Review of Literature:

Aerobiology:

The earliest observation of microorganisms in the air was made by Hippocrates (ca. 460BC — ca. 370 BC). He believed that some of the diseases occur through inhalation of contaminated air. Lucretius in 55 B.C. held a view that particles were carried by wind.

In the beginning of 19th century it was clear that pollen of higher plants and spores of fungi, bryophytes and pteridophytes were liberated into the air and transported by wind. Aerobiological studies by the International Biological Program (IBP) have led to the establishment of International Aerobiology Association (I.A.A.) in 1974 at Hague, Netherlands. It greatly helped to promulgate new approaches to aerobiology. The major function of I.A.A. is the promotion, in the largest possible sense, of aerobiology as a scientific discipline.

Several countries in Europe have daily news bulletins about the incidence of pollen in the air which serves as a useful information to the allergenic patients. Currently abiotic particulates or gases affecting living organisms have been included in the concept of aerobiology by International Biological Programme (IBP) in 1964. Major aerobiological research centers in India are located in Srinagar, New Delhi, Shillong, Lucknow, Jaipur, Gwalior,
Bhopal, Kolkata, Aurangabad, Visakapatnam, Chennai, Bangalore, Mysore and Thiruvananthapuram (Agashe, 2006).

The first report on systematic aerobiological study in India was by Cunningham (1873) who carried out aerobiological survey over Presidency jail premises of Culcutta. His work was published in the book "Microscopic Examination of Air" (Cunningham, 1873). He attempted to relate the incidence of cholera and other fevers using an aeroconiscope in Culcutta jails. About half a century after Cunningham's pioneering work, aerobiological studies in India were once again commenced by plant pathologists such as Mehta (1952) and Padmanabhan et.al (1952).

Several Indian workers have assessed the quantum of pollen discharge into the atmosphere (Khandelwal and Mittre, 1973; Agnihotri and Singh, 1975; Reddi, 1976; Mondal and Mandal, 1998). Systematic investigations on airborne pollen were initiated early at different localities in India.

Kasliwal et.al (1955, 1959) studied the atmospheric pollen grains of Jaipur. Lakhanpal and Nair (1958) surveyed atmospheric pollen at Lucknow. Sreeramulu (1959) carried out systematic and intensive studies on aeromycology at Visakhapatnam using Hirst volumetric spore trap. Shivpuri et.al (1960) and Dua and Shivpuri
(1962) studied the aerobiology of Delhi. Subsequently two new centers, one at Aurangabad and another in Mysore came into existence. The former was initiated by S.T. Tilak in 1966 and the latter was started by A. Ramalingam in 1965. Aerobiological investigations were commenced during 1970s at Bose Institute, Calcutta by S. Chanda and in Bangalore by S.N. Agashe in 1973. Three others centres, one each at Allahabad, Nagpur and Gorakhpur, came into existence more or less at the same time in the 1970s. Aeromycological studies at Madras were started by B.P.R. Vittal using volumetric samplers in 1976. Many centres came up during the 1980s which include Gwalior, Jabalpur, Santiniketan, Manipur, Bodh Gaya, Gulbarga, and Trivandrum.

Systematic aerobiological investigation, especially of airborne pollen, was initiated at Patel Chest Institute, Delhi in 1957 by Shivpuri and his co-workers. Sreeramulu (1960) studied the spore content of Darjeeling. Nair (1963) surveyed airborne pollen at Vellore. Gupta and Singh (1965) prepared a pollination calendar of allergenic plants of Bikaner and studied out aerial survey of pollen and fungi. Baruah and Chetia (1966) studied air spora of Guwahati from allergy point of view. Sreeramulu (1967) reviewed the aerobiological status of India. Talde (1969) studied the suspended airspora over banana fields in Parbhani, Maharastra. Subba Reddi(1970) carried out a
comparative survey of atmospheric pollen and fungal spores at two places twenty miles apart. The aerobiological study of Aurangabad caves was carried out by Tilak and Kulkarni (1972). Pande (1976) studied the airspora over several agricultural fields at Nanded, Maharashtra. Millins et.al (1976) identified the sources and incidence of airborne *Aspergillus fumigatus*.

relation to season and vegetation at Kodailcanal, Tamil Nadu. Rapiejko et al. (1998) evaluated pollen count at different heights and distance.


Tiwari et al. (2006) have compiled a pollen calendar of Raipur and also identified the pollen grains of allergenic nature. Pandey et al. (2006) carried out aeropalynological survey of Banda District, U.P. An aerobiological survey of Guwahati was conducted by Devi (2007). Jyothi and Bhagyalakshmi (2007) conducted aeropalynological studies of exhibition grounds in Hyderabad. Hazarika et al. (2007) presented a report of the aerobiological studies carried out at Assam.

Das and Gupta - Bhattacharya (2007) have shown the relationship between airborne culturable fungal flora of an
agricultural farm in West Bengal and meteorological factors.

Pollen calendar is being prepared by many world around. This is to aid the pollen allergic population as well as treating physicians. Like one by Abbas et. al (2012). In this pollens and mold spores trapped by the Burkard spore trap were collected for 3 years (2005, 2006, and 2007). A total of 600, 240 pollens and 491, 904 fungal spores were trapped in 2005; in 2006, there were 560, 712 pollens and 546, 072 mold spores trapped; and in 2007, 559, 248 pollens and 433, 549 mold spores were trapped. For convenience sake, the counts were divided into 4 groups (trees, grasses, weeds, and fungal spores). The occurrence of tree pollen during the year 2005 to 2007 dominated as compared with grass and weed pollen. The results indicated that there were 2 main pollen plants that contributed to seasonal allergies. These were *Broussonetia papyrifera* and *Cannabis sativa* during the March/April season and the July/September season, respectively. Although mold spores were continuously detected throughout the year, the most prominent mold was undetected mold and unconfirmed mold species similar to *Stachybotrys* species, which was high from July to September/October.

Similarly Jae-won Oh et. al (2012) provided new information on pollen distributions and concentrations for
the general public or allergic patients through the website in order to prevent the occurrence of pollinosis. Alder, birch and Japanese cedar started to appear in February.

Japanese cedar showed a highest pollen concentration in Jeju. Pine became the highest pollen in May, and the pollen concentrations of oak and birch also became high. Common ragweed appeared in the middle of August and showed the highest pollen concentration in the middles of September. Japanese hop showed a high concentration between the middle of August and the end of September, and mugwort appeared in the middles of August and its concentration increased up until early September. Birch appeared earlier in Kangneung, and pine showed a higher pollen concentration than in the other areas. In Daegu, Oriental thuja, alder and juniper produced a large concentration of pollens. Pine produced a large concentration of pollens between the middle of April and the end of May.

Weeds showed higher concentrations in September and mugwort appeared earlier than common ragweed. In Busan which is the southeast city, the time of flowering is relatively early, and alder and Oriental thuja appeared earliest among all areas. In Kwangju, Oriental thuja and hazelnut appeared in early February. In Jeju which is the end of southern island, Japanese cedar showed a higher pollen concentration than the other areas.
Websites to show regular pollen counts is also now days in practice and thus people around globe have an update of their aerobiological surrounding which keeps them aware.

