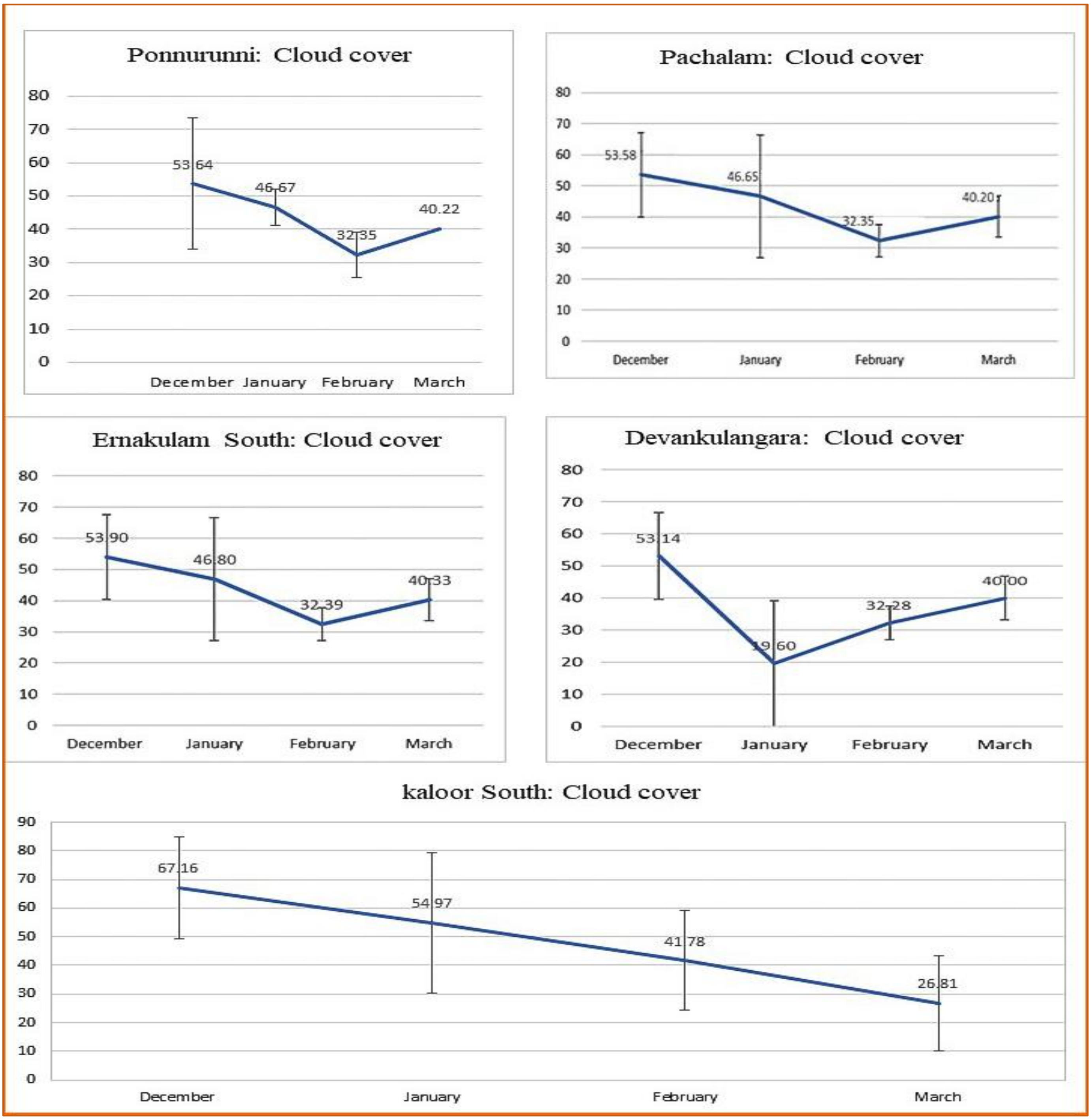

Fig 7: Cloud cover graphs of five wards from December to March

4.3.2 Abundance of Herbaceous and Tree Species:

The abundance data of herbaceous and tree species collected from the study area provided valuable insights into the distribution and prevalence of plant species within the urban environment of Cochin Corporation.

a. Herbaceous Species (Fig:8):

The abundance of herbaceous plants varied significantly, with some species exhibiting higher numbers compared to others.

