

Occurrence of Indoor Insect Pests and Illnesses of Inhabitants in Malappuram, Kerala, India

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Abstract:

Indoor insect pests have a direct and negative impact on human health by inflicting bites and stings, causing allergic reactions and transmitting diseases. Certain volatile and non-volatile organic compounds, secreted by indoor insect pests, are important components of indoor air quality. Volatile compounds have been associated with numerous health disorders. In this study, we used a questionnaire-based approach to quantify the insect populations from 403 indoor spaces along with the features of the indoor systems and the symptoms observed by the inhabitants. We recorded surrounding environmental variables, biological contaminants and possible reasons that the inhabitants thought were behind the increase in the number of certain pests. The indoor environment was the second most common reason attributed to the occurrence of indoor illness, likely due to the pandemic. We also found a significant relation between the indoor biological contaminants recorded and the increasing number of illnesses. Although insects were considered a nuisance in many households, they were not found to be directly related to higher numbers of ill inhabitants. Nonetheless, the increasing number of patients with allergies in the past few years and the increasing health issues reported from indoor spaces with higher pest populations indicates their potential impact.

Keywords: indoor insect pests, semiochemicals, insect allergens, indoor air pollution

Introduction:

Indoor air quality is a matter of critical importance for human health. The level of pollutants in indoor spaces has been increasing more than outdoor levels (Tran 2020). Indoor pollutants have been recorded to be at least 2-5 times or even 100 times higher than the outdoor levels (USEPA 2020). The concentration of harmful chemicals and other volatile organic chemicals (VOCs) was recorded to be 10 times higher in Indian indoor environments compared to outside (Kankaria et al. 2014). VOCs are suspected to be responsible for the death of at least 38 million people annually (WHO 2022). Humans spend 80% to 90% of their lifetime indoors, where they may be exposed to a wide range of pollutants just by inhaling the indoor air (Ahmed et al. 2019). Toxic VOCs have been associated with allergies, eye irritation, lack of concentration, nose and throat malfunction, tiredness, vascular nervous dysfunction, acute chronic health pathologies and cancer (Li et al. 2021). Higher concentrations and long-term exposures of these were also reported to cause harm to the lungs, kidney, liver and the central nervous system (Shuai et al. 2018). Thus, although symptoms of most diseases caused by VOCs tend to be less severe than more acute diseases, they nonetheless need to be taken seriously as these symptoms may result in long-term effects (WHO 2001).

Additionally, the presence of certain biological substances, mainly spores from mould and other fungi, is reported to have negative effects on air quality and human health mostly resulting in sick building syndrome (SBS) and organic dust toxic syndrome (ODTS) (Moldoveanu 2015, Tran et al. 2020).

Insect allergies are usually limited to the areas surrounding insect bites/ stings and include pain, itching, swelling and redness in the affected areas. However, many volatile and non-volatile organic compounds secreted by indoor insect pests (such as ants, bugs, beetles, cockroaches, houseflies, mosquitoes, moths, etc.), known as semiochemicals or pheromones are also considered an important component of indoor air quality. Airborne particles from cockroaches, cat fleas and clothes moths are a significant health concern for individuals in socioeconomically disadvantaged groups (Mathews 1989). Studies focussing on house dust mites (Calderon et al. 2015) have shown that their effects can manifest in the respiratory system causing asthma and allergic rhinitis. It has been documented that being exposed to a high density of insects can result in occupational allergy (Fukutomi and Kawakami 2021).

In India, it was observed that *Luprops tristis*, commonly known as the Mupli beetle, caused skin and eye irritations as a result of a phenolic secretions that the beetle releases when disturbed (Sabu et al. 2008). Similarly, in this study, we conducted a detailed survey to explore the relationship between the presence of insects in indoor environments and the occurrences of allergic symptoms in inhabitants. The increased amount of time spent indoors by an individual, particularly during the COVID-19 pandemic and its long-term effects, make the investigation especially topical and important.

Methodology

A detailed survey was conducted at 403 randomly chosen indoor systems for a period of approximately 5 months (23-09-2020 to 17-3-2021). The survey covered 322 indoor spaces from 56 rural villages and 81 indoor spaces from 4 municipalities of the district of Malappuram (Coordinates: 11°N 76°E), in the State of Kerala, India. Three methods were deployed to collect the information: direct interview, telephonic interview and self-administered questionnaires.

Population figures, geographical position, surrounding vegetation and pollution sources were considered before data collection to ensure answers from a range of environments. Houses with traditional mud tile, concrete, asbestos and combined roofing systems were included. Flats, shops, and school and college buildings were also surveyed as a unit.