Aerobiological Study of Anemophilous Pollens in the City of Toluca, Mexico is done by Izquierdo et.al (2012), found 14, 078.61 pollen grains, coming from 32 different pollinic types in the 12 Transverse traverses in the year analized. The 6 leading taxa, in order of abundance, were: Cupressaceae (49%), Oleaceae genus Fraxinus sp (17%), Betulaceae genus Alnus (14%), Pinaceae (11%), Gramineae (6%), Asteraceae or Compositae (3%). The most prevalent months regarding pollen counts were January and February 2005 in which Cupressaceae and Oleaceae genus Fraxinus were accounted. In aerobiological terms both Cupressaceae and Fraxinus seem to be a major risk for potential sensitized individuals due to its known allergenicity and its high atmospheric concentrations between late winter and early spring, followed by Alnus, Pinaceae, Gramineae, Asteraceae, Casuarinaceae, Schinus, Cheno/Amp and Moraceae. This was the first effort to create the Mexican Aerobiological Network (REMA), and further studies are needed to correlate clinical data.
There are studies which show that due to the help of aerobiological studies the pollen prediction can be made which is quite near to the actual pollen numbers as done by Anderson, et.al(2009).
Pollen Allergy:

Pollen is an aeroallergen, an airborne allergy-causing substance that irritates the respiratory system, that leads to health conditions such as allergies and asthma (Bernard, Samet, Grambsch, Ebi, & Romieu, 2001; Gilmour, Jaakkola, London, Nel, & Rogers, 2006). Exposure to higher concentrations of pollen at earlier stages in life increases individual susceptibility to developing asthma later (Pearce, Douwes, & Beasley, 2000; Bjorksten & Suoniemi, 1981). Therefore, one of the potential consequences of higher pollen concentrations is growing asthma incidence (Cecchi et al., 2010). In addition to the increasing number of new cases of asthma, studies suggest that aeroallergens may impact the severity of asthma as well. For instance, a study in Chicago found that the odds of death due to asthma on days with high mold spore counts were 2.16 times greater than on days with lower mold spore counts (Targonski, Persky & Ramekrishnan, 1995). Furthermore, severe symptoms of asthma may prompt individuals to visit emergency rooms. Cases of asthma reported in emergency rooms (ERs) in both Virginia and Texas found that asthmatics exposed to more pollen and fungal spores in their homes were more likely to visit an ER due to asthmatic symptoms (Pollart, Reid, Fling, Chapman, & Platts-Mills, 1998). The relationship between asthma and pollen is important to study as aeroallergen concentrations increase with climate change.

The response of the immune system to the inhalation of pollen grains is due to the presence of allergens, usually proteins, which are mostly located on the pollen wall, and these are generally
specific (Barber, 2003). The pollen wall also harbors a number of minor allergens that act as pan allergens, i.e., that are present in various species and responsible for the appearance of pollen–pollen cross-reactions (Weber, 2003). Knowledge about the patterns of cross-allergenicity between different pollen types is essential for the identification of many allergic symptoms for which there is no apparent cause.

Singh and Kumar (2002) made a review of allergy aspects with particular reference to pollen allergy in India. All India Coordinated Project on Aeroallergens and Human Health was undertaken to discover the quantitative and qualitative prevalence of aerosols at 18 different centres in the country. Predominant airborne pollen found were Holoptelea, Poaceae, Asteraceae, Eucalyptus, Casuarina, Putanjiva, Cassia, Quercus, Cocos, Pinus, Cedrus, Ailanthus, Cheno/Amaranth, Cyperus, Argemone, Xanthium, Parthenium and others. Clinical and immunological evaluations have revealed allergenically important taxa - some of them for the first time. Allergenically important pollen were Prosopis juliflora, Ricinus communis, Morus, Mallotus, Alnus, Quercus, Cedrus, Argemone, Amaranthus, Chenopodium, Holoptelea, Brassica, Cocos, Cannabis, Parthenium, Cassia and grasses.

Further cross-reactivity of the IgE antibodies was a common phenomenon among various pollen allergens. Ricinus communis pollen from commonly growing weeds in India, cross-reacts with latex (Hevea brasiliensis), Mercurialis annua and also with seeds of Ricinus communis – all belonging to family Euphorbiaceae. Areca
catechu cross-reacts with other members of Arecaceae such as Phoenix sylvestris, Cocos nucifera and Borassus flabelifer. Several reports on pollen and fruit syndrome have been analyzed. Experiments conducted by them revealed that pollutants (NO2 and SO2) not only affect pollen morphology but also changes their allergenic potency. Immunotherapy with recombinant proteins having similar epitopes from different allergens have been advocated, besides allergen avoidance.

Singh et al. (2012) Engineered forms of major grass pollen allergens as candidate vaccines for grass pollen allergy.

Tree pollens are among the most important allergen sources. Silver birch and some related tree species have been described as the most potent and frequent allergen sources (Mothes et al. 2004; Mothes and Valenta 2004). This has been recorded in the literature for many years.

As per World Allergy Organisation’s White Book on Allergy 2011-2012: Executive Summary Seasonal hay fever became common in Northern Europe and the USA over a 70 year period from 1870 to 1940. This was a period during which several changes occurred; there were major improvements in hygiene, the population became increasingly urban, and there was an increase in heavily pollinating plants such as rye grass and ragweed. In addition to the distinctive and often strictly seasonal pattern of the symptoms, hay fever is also distinguished from perennial rhinitis by the presence of conjunctivitis. This reflects exposure under conditions where the allergen particles are “blown” with sufficient velocity to impact in
the eyes which is much less common indoors. The most common outdoor allergens are the pollens of grasses, trees or weeds, each with specific seasons. Characteristically, the higher the no of pollen: i) the higher the prevalence of IgE antibodies; ii) the higher the titre of IgE antibodies; and iii) the greater the severity of the seasonal symptoms. Pollen grains release species-specific proteins that act to trigger formation of a pollen tube. Thus rapid release of proteins is a primary function of a pollen grain. Most (but not all) pollens can be distinguished under a microscope.

Based on clinico-immunological studies with pollen antigens, important allergenic pollens of India have been identified. The work on pollen allergy was initiated in 1950s by Shivpuri in Delhi. Subsequently, Kasliwal and his colleagues reported important pollen allergens of Jaipur. Shivpuri & Parkash observed *Prosopis juliflora* as a major cause of pollinosis with 12% patients showing a positive skin reaction. Later, important pollen causing allergy were identified for Delhi by Shivpuri and his colleagues(1979), some of them are *Ageratum, Ailanthus, Amaranthus, Anogeissus pendula, Artemisia, Cassia siamea, Cenchrus, Chenopodium, Cynodon. Ipomoea fistulosa, Paspalum distichum* and *Poa annua* recorded positive skin reactions in 16.9% patients to *Pinus roxburghii* from the foot hills of Himalayas.