- *Panicum repens* was the most abundant herbaceous species, with a total of 573 individuals recorded.
- Other highly abundant herbaceous species included *Elusine indica* (513 individuals), *Mikania micrantha* (315 individuals), *Panicum maximum* (219 individuals) and *Pennisetum polystacion* (254 individuals).
- Several herbaceous species, such as *Cyanthillium cinereum*, *Chloris barbata* and *Kyllinga brevifolia* also displayed notable abundance levels, with 174, 95 and 184 individuals recorded, respectively.

b. Tree Species (Fig:9):

Similarly, the abundance of tree species varied across the study area, reflecting the diversity of woody vegetation:

- *Cocos nucifera* emerged as the most abundant tree species, with a total of 406 individuals observed.
- Other prevalent tree species included M*angifera indica* (197 individuals), *Dypsis lutescens* (97 individuals), *Roystonea regia* (76 individuals) and *Artocarpus heterophyllus* (17 individuals).
- Notably, *Mimusops elengi, Tectona grandis, Terminalia catappa* and *Azadiracta indica* were also present in the study area, although in lower abundance compared to other tree species.

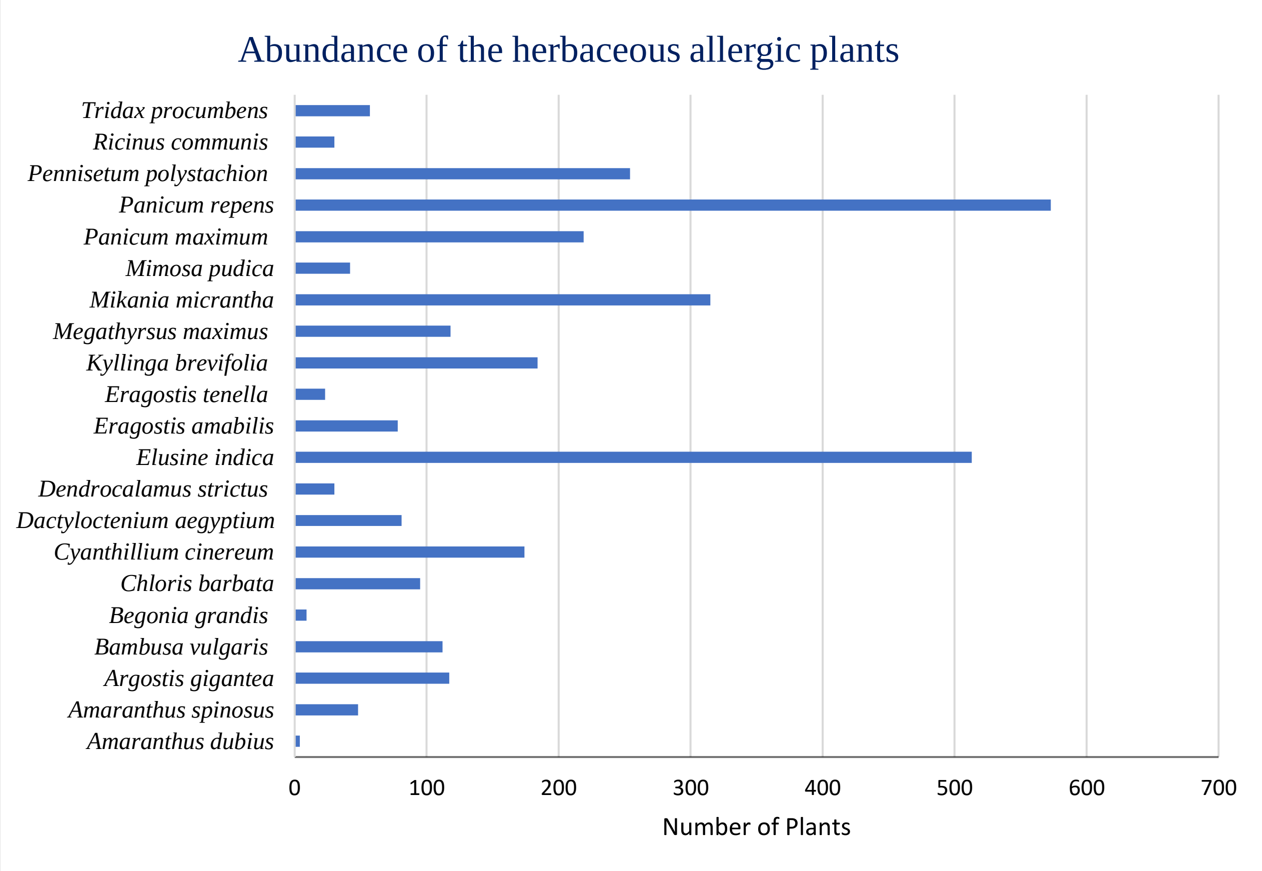

Fig 8: Abundance of herbaceous allergic plants in study area.

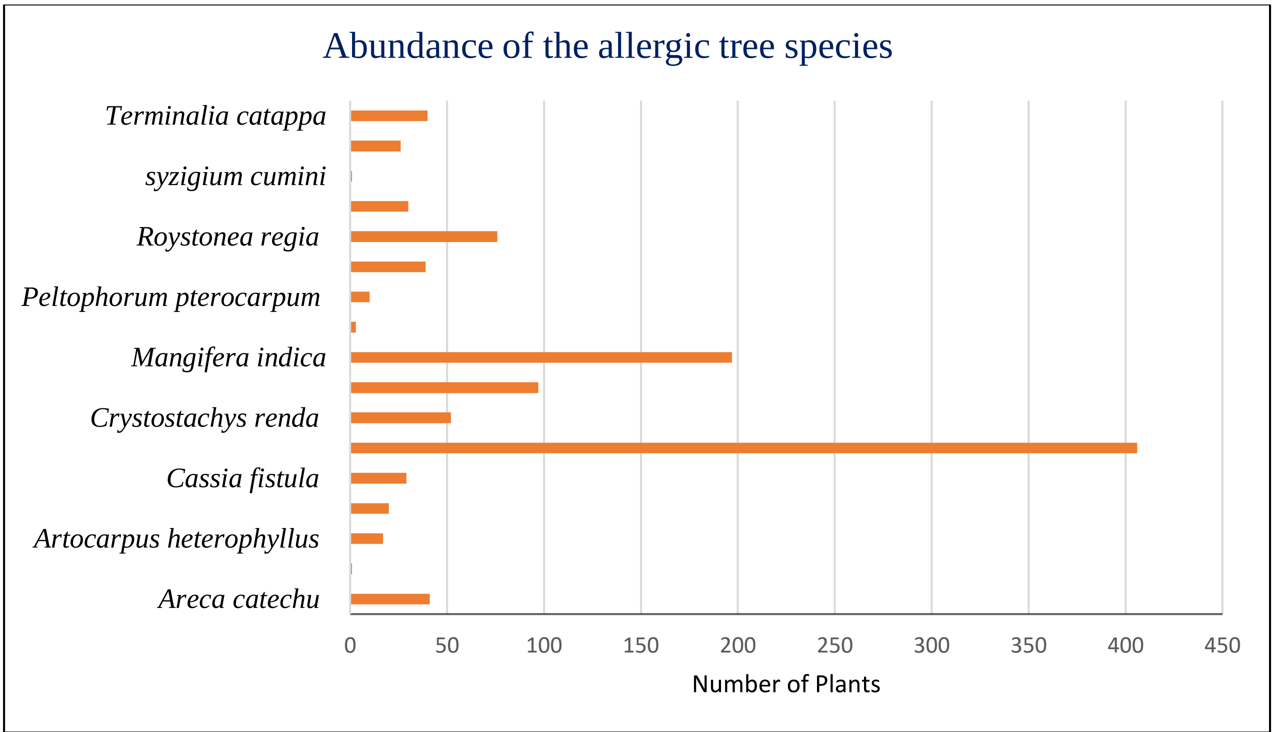

Fig 9: Abundance of allergic tree species in study areas.