Observations by inhabitants on the abundance and diversity of indoor insects, mainly mupli beetles, ants and mosquitoes were noted along with illnesses and other disease symptoms of the indoor inhabitants. More details were collected about insects believed to cause allergies; the kinds of allergies caused by insect infestation (if any) along with other reactions to insect bites/stings. Possible reasons for the increase in numbers of allergic conditions were listed along with the seasons during which the disease symptoms mostly appeared. The presence of other biological contaminants such as mites, moulds and pollen were also noted. During the survey, additional information was also collected from a number of other questions (see appendix). However, as these variables were not relevant to the present study, they were not further analysed here.

The approximately 5-month data was aggregated for statistical analysis using R (version 4.0.5). Chi square test were used with absence/presence of illnesses as the first variable and the absence/presence of insects as the second variable.

Results:

Numerous symptoms and disease conditions were reported by the indoor inhabitants, some of which also included lifestyle diseases such as diabetes, cholesterol and high blood pressure (Fig. 1). Genetic disorders, such as Parkinson's disease, were also reported. The most common symptoms were headaches, multiple colds, allergic rhinitis and fatigue (Fig. 1). Most of the symptoms were connected to the respiratory system, including frequent coughing, wheezing, shortness of breath and asthma. Surprisingly, no instances of COVID were reported by any of the households, but that might be due to limited availability of testing and a general reluctance to admit a positive test.

The climatic seasons during which the indoor-related symptoms first appeared or became worse were looked into. Most of the respondents estimated that their symptoms were independent of the climatic

conditions (Fig. 2-A). Furthermore, the second most common reason given was the indoor environment although without the pollutants specifically identified. The third most common reason was the onset of rain. This study which focussed on the allergic issues with insects, surveyed inhabitants of indoor spaces who mostly did not believe insects to be a major source. Less than 15% of respondents named a specific insect species, although 5 insects were nonetheless considered to be causing one or more type of allergic reaction in different indoor environments (Fig. 2-B). Furthermore, the most common type of allergy caused by these insects were coughing and sneezing (Fig. 2-C), which would not result from coming into direct contact with most of the allergy causing insects observed. Allergic reactions caused by direct contact with insects (predominantly swelling and a burning sensation) were relatively rare (Fig.2-C).

The number of beetles reported from indoor spaces with ill inhabitants (Fig. 3) was 96%, which did not significantly differ from the 95 % of beetles recorded from those spaces without any illness ($\chi^2 = 0.003$, $df=1$, $p= 0.951$). With only a one-digit increase observed in the presence of mosquitoes in households with ill inhabitants (97%), these insects were observed to be having a non-significant relation with number of inhabitants being ill ($\chi^2 = 0.088$, $df= 1$, $p= 0.76$). The difference in relation to ants were slightly larger. While the number of indoor spaces with no illnesses had ants in 93% of them, those with the illnesses had 98%. This difference, however, was statistically insignificant ($\chi^2 = 2.639$, $df= 1$, $p= 0.104$). In the case of biological contaminants, mites and mould were observed slightly more frequent than that of indoor spaces with no inhabitants with an illness, while the opposite was true for pollen. There was a significant relation between the presence of biological contaminants and the number of inhabitants being ill ($\chi^2 = 6.32$, $df= 2$, $p= 0.04$).

Discussion:

Indoor air pollution is influenced by several factors including occupant density, inappropriate material used during building constructions, excessive use of chemical products - pesticides and disinfectants, combustion gases and pollutants coming from outside sources. Some biological pollutants, including bacteria, viruses, animal dander, cat saliva, mites, cockroaches and pollen (US EPA 2019), are labelled as very powerful biological allergens. Among biological contaminants, mould and pollen were reported in higher concentrations in the indoor spaces surveyed (Fig. 3-D). Damp indoor surfaces promote the presence of moulds, mildews, bacteria and insects (US EPA 2019) and humidity also serves as an attractive microclimate for many indoor pests such as rodents, woodlice and insects and even some birds (Pinniger 2021).

The number of patients with bronchial asthma (Bhalla et al. 2018; Dharmage et al. 2019; Cevhertas et al. 2020) and allergic rhinitis (Wheatley & Togias 2015; Krishna et al. 2020; Scadding et al.2021) is currently increasing globally. During this survey, which was mostly carried out during the COVID-19

pandemic, where inhabitants mostly stayed indoors, headaches, multiple colds and allergic rhinitis were reported as the most common symptoms (Fig. 1). The respondents partly ascribed these symptoms to indoor air quality (Fig. 2-A). However, a higher number of people responded that their symptoms were independent of the climatic conditions and people were also unsure about blaming the most easily agreeable reason for their allergic issues – outdoor pollution, possibly because of respondents being in lockdown at the time of answering the questionnaire. Therefore, irrespective of the climatic changes, the indoor environment is suspected to be an important reason. About 20% of the respondents also suspected the onset of rain a reason for their deteriorating health conditions (Fig. 2-A). Such monsoon illnesses may occur due to the synchronised activity of the life cycle of insects and temperature changes (Chowell 2019). Insect pests, such as the mupli beetles have their life cycles synchronised with climatic conditions causing them to wake from the 11-month diapause at