Pollen causing allergy are quite variable in different ecozones which makes it very important to identify pollinosis causing species from every region and prepare extracts from them for diagnosis and immunotherapy for the benefit of allergy sufferers.
From Northern India, important allergens identified are *Prosopis juliflora*, *Ricinus communis*, *Morus*, *Mallotus*, *Alnus*, *Quercus*, *Cedrus*, *Argemone*, *Amaranthus*, *Chenopodium*, *Holoptelea* and grasses.

From Central India important pollen allergens are *Argemone*, *Brassica*, *Cannabis*, *Asphoedelus*, *Parthenium*, *Cassia*, *Azadirachta*, grasses, *Alnus*, *Betula*, *Malotus*, *Trewia nudiflora*. From Eastern India, allergenically significant pollen types were found as *Lantana*, *Cucurbita maxima*, *Cassia fistula*, *Cocos nucifera* and *Calophyllum*. Recent studies based on clinical and immunologic parameters reported *Phoenix*, *Ricinus communis* and *Aegle marmelos* as causative agents of allergy in this region. From South India *Cassia*, *Ageratum*, *Salvadora*, *Ricinus*, *Albizia lebbeck* and *Artemisia scoparia* have been reported as important aeroallergens. (Acharya, P.J. *et al*; 1980; Agashe, S.N. *et. al*; 1982; Subbarao, M. *et.al*; 1985) recorded allergenicity to *Parthenium hysterophorus* pollen extracts in 34% of allergic rhinitis and 12% bronchial asthma patients from Bangalore. (Agashe, S.N. *et.al* 1992) recorded high skin reactivity to *Casuarina equisetifolia* in patients from Bangalore.

Clinical studies undertaken recently by various medical centres under AICP on Aeroallergens and Human Health revealed important allergenic pollen for various regions in India. More than 35 pollen antigens were tested on atopic population to see the allergenicity.

As per the *Clinical and Experimental Allergy 2012*- Grass pollen allergens globally; the contribution of subtropical grasses to
burden of allergic respiratory diseases by Janet M Davies.

Grass pollens of the temperate (Pooideae) subfamily and subtropical subfamilies of grasses are major aeroallergen sources worldwide. The subtropical Chloridoideae (e.g. *Cynodon dactylon*; Bermuda grass) and Panicoideae (e.g. *Paspalum notatum*; Bahia grass) species are abundant in parts of Africa, India, Asia, Australia and the Americas, where a large and increasing proportion of the world's population abide. These grasses are phylogenetically and ecologically distinct from temperate grasses. With the advent of global warming it is conceivable that the geographic distribution of subtropical grasses and the contribution of their pollen to the burden of allergic rhinitis and asthma will increase. This review aims to provide a comprehensive synthesis of the current global knowledge of i) regional variation in allergic sensitivity to subtropical grass pollens, ii) molecular allergenic components of subtropical grass pollens and iii) allergic responses to subtropical grass pollen allergens in relevant populations.

Patients from subtropical regions of the world show higher allergic sensitivity to grass pollens of Chloridoideae and Panicoideae grasses, than to temperate grass pollens. The group 1 allergens are amongst the allergen components of subtropical grass pollens, but the group 5 allergens, by which temperate grass pollen extracts are standardized for allergen content, appear to be absent from both subfamilies of subtropical grasses. Whilst there are shared allergenic components and antigenic determinants, there are additional clinically relevant subfamily-specific differences, at T and B cell
levels, between pollen allergens of subtropical and temperate grasses. Differential immune recognition of subtropical grass pollens is likely to impact upon the efficacy of allergen immunotherapy of patients who are primarily sensitized to subtropical grass pollens. The literature reviewed herein highlights the clinical need to standardize allergen preparations for both types of subtropical grass pollens to achieve optimal diagnosis and treatment of patients with allergic respiratory disease in subtropical regions of the world.

In allergy journal a paper shows that symptom-free consumption of pollen-related food allergens may have implications for the pollen-specific immune response of allergic individuals. Patients with birch pollen allergy frequently develop allergic reactions to certain food items, e.g. apples, celery, carrots and hazelnuts. These reactions are mainly caused by IgE-antibodies specific for the major birch pollen allergen, Bet v 1, which cross-react with homologous proteins in these foods. Analyzing the T-cell response to Bet v 1-related food allergens revealed that these dietary proteins contain several distinct T-cell epitopes and activate Bet v 1-specific T cells to proliferate and produce cytokines. Several of these cross-reactive T-cell epitopes were not destroyed by simulated gastrointestinal digestion of food allergens and stimulated Bet v 1-specific T cells despite nonreactivity with IgE antibodies. Similarly, cooked food allergens did not elicit IgE-mediated symptoms (oral allergy syndromes) but
caused T-cell-mediated late-phase reactions (deterioration of atopic eczema) in birch pollen-allergic patients with atopic dermatitis because thermal processing affected their conformational structure and not the primary amino acid sequence. Thus, T-cell cross-reactivity between Bet v 1 and related food allergens occurs independently of IgE-cross-reactivity in vitro and in vivo. Bohle, B. (2007) speculated that symptom-free consumption of pollen-related food allergens may have implications for the pollen-specific immune response of allergic individuals. Using these food items without any allergic reaction also show that the subjects are not positive to the specific pollen allergy.

There is community concern regarding the risk of allergic reaction from Plane tree pollen in the city centre of Sydney, where Plane tree plantings are very common. Study done to characterize the length and severity of the plane tree pollen season and to characterize skin test reactivity to the pollen in a group of atopic individuals with respiratory symptoms. This could be seen in Burton (2006) Description of Platanus (London Plane Tree) Pollen Levels and Pollen Sensitization in an Australian Population.

Work to produce allergy vaccines especially for pollen allergy is also pacing up in recent time, as more and more pollen allergy cases are coming positive as per

A study of the tree species lining urban thoroughfares in Mediterranean areas of the Iberian Peninsula focused on the 12 most representative species in each town or city sampled. The results highlighted the limited diversity present: the total list included only 16 species, and the London plane (Platanus hispanica) appeared in almost all of the towns sampled. Additionally, the analysis of the species commonly used as ornamentals in urban areas shows that many of these are anemophilous species producing large amounts of pollen that have a demonstrated allergenic effect on the local population, with more than 500,000 million grains being produced by a single tree in some cases (Piotrowska, 2008; Tormo Molina, Muñoz Rodriguez, Silva Palacios, & Gallardo Lopez, 1996). This category includes all species for which more than one scientific paper has reported a moderate degree of allergenicity in terms of various existing scales (e.g., Ogren Plant-Allergy Scale (OPALSTM, Ogren, 2000), the Allergen Index (Hruska, 2003; Hruska & Staffolani, 2010).