4.3.3 Diversity of Vegetation in Study Locations

The Shannon index was used to assess the diversity of vegetation in five selected locations within Cochin Corporation. The index accounts for both species richness and evenness, providing a comprehensive measure of biodiversity (Fig: 10).

- Devankulangara: The Shannon index for herbaceous vegetation in Devankulangara was 1.890, indicating moderate diversity. In contrast, tree diversity was higher with a Shannon index of 2.041, suggesting a more diverse tree canopy in this location.
- Ernakulam South: This area exhibited higher diversity in herbaceous vegetation with a Shannon index of 2.320, indicating greater species richness and evenness among herbaceous plants. Tree diversity was comparatively lower, with a Shannon index of 1.738.
- Kaloor South: This area demonstrated moderate diversity in both herbaceous and tree vegetation, with Shannon indices of 2.162 and 2.009, respectively.
- Pachalam: Pachalam exhibited lower diversity in herbaceous vegetation, with a Shannon index of 1.854, while tree diversity was relatively higher, with a Shannon index of 2.138.
- Ponnurunni: This area displayed moderate to high diversity in both herbaceous and tree vegetation, with Shannon indices of 2.046 and 2.004, respectively.

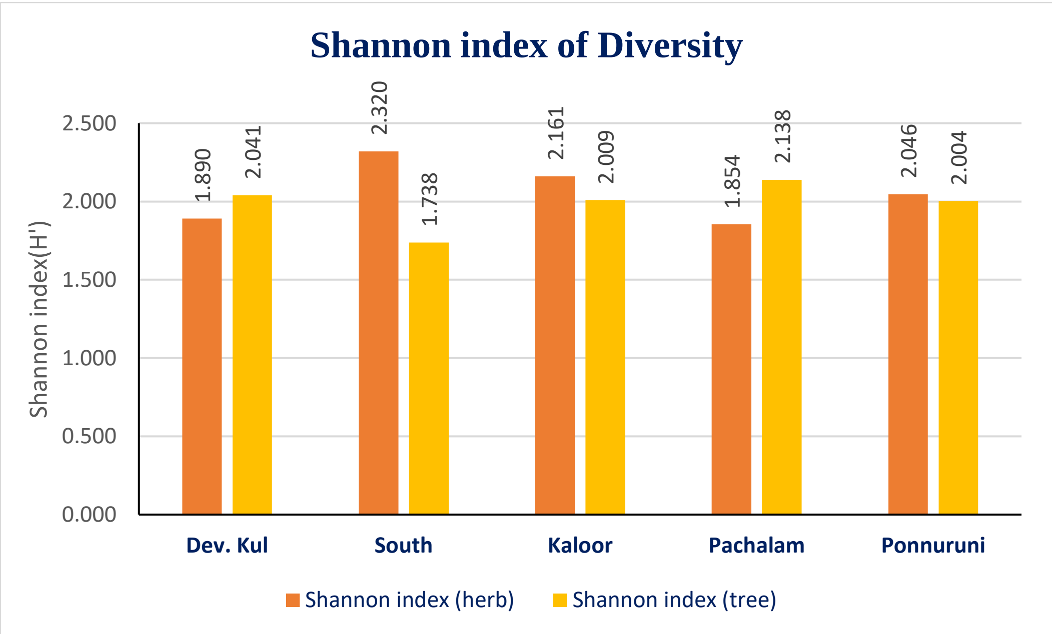

Fig 10: Diversity of vegetation in study areas (Shannon index graph).