Two Spanish cities provide specific illustrative examples of this phenomenon. Madrid has almost 300,000 roadside trees, which is one of the highest figures for this parameter in the world, of which over 60,000 are Platanus×hispanica and P. orientalis. In Barcelona, these species account for over a third of the 150,000 trees planted in urban areas. Platanus species are anemophilous, with an estimated pollen production of 13×10⁶ pollen grains per inflorescence (Tormo
Molina et al., 1996). Madrid and Barcelona are among the highest ranking Spanish cities in terms of airborne Platanus pollen counts during the pollen-producing season (Díaz de la Guardia et al., 1999); not surprisingly, these trees represent one of the main causes of pollen allergies among local people (Gabarra, Belmonte, & Canela, 2002; Sabariego-Ruiz, Gutierrez Bustillo, Cervigon Morales, & Cuesta, 2008).

Members of the Cupressaceae (Cupressus spp., Platycladus sp., Calocedrus sp., Chamaecyparis sp., Juniperus spp., and Thuja spp.) are very common in the city of Granada (southeastern Iberian Peninsula), where they are a key element of the city’s famous historic gardens (Casares, 2010) and feature prominently in various districts of the Old Town. There are over 3000 Cupressaceae in the city. Due to the well established allergenic capacity of these species (Charpin, Calleja, Lahoz, Pichot, & Waisel, 2005) and to their exhibiting some of the highest pollen production levels of all anemophilous species, with more than $1100 \times 10^6$ pollen grains being produced by each tree (Hidalgo, Galán, & Dominguez, 1999), the incidence of allergic sensitization is estimated at close to 30%. Additionally, Cryptomeria japonica (Japanese cedar) is a species of Cupressaceae that is frequently used as a roadside tree along Japanese city streets, and its pollen is one of the main causes of pollen-related disease in these areas (Okuda, 2003).

Medicinal plants are a source of bioactive compounds and are of great value for developing some novel therapeutic agents. Due to this tremendous potential they offered new drugs against diseases
that affect the health of mankind (Shrinivas, 2008). Most of the medicinal plants are being utilized since centuries in various formulations specially in Pakistan and India as Unani medicines and they are also the part of Allopathic medicine too.
Holoptelea integrifolia:

Holoptelea integrifolia belongs to the family Ulmaceac, having 15 genera and about 200 species, distributed over tropical and temperate regions of Northern hemisphere including Indian peninsula to Indo China and Srilanka (Parrotta, 2001). It is found mostly in the sub Himalayan hills to Assam. Ulmus also occurs in different areas especially in Karachi and some adjoining parts of Sindh.

This is locally called as Chilbil papri while in English this is known as Indian Elm. Many chemical constituents such as terpenoids, sterols, saponins, tannins, proteins, carbohydrates and alkaloids have been reported from various species of this plant (Minetal, 2000, K. Machida et.al, 2005).

The plant is useful in the treatment of obesity, edema, bronchitist (Nasir & Ali, 1985, Baquar, 1995), and also possess ovipositor deterrent activity and protease inhibitor activity (Sastri, 1950, Singetal, 1992). Its bark and leaves are also known for its medicinal importance. The mucilage and juice obtained from the boiled bark is reported to be useful as an external application against rheumatism (Bajapi et.al, 1995), intestinal tumors (Sabnis & Bedi, 1983) and is oxytotic in pregnancy (Tiwari & Padhye, 1993). The paste of seeds and stem bark is externally applied against ringworm, eczema and cutaneous affections (Sharma et.al, 1992). Paste of the stem bark is externally applied to treat the inflammation of lymph gland, common fever (Singh & Ali, 1994) ringworm and scabies. Stem bark acts as anti-inflammatory agent, especially for eye
Review of Literature

(Mudgal & Pal, 1980). Bark and leaf paste are applied externally on leucoderma

Rao et al. (2012) Studied ultrastructural changes in the cell walls of cambial derivatives during wood formation in Indian ELM (Holoptelea integrifolia). They noticed sequential changes occurring in cell walls during expansion, secondary wall (SW) deposition and lignification in the differentiating xylem elements of Holoptelea integrifolia using transmission electron microscopy. The PATAg staining revealed that loosening of the cell wall starts at the cell corner middle lamella (CCML) and spreads to radial and tangential walls in the zone of cell expansion (EZ). Lignification started at the CCML region between vessels and associated parenchyma during the final stages of S2 layer formation. The S2 layer in the vessel appeared as two sublayers, an inner one and outer one. The contact ray cells showed SW deposition soon after axial paratracheal parenchyma had completed it, whereas noncontact ray cells underwent SW deposition and lignification following apotracheal parenchyma cells. The paratracheal and apotracheal parenchyma cells differed noticeably in terms of proportion of SW layers and lignin distribution pattern. Fibres were found to be the last xylem elements to complete SW deposition and lignification with differential polymerization of cell wall polysaccharides. It appeared that the SW deposition started much earlier in the middle region of the fibres while their tips were still undergoing elongation. In homogeneous lignin distribution was noticed in the CCML region of fibres.
Studies on Holoptelea integrifolia was done to see natural and effective control of air pollution through plants by Kapoor et.al (2012). As gaseous and industrial air pollution is becoming a serious problem throughout the world. It is also affecting human health and plants are also facing negative impact on their biochemical processes. This is exhibited in terms of reduction in various growth parameters. The effect of air pollution is being felt even in remote areas, because pollutants can be transported over long distances. It is well known that plants absorb gaseous/particulate pollutants and help in controlling air pollution. In order to test *Holoptelea integrifolia* L. as an effective and natural means for controlling air pollution this study was undertaken. It was observed that the tree species tolerate well various pollutants present in the air, so *Holoptelea integrifolia* L. can be used as an efficient method for minimizing of concentration pollutants to a safer level into the environment.

Medicinal plants are a source of bioactive compounds and are of great value for developing some novel therapeutic agents. Due to this tremendous potential they offered new drugs against diseases that effect the health of man kind (Shrinivas, 2008). Most of the medicinal plants are being utilized since centuries in various formulations specially in Pakistan and India as Unani medicines and they are also the part of Allopathic medicine.

Kumar et.al (2012) did pharmacognostic evaluation of leaf and root bark of Holoptelea integrifolia Roxb. They found the characteristic microscopic features of leaves to be as trichomes,
multicellular trichomes, xylem cells, phloem cells, collenchyma, vascular bundles, spongy parenchyma and palisade cells. The characteristic microscopic features of root bark included cork cambium, primary cortex, phloem fibers, medullary rays, endodermis, pericycle and lignified fibers in the transverse section and longitudinal section. The characteristic microscopy of root bark powder showed the presence of cortex cells, sieve tubes, calcium oxalate crystals and lignified fibers. Macroscopic study showed that leaf shape-oval, apex-acute, base-cordate and leaf margin was entire with glabrous surface, bitter taste and characteristic odour. The morphological features of root bark showed deep fissured, rough and firm surface with rhitydome and the periderm parallel to cambium. Various pharmacognostic characters observed in this study help in the identification and standardization of H. integrifolia.

Kumar et.al (2012) gave a mini review on chemistry and biology of Holoptelea integrifolia Roxb. Planch (Ulmaceae). Phytochemical investigation shows the presence of chemical constituents such as terpenoids, alkaloids, glycosides, carbohydrates, steroids, sterols, saponins, tannins, proteins and flavanoids. The isolated principles such as β-amyrin, β-sitosterol, holoptelin-A, holoptelin-B, hederagenin, hexacosanol, β-D-glucose, friedelin, epifriedelin, 2-amino naphthoquinone, 1,4-naphthalenedione, are considered as responsible for various activities. This review highlights the traditional uses, reported biological/pharmacological activities, isolated compounds and therapeutic applications of Holoptelea integrifolia which might be helpful for scientists and
researchers to find out new chemical entities responsible for its claimed traditional uses.

Antioxidant, heavy metals and elemental analysis of *Holoptelea integrifolia* planch done by Saraswathy.A.et.al (2008). The free radical scavenging potential of the extract was evaluated by two different antioxidant methods; ferric thiocyanate and thiobarbituric acid method. The ethanol extract was found to exhibit good antioxidant property. Further physico-chemical constants, elemental and heavy metal analysis of stem bark have also been described. The present study reveals that *Holoptelea integrifolia* showed antioxidant property which is comparable to the standard vitamin E. Thus ethanol extract exhibited significant *In vitro* antioxidant activity by inhibiting the oxidation of linoleic acid in both FTC and TBA methods. The activity was comparable with standard vitamin E. Physicochemical data of the stem bark of Holoptelea integrifolia showed ash content of 11.75% and water soluble ash of 10.5% indicating the presence of inorganic matter. Acid insoluble ash 0.36% showed the presence of silicates in the bark. Water soluble extractive value (10.52%) was due to the presence of sugars, acids, polar constituents, glycosides of steroid, alkaloids and coumarines. n-Hexane soluble extractive value (0.62%) revealed the presence of less polar straight chain compounds and waxy materials. Alcohol soluble extractive value (2.18%) showed the presence of fewer amounts of polar substances like phenols, tannins, glycosides and flavonoids in the stem bark. These physicochemical data would help for the identification of the
drug from its substitutes/adulterants. Heavy metals viz. lead (0.11),
cadmium (0.03) and mercury (0.001) of the stem bark was found to
be within the permissible limits as per WHO guidelines. The stem
bark was free from arsenic, thereby proving the safety of its
utilization in Ayurveda and Siddha systems. Mineral elements such
as iron (2.17), copper (0.05), manganese (0.08), zinc (0.93), nickel
(0.02), cobalt (0.11), chromium (0.13) were found in considerable
amount which may be directly or indirectly helpful in the
management of many diseases. Thus the results of the present study
support the view that some traditionally used Indian medicinal plants
particularly the stem bark of Holoptelea integrifolia are promising
source of potential antioxidants.

Vinod. et.al (2010) studied inhibition of Beta-Lactamase by
1,4-Naphthalenedione from the Plant Holoptelea integrifolia; The
most important mechanism of the beta-lactam antibiotic resistance is
the destruction of the antibiotics by the enzyme beta-lactamase. Use
of beta-lactamase inhibitors in combination with antibiotics is one of
the successful antibacterial strategies. The inhibitory effect of a
phytochemical, 1,4-naphthalenedione, isolated from the plant
Holoptelea integrefolia on beta-lactamase is reported here. This
compound was found to have a synergistic effect with the antibiotic
amoxicillin against a resistant strain of Staphylococcus aureus. The
enzyme was purified from the organism and incubated with the
compound. An assay showed that the compound can inhibit the
enzymatic activity of beta-lactamase. Modeling and molecular
docking studies indicated that the compound can fit into the active
site of the beta-lactamase. Hence, the compound can serve as a potential lead compound for the development of effective beta lactamase inhibitor that can be used against beta-lactam-resistant microbial strains.

In 2013 a study for screening of behavioural, muscle coordination and anxiolytic activities of methanolic extract of Holoptelea Integrifolia (Roxb) was done by Kavaya et.al (2013).

Studies on anti-inflammatory effect of aqueous extract of leaves of Holoptelea integrifolia, Planch in rats was done by Shrinivas.et.al (2013) they studied Hypolipidaemic Effects of Methanol Extract of Holoptelea integrifolia (Roxb.) Planchon Bark in Diet-Induced Obese Rats.

The extract administered orally at doses of 250 and 500 mg/kg p.o produced a significant (P < 0.05) dose dependent inhibition of edema formation.

Thus a significant % inhibition of paw edema by the aqueous extract of leaves of H. integrifolia, Planch. and its almost nearby same % inhibition with indomethacin suggest its usefulness as an anti-inflammatory agent.

Wanjari.et.al (2012) found absence of hypolipidemic effect of Holoptelea integrifolia leaf extract in tyloxapol-induced hyperlipidemic rats administration of the HIAE neither caused any significant effect on the lipid profile in normolipidemic rats nor attenuated tyloxapol-induced hyperlipidemia. The present investigations revealed that the aqueous extract of the leaves of Holoptelea integrifolia did not exhibit a hypolipidemic effect and
did not substantiate its traditional use in lipid disorders and obesity.

As per The Hindu: Thursday, June 08, 2000- In July, the air in Bangalore will have an abundant measure of the allergy-causing pollen, mainly from parthenium. Its presence in the atmosphere will continue till September, a study has revealed. The study conducted by Dr. Shripad et.al of the Aerobiology and Allergy Laboratory, Department of Botany, Bangalore University.

The study has found that different pollen achieved a peak and declined in a particular time of the year. A case in point is the pollen count of Holoptelea integrifolia. The plant is a high pollen producer, though it flowers only for a short duration in January or February. During its peak flowering period, the atmosphere is dominated by its pollen, though there are only a few trees of this species in the City. This pollen has been clinically proved to be highly allergic, particularly to asthmatics.

They have found that the largest allergenically-significant predominant pollen is the one originating from Holoptelea integrifolia, which accounts for 41.3 per cent, followed by some unidentified pollen (16 per cent), Casuarina eqisetifolia (15.7 per cent), eucalyptus (11.8 per cent), and parthenium (10.8 per cent).
**Parthenium hysterophorus:**

Parthenium hysterophorus L. (family: Asteraceae), commonly known as parthenium, is a weed of global significance (Navie et.al, 1996). Parthenium hysterophorus L. is an annual weed known with various common names, such as false ragweed, star weed, bitter weed, white top, bastard feverfew etc. and is found in tropical and subtropical regions (Tiwari et.al 2005). It is native to the subtropics of North and South America. The weed is now widely distributed in a number of tropical and subtropical countries, like Australia, India, China, and Kenya (Navie et.al 1996; QNRM 2004).

Parthenium is a major weed in Australia and India. In Australia, parthenium was first identified in 1955, but was proclaimed as a noxious plant in 1975 (Auld et.al, 1983).