4.3.4 Pollen Allergy Prevalence and Demographic Characteristics

Personal interviews were conducted with residents from five wards in Cochin Corporation to assess pollen allergy prevalence and gather demographic information. A total of 50 responses were obtained, with the following distribution across age groups: 36% were in the 18-25 age group, 26% in the 26-35 age group, 4% in the 36-45 age group, 24% in 46-55 age group and 10% were 56 and above (Fig:10).

In terms of gender, 58% of respondents were male, while 42% were female. A significant proportion of respondents (52%) reported experiencing pollen allergy symptoms.

a. Peak Allergy Period and Precautionary Measures

Respondents identified the summer season, particularly the period from February to April, as the peak allergic period. During this time, individuals reported experiencing high allergy symptoms due to increased pollen levels in the environment.

To alleviate allergy symptoms, affected individuals commonly implemented precautionary measures, including regular washing of affected areas, staying away from flowers and maintaining cleanliness in their homes.

b. Public Measures to Reduce Allergy Impact

When asked about measures that could be implemented in public spaces within their ward to reduce the impact of pollen allergies, three respondents suggested avoiding the planting of allergy-causing plants.

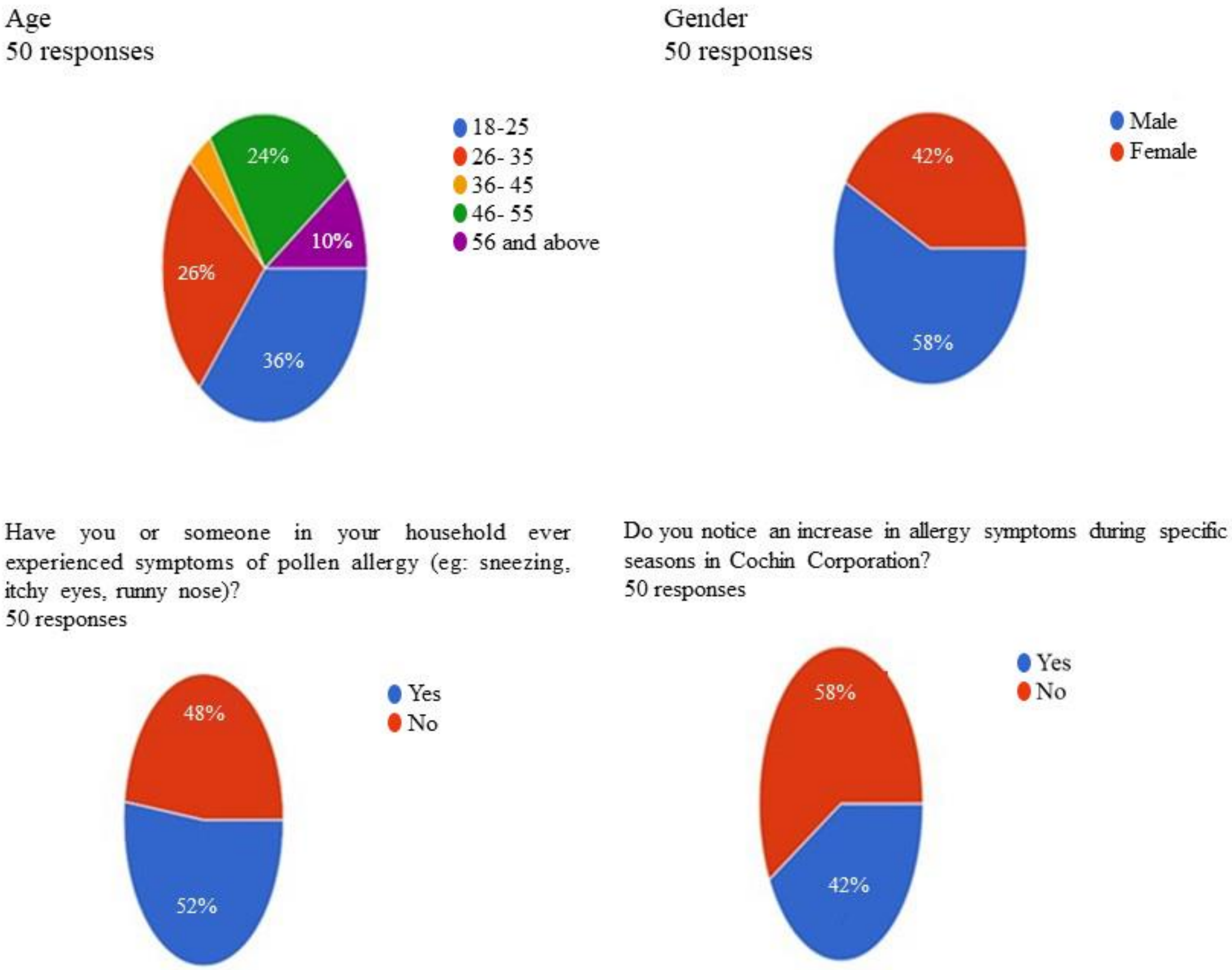

Fig 11: Pie diagrams obtained from public interview

CHAPTER 5

5.0 DISCUSSION

The integration of plant morphology studies, pollen morphology data, weather parameters and plant diversity metrics provides comprehensive insights into pollen allergy dynamics and informs effective pollen allergy management strategies in urban environments. Weather parameters such as temperature, precipitation, humidity, wind speed and cloud cover play a significant role in studying pollen production and dispersal patterns. During the study period, the average temperature ranged from 25°C to 30°C. Higher temperatures were observed in February and March across the four study areas, with Kaloor South experiencing elevated temperatures only in February. Precipitation showed the highest values in January, remaining relatively constant across all the study areas. Higher temperatures and increased precipitation levels during January may stimulate plant growth and flowering, potentially leading to elevated pollen production during this period. As a result, individuals with pollen allergies may experience heightened symptoms in January due to increased pollen exposure. Similar work was done