This weed is highly allergic which includes skin allergy when gets directly in contact and also other allergies including respiratory when its pollen are inhaled with air as per Allergy to Parthenium; *Allergy to Parthenium*. N.p., n.d. Web. 5 July, 2014.

Parthenium causes dermatitis which was studied by Sharma. et.al (2007) in this study they came out with the results which clearly indicated that the parthenium weed has a marked tendency of causing dermatitis.

Verma. et.al (2007) noted Type I hypersensitivity to *Parthenium hysterophorus* in patients with parthenium dermatitis and was found that the cases of dermatitis gave the hypersensitivity towards parthenium and this was in a significant manner.
Parthenium was accidentally introduced into India in 1955 (Rao, 1956), and has since spread to neighboring countries, including Pakistan (Javaid and Anjum, 2005; Shabbir and Bajwa, 2006), Sri Lanka (Jayasuriya, 2005), Bangladesh, and Nepal. Parthenium also occurs in southern China, Taiwan, Vietnam, and Israel in Asia (Nath, 1981; Joel and Liston, 1986), several Pacific islands including New Caledonia, Papua New Guinea, Seychelles, Vanuatu (Adkins et.al, 2005), and several African countries including Ethiopia, Kenya, Madagascar, Mozambique, South Africa, Somalia, Swaziland, and Zimbabwe (i.e. Wood, 1897; Hilliard, 1977; Njoroge, 1986, 1989, 1991; Nath, 1988; Frew et.al, 1996; Tamado and Milberg 2000; Tamado et.al, 2002a; MacDonald et.al, 2003; CABI, 2004; Da Silva et.al, 2004; Fessehaie et.al, 2005; Taye et.al, 2004b; Strathie et.al, 2005).

Parthenium is an annual herb with a deep-penetrating taproot system and an erect shoot system. Young plants form a rosette of leaves close to the soil surface. As it matures, the plant develops many branches on its upper half, and may eventually grow up to two meters (McFadyen, 1992). With good rainfall and warm temperature, parthenium has the ability to germinate and establish at any time of the year (e.g. Navie et.al, 1996; Tamado et.al, 2002b). Flowering usually commences 6–8 weeks after germination and soil moisture seems to be the major contributing factor to flowering (Navie et.al, 1996).

Pollination is primarily by wind (Lewis et.al, 1988). Parthenium is a prolific seed producer and a fully-grown plant can
produce more than 15,000 seeds in its lifetime (Haseler, 1976). Seeds persist and remain viable in the soil for reasonably long periods, with a seed bank half-life of approximately six years (Navie et al., 1998a).

Parthenium weed is studied in its various growth stages as done by Fauzi et al. 2009. Study was conducted to investigate the biological control ability of Puccinia abrupta var. partheniicola infected to parthenium weed (Parthenium hysterophorus L.) at various stages of growth in a glasshouse. The study also investigated the combined effect of the infection and the competitor plant, i.e. buffel grass (Cenchrus ciliaris L.), a pasture species usually found in the weed habitat in Central Queensland. The 2 x 3 factorial experiments were arranged in a completely randomized design with six replicates in each treatment. The parthenium weeds were planted with or without buffel grass. The plants were inoculated with P. abrupta var. partheniicola urediniospores either at the rosette, flowering or mature growth stage of development. As controls, an additional six non inoculated plants with and without buffel grass were planted. The results showed that P. abrupta var. partheniicola affected more on the younger plants than on the older ones. Its infection decreased the plant height. A higher reduction in plant above ground biomass was recorded because of the rust when the plants were inoculated at the rosette growth stage of development in the presence of competition. The impact of the rust was greatest on the ability of parthenium to produce seeds.
History of Introduction and Spread:

\textit{P. hysterophorus} is presumed to have entered India along with food grains imported from the USA (Vartak, 1968). It was identified and described by Rao (1956) in Pune (formally Poona), in the Maharashtra district, where it was first observed in 1955 (Vartak, 1968), and has since spread to most of the sub-continent (Nath, 1988). It is thought to have entered Pakistan, Nepal and Bangladesh via road connections, where thousands of vehicles cross between India and these countries every day at several places. In Pakistan, parthenium weed was first reported from Gujarat district of the Punjab Province in 1980s (Razaq et.al, 1994) and since then it has rapidly spread throughout the Province of Punjab, Islamabad Capital Territory (ICT) and parts of Khyber Pukhtunkhwa Province. The weed is thought to have entered Nepal from India and is currently found throughout most of the lowland Tarai region that borders India, and within most of the cities and urban areas in the Dun Valleys of the Siwalik range and the Mid-hill region. First occurrence of the weed in Nepal was reported by Malla from Trishuli in 1967 (Tiwari et.al 2005). A report suggested that the weed has been finding its place in Kathmandu valley since 1986 (Mishra 1991; Adhikari and Tiwari 2004).

In Australia, \textit{Parthenium} was first recorded near Toogoolawah in South-East Queensland in 1955, although this infestation did not spread widely (Auld et.al, 1983). It was introduced to Australia only
50 years ago (CRC 2003). It has been suggested that this introduction was due to the movement of aircraft and machinery parts into Australia during the Second World War. A second accidental introduction occurred in central Queensland, north of Clermont, in 1958 and originated from contaminated pasture seed (Navie et al., 1996). This spread rapidly and affected many hundreds of square kilometres (McFadyen, 1992).

Mcfadyen, R. E. and Cruttwell (2000) studied biology and host specificity of the stem galling weevil Conotrachelus albocinereus Fiedler a biocontrol agent for Parthenium Weed Parthenium hysterophorus L. (Asteraceae) in Queensland, Australia; In the study it was found that newly emerged larvae feed on epidermal cells and burrow vertically into the stem to feed on the nutrient-rich parenchyma cells. Larval feeding induces elliptical galls on the main shoot axes. Larvae remain within the galls for about two months. The final larval instar chews a hole at the end of the tunnel and emerges through that to move to the soil for pupation. The adult emerges after three weeks. Adult feeding damage is not significant, and causes only minor damage to young leaves Damage is mainly due to larval feeding which results in the fracturing of the vertical continuity of vascular tissues, thereby disrupting the host plant’s overall metabolism

In 2000 Launceston, Tas.: National Weeds Strategy Executive Committee published Parthenium weed (Parthenium hysterophorus): strategic plan, this showed that .

In 2012 researchers like Odero, Dennis C. studied ways to
control this weed and in the sequence they found response of Ragweed Parthenium (Parthenium hysterophorus) to Saflufenacil and Glyphosate;.

Parthenium weed was first recorded from southern Africa in 1880 but did not become a weed there until the mid-1980s. McConnachie et.al, (2011) as part of an international collaborative project, attempted to improve the understanding of the geographical distribution of *P. hysterophorus* in eastern and southern Africa. The climate modelling program CLIMEX was used to assist in the selection of survey localities. Roadside surveys of the distribution of the weed were conducted in Botswana, Ethiopia, South Africa, Swaziland and Uganda. Prior to these surveys, only limited *P. hysterophorus* locality records existed; substantially more records were obtained from surveys. Most infestations were high density (>3 plants m$^{-2}$). Distribution records were used to validate the CLIMEX model, which proved a useful tool. This study increased current understanding of the distribution of *P. hysterophorus* and developed a baseline from which to monitor future spread and abundance of *P. hysterophorus*. Additional surveys would be required in other countries in Africa which were predicted by CLIMEX to be at risk. This will enhance integrated management decisions for the control of a weed which has implications for food security and human health.

It was recorded in Kenya in 1975 from Nairobi herbarium records, and has become a weed of Kenyan coffee plantations as per Njoroge, 1991.
Ayana et al. (2011) conducted study in Awash National Park (ANP), East Shewa Zone of Oromia National Regional State, Ethiopia. Study was done to determine the impact of parthenium weed (*Parthenium hysterophorus* L.) on herbaceous diversity. A transect belt of 13.5 km X 0.10 km of parthenium weed infested land was identified for the determination of the impact. Four quadrats were purposively laid every 250 m interval two for infested and two for non-infested each from both sides of the road and a total of 216 quadrats of 2 m x 2 m (4 m$^2$) were considered. A total of 91 species were identified from which five of them were out of the quadrats. All species were categorized into 21 families, from which Poaceae and Fabaceae shared about 40%. The species in the non-infested quadrats were found to be more diverse and even when compared to those of the infested quadrats. Infested quadrats were found to be more abundant and dominant. *Tetrapogon tenellus* was found the dominant species in the non-infested quadrats while *Parthenium hysterophorus* was found dominant in the infested followed by *T. tenellus*. There was no statistically significant difference between the total stand crop biomass of the infested and non-infested. Parthenium weed have been found creating great challenge on herbaceous plant diversity of ANP. In Ethiopia, parthenium weed was reported at Dire Dawa in 1988 and Fasil (1994). There are two speculations: either the weed was introduced through wheat seed donated for relief from abroad or that it was introduced during the Ethio-Somali war in 1976/77. However, parthenium weed was recorded in 1968 at the Alemany University of Agriculture, Ethiopia
(Tamado, 2001). From the presence of parthenium weed in Kenya and Somalia (Njoroge, 1991; Frew et.al, 1996), and the capacity of parthenium weed seed to travel long distances through wind, water and other means, it is possible that it might have been introduced to Ethiopia from these neighbouring countries (Taye, 2002). Tamado et.al (2004) found Control of Parthenium hysterophorus in Grain Sorghum (Sorghum bicolor) in the Smallholder Farming System in Eastern Ethiopia.

The name *Parthenium hysterophorus* is universally accepted for this increasingly widespread weed, commonly known as parthenium weed. Dale (1981) distinguished 'North American' and 'South American' races, the latter race having larger flower heads and disc florets, yellow rather than white petals and less development of axillary branches. Picman and Towers (1982) suggested that, based on a chemical analysis of the sesquiterpene lactones, these may be separated at the subspecies or even the species level.

*Parthenium hysterophorus* L., being a declared invasive weed is threatening the biodiversity and human health in several areas of India. Several researchers have documented the allelopathic effect of this weed.

Indian scientists like Reddy et.al (2007) experimented to control Ragweed Parthenium (Parthenium Hysterophorus) with Preemergence and Postemergence Herbicides and came out with some good methods of controlling this weed.
Singh.et.al (2004) also did work to control Ragweed Parthenium (Parthenium hysterophorus) and Associated Weeds.

Kishor.et.al (2010) studied potential use of Parthenium hysterophorus L. in Agriculture. They found that the nutrient composition of composted Parthenium was higher than Farm Yard Manure. Hence recycling of Parthenium plants by composting and Parthenium extract seems to be an efficient way for utilizing the tremendous agricultural weeds. Composting is a resource for low external input sustainable agriculture and is also a good method for solving control weeds and pollution problems. Parthenium management would remain a great concern of the century. However, several studies proposed that Parthenium can be used as a Green manure, compost, biocontrol, soil ameliorate that may improve physical, chemical and biological properties of the soils and is a source of readily available plant micro- and macro-nutrients.

Numerous studies revealed that the integrated use of Parthenium in soil modifies the physico-chemical, biological and nutritional quality of the soil. Parthenium has great potentiality in agriculture due to its efficacy in modification of soil health and crop performance. The high concentration of elements (N, P, K, Fe, Mn, Cu and Zn) in composted Parthenium increases the yield of many agricultural crops. An exhaustive review of numerous studies of last two decades took place in this study, which systematically covers the importance, scope and apprehension regarding utilization of Parthenium in agriculture. *Parthenium hysterophorus* can be used as a bioherbicide. Appreciable quantity of nutrients in Parthenium can
be utilized to nourish the crops after composting and a lot of green Parthenium can be destroyed. This suggests that composting of uprooted Parthenium, or use as a green manure and Parthenium extract may reduce its spreading and inhibit the weed growth as well as menace of human health hazards worldwide.

Kumar et al. (2009) did comparative analysis of the complete sequence of the plastid genome of Parthenium argentatum and identification of DNA barcodes to differentiate Parthenium species and lines in which they found that the complete plastid genome of *P. argentatum* is 152,803 bp. Based on the overall comparison of individual protein coding genes with those in *L. sativa*, *G. abyssinica* and *H. annuus*, they demonstrated that the *P. argentatum* chloroplast genome sequence is most closely related to that of *H. annuus*. Similar to chloroplast genomes in *G. abyssinica*, *L. sativa* and *H. annuus*, the plastid genome of *P. argentatum* has a large 23 kb inversion with a smaller 3.4 kb inversion, within the large inversion. Using the *matK* and *psbA-trnH* spacer chloroplast DNA barcodes, three of the four Parthenium species tested, *P. tomentosum*, *P. hysterophorus* and *P. schottii*, had been differentiated from *P. argentatum*. In addition, they identified lines within *P. argentatum*.

Parker (1989) identified two biotypes with different flowering patterns in Mexico, whilst two genetically distinct biotypes (Clermont and Toogoolawah) have also been delimited in Australia. PAG, 2000 gave a Parthenium Action Group Information Document. CSIRO, Australia. (Adkins et al. 1997). Recently, Hanif
et.al (2011) found that these two biotypes are different in their morphology and reproductive behaviour; in particular, the Toogoolawah biotype shows a greater tendency towards self-pollination. The chromosome number has been reported as 2n=18 in India (Hakoo, 1963) and Australia (Navie et.al, 1996); however, both lower (=9) and higher (=34) chromosome numbers have also been attributed to parthenium weed (Kohli and Rani, 1994).

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The fact that parthenium pollen peaks in July-September has been positively correlated by skin-prick tests conducted on several allergy patients. A retrospective study of these three months also showed that maximum admissions of respiratory allergy patients were reported in Victoria Hospital in Bangalore.
Palynology:

The word palynology was coined by Hyde in 1944. The scientific study of pollen grain started after 1665 when Robert Hooke invented the compound microscope. Crompton (1982) mentioned that in 1671 Nehemiah Grew described borage (Boraginaceae), mallows (Malvaceae) and legume pollen grains.