by (Schramm et al., 2021). Based on this study warmer temperatures result in earlier and longer pollen seasons. Similar studies about precipitation and pollen concentration have been seen in (Kluska et al., 2020, Bruffaerts et al., 2018). Based on the study, the occurrence of pollen concentration was negatively correlated with Precipitation. Washout processes are driven by raindrops that will attract airborne pollen (Pérez et al., 2009). Relative humidity levels ranged from 10 to 21 km/h across the study areas, with higher values observed in Kaloor South during December and March. Wind Speed data indicated higher values in Ponnurunni during February and in Devankulangara, Pachalam and Ernakulam South during March. Cloud cover fluctuated between 19% to 53% during the study. Elevated levels of humidity may create favourable conditions for pollen dispersion during December and March, particularly in Kaloor South. Additionally, higher wind speeds during February and March could facilitate pollen transport over long distances, increasing the potential for allergen exposure among individuals. In the study of (Gross et al., 2019) it says that wind speed and cloud cover can affect pollen concentration.

Based on abundance data obtained from five units the species *panicum repens* (573) and *Elusine indica* (513) were the most abundant from herbaceous plants, while *Cocos nucifera* (406) and *Mangifera indica* (197) exhibited greater abundance among tree species. These findings align with previous studies conducted by other scientists, which shed light on the prevalence of allergenic plant species and their association with pollen allergy. (Sabit et al., 2020), conducted skin prick tests and the results showed greater pollen allergy in the case of *Mangifera indica*, and *Cocos nucifera*, which are the most abundant tree species observed in our study area. Additionally, the presence of *Mimusops spp* and *Terminalia catappa*, which were also noted in our study, further corroborates their potential role as allergenic plant species contributing to pollen allergy prevalence. In the study of (Olowokudejo et al., 2017) Poaceae members show dominance in Pollen allergy in Nigeria including *Panicum repens.* The abundance of this species in our study warrants attention, as it may contribute to elevated pollen exposure and allergic reactions among susceptible individuals.

(Verma et al., 2014) identified *Cassia* and *Ricinus* as important aeroallergens in South India, corroborating our findings regarding the abundance of *Ricinus communis* among herbaceous plants in our study area.