Between 1798 to 1833, Francis Saucer, the draughtsman and botanical illustrator to King George ITT, illustrated pollen grains of 175 taxa representing 120 genera and 57 families.

The study of palynology started with the publication of the "pollen grains" by wodehouse (1935). Erdtman (1952) presented his monumental work "pollen morphology and plant taxonomy/ Angiosperms". His work laid the foundation of the basic knowledge of the subject.

Wodehouse (1935) made an extensive study of plants commonly found in the U.S.A. He emphasized the importance of pollen characters in phylogenetic considerations. Erdtman (1965) discussed various morphological characters of pollen wall and emphasized the possible line of evolution of the various apertural types in pollen and spores thus considered their importance in phylogeny and taxanomy. Wodehouse (1935) and Erdtman (1952, 1964) laid down the foundations and the principles of palynological studies.

The earliest microscopic observation of pollen was made by the English botanist Nehemiah Grew in the 1640s.

Henry Baker, fellow of the Society of Antiquaries and of the
Royal Society, was the first to describe dinoflagellates in his work “Employment of the microscope” in 1753.

Robert Brown, in 1809 discovered that pollen could be used for systematic studies of seed plants.

Hugo von Mohl, a German botanist, published in 1834 the first morphological classification of pollen. And in 1838, Heinrich Göppert was the first to describe and illustrate fossil pollen.

Christian Gottfried Ehrenberg, a German naturalist, was one of the most prominent figures in the history of Palynology. He studied many samples of waters, soils and rocks and described new species of diatoms, flagellates and radiolarians, and many fossil cyst of dinoflagellates. His book “Mikrogeologie” (1854) has many illustrations of a great number of microfossils.

In 1921, Gunnar Erdtman, a Swedish botanist, published his thesis about pollen as a tool for study the Quaternary vegetation and climate change.

George Deflandre, one of the most important figures in the field, worked with dinoflagellates fossils in the ’30s. Alfred Eisenak, was the first to describe quitinozoan in 1931.

Robert Potonié, studied miospores and pollen from the Carboniferous of Germany and made a very significant contribution to paleopalynology with systematic and biostratigraphic studies.

Later in 1949, Robert Lewis Moore created the school of Palynology at the University of Sheffield. Isabel Clifton Cookson studied miospores and dinoflagellates from the Mesozoic and Cenozoic of Australia
Evitt was the first to coin the term acritarchs, to refer to elements of uncertain affinity and Timofeyev was the pioneer in the study of palynofloras from the Mesozoic.

In the US, Leonard R. Wilson published over 200 scientific papers about the relationships of plants to sediments and rocks through time. He is one the pioneers of the study of palynology in US, along with James Schopf, Aurea Cross and William S. Hoffmeister.

Alfred Traverse, another pivotal figure, publishes in 1988 the first edition of Paleopalynology, the first comprehensive book in English on the subject, now book of reference all over the world. It was the rise of the oil industry in the 1950s and 1960s, which accelerated palynologic research in Argentina. The first study was made by Hector Orlando in 1954. In the 1970, Sergio Archangelsky and Juan Carlos Gamerro wrote about miospores and dinoflagellates from the Mesozoic and Cenozoic of Patagonia. Another pioneer was Diana Pothe de Baldis who studied dinoflagellates.


In India Nair (1965) explored the pollen grains of Western
Himalayas. Chaubal and Deodikar (1966-67) studied the pollen morphology of the family Acanthaceae from parts of the Western ghats. Basak (1967) analysed the pollen morphotypes of 93 species belonging to 28 genera of the family Solanaceae and attempted to classify pollen types to evaluate their taxonomic significance. Jain and Nanda (1966-67) investigated the pollen morphology of about one hundred species of flowering plants from Pilani (Rajasthan). Vishnu Mitre and Sharma (1962) undertook an investigation of the whole Leguminosae including Papilionaceae, in which they tabulated the pollen characters of some plants of the groups. Further they grouped the various taxa under different apertural categories and pointed out that Papilionaceae is dominated by 3-zonocolporate pollen type.

Rao and Shukla (1975) made studies on the flora of the upper Gangetic plains. Nair and Chaturvedi (1978) analysed the pollen morphotypes in some Indian monocotyledons. They studied 96 species belonging to 50 genera of seven monocot families. Further Tewari and Nair (1979) explored the pollen morphology of some Indian Papilionaceae. They scrutinised pollen grains of 92 species of Indian Papilionaceae belonging to 36 genera under 8 tribes. They reported 3-zonocolporate pollen grains and indicated that, the endocolpium was a useful criteria in separating species (e.g. Crotalaria spp.). Sharma (1979) investigated the pollen morphology of family Cucurbitaceae. Parabia et. al; (1979) studied the palynology of the Cyperaceae from Gujarat. Gill and Bedi (1983) investigated the cytopalynology of woody members of family Verbenaceae from
north-west and central India. Singhal and Gill (1983) studied the cytopalynology of 13 species of family Rutaceae.


Lorence et.al (1984) conducted palynological studies on the Monimiaceae in the Malagasy region (South West, Indian Ocean). 20 species belonging to the 6 genera of Monimiaceae were examined and described palynologically. Agashe and Nagalakshamma (1985) carried out investigations on the pollen flora of Lalbagh, Botanical...
Garden, Bangalore. The study covers 20 important tree genera belonging to 15 dicot Angiospermic families. Sreenivas (1986) studied the pollen morphology of six species viz. Hydrocotyle javanica, Pimpinella monoica, Seseli indicum and coriandrum sativum belonging to two subfamilies of Apiaceae. Sporne (1972) studied the evolution of pollen types in dicotyledons. According to him, tricolpate pollen is more primitive than trirporate.

Polyporate and polycolpate are negatively correlated with two and six primitive characters respectively. While multi aperturate pollen is negatively correlated with 7 primitive characters. Evolution therefore, has involved a progressive increase in the no. of apertures. This conclusion is supported by the fossil record. Faegri and Iverson (1964) agree that "phytogenetically furrows are primitive from, pores having developed later.

Layka (1976) studied the pollen morphology of 22 species of genus Argemone.

Skvarla et. al: (1978) investigated viscin threads in the family pnergraceae. They observed that viscin threads are upto 2000 μm long and 0.04 to 4.0 μm wide made up of sporopollenin. Micker (1981,1984 ) observed viscin threads from Onagraceae, Sriaceae and Caesalpiniaceae. Viscin threads are flexible,fragile strands or rope like structure on the surface of pollen tetrads or single pollen grains, which are coalesced with the exine. Maria (1984) investigated the viscin threads and other pollen connecting threads in the family Ericaceace, Caesalpiniaceae and Mimosaceae. Crompton (1982) reviewed the history of palynology and it's usefulness in