The Shannon diversity indices reflect the diversity of herbaceous and tree species within the study area. Locations with higher tree diversity indices, such as Pachalam and Devankulangara, and higher herbaceous diversity in Ernakulam South and Kaloor South may harbour a wider range of allergenic plant species, potentially leading to elevated pollen allergy risk. Species with high abundance may exert a significant influence on pollen allergy prevalence due to their prolific pollen production and allergenicity. Plant richness and diversity studies in plants were done using the Shannon index by (Motz et al., 2010, Bernholt et al., 2009)

Based on the pollen morphology study, small-sized, rough spiny outlines having pollens are considered to be more pollen-allergic. *Mangifera indica* and *Cocos nucifera* pollen are comparatively large and spherical, with smooth or slightly granular surfaces. Pollen morphology studies *Mangifera i*. done by (Muniraja et al., 2020). Even though they are present in large quantities they cannot be considered as the major contributors to pollen allergies because their pollen is primarily dispersed by insects than wind. They possess more than one furrow and distinct aperture. The pollen grains of *Elusine indica* and *Panicum repens* are small and spherical, with a granular surface. They also possess three furrows and are adapted for wind dispersal. These plants can be considered to contribute to pollen allergy. In the study of (Pope, 1925). Air pollution can also severely reflect and enhance pollen allergy (Ravindra et al., 2022). Poor air quality was observed in Cochin Corporation (Lal et al., 2020).

Personal interviews conducted with residents from five wards in Cochin Corporation provided insights into pollen allergy prevalence and demographic characteristics. The distribution of 50 responses across age groups revealed that younger individuals, particularly those in the 18-25 age group, constituted the majority of respondents (36%), followed by the 26-35 age group (26%). Interestingly, a significant proportion of respondents (52%) reported experiencing pollen allergy symptoms, indicating the considerable impact of pollen allergies on the local population.

Respondents identified the summer season, specifically the period from February to April, as the peak allergic period. During this time, individuals reported heightened allergy symptoms attributed to increased pollen levels in the environment. To alleviate these symptoms, affected individuals commonly implemented precautionary measures, including regular washing of affected areas, avoiding contact with flowers and maintaining cleanliness in their homes. These findings underscore the seasonal nature of pollen allergies and the importance of proactive measures in managing allergy symptoms during peak periods.

The data gathered from personal interviews highlight the importance of understanding pollen allergy prevalence and its impact on the local population. By identifying peak allergy periods and common precautionary measures, healthcare providers and policymakers can develop targeted interventions to support individuals affected by pollen allergies.

CHAPTER 6

6.0 CONCLUSION

This study provides comprehensive insights into the dynamics of pollen allergies in urban environments, focusing on the combination of plant morphology studies, pollen morphology data, weather parameters and plant diversity matrices. The findings underscore the significant role of weather parameters, such as temperature, precipitation, humidity, wind speed and cloud cover in shaping pollen production and dispersal patterns. Elevated temperatures and increased precipitation levels during certain periods may stimulate plant growth and flowering, leading to high pollen production and allergen exposure. Similarly, higher humidity levels and wind speeds can facilitate pollen dispersion over long distances, further increasing the potential for allergic reactions among susceptible individuals. The study highlights the prevalence of allergenic plant species and their association with pollen allergy prevalence. These findings are consistent with previous research, which has demonstrated the allergenicity of these plant species and their contribution to pollen allergy prevalence in the study area. Shannon indices reflect the diversity of herbaceous and tree species within the study area, indicating the locations with higher diversity may harbour a wider range of allergenic plant species, thereby increasing pollen allergy risk. Based on this study, proactive measures, including targeted interventions and public health campaigns, are crucial for managing pollen allergies and alleviating symptoms among affected individuals. By understanding the seasonal patterns of pollen allergy prevalence and implementing appropriate mitigation strategies, healthcare providers and policymakers can effectively support the local population in managing pollen allergies.

Furthermore, the main aim of this study is to develop a pollen calendar, laying the foundation for future research in pollen allergy studies and providing valuable insights into the seasonal patterns of pollen allergy thus holds promise for enhancing our understanding of seasonal allergy patterns.

CHAPTER 7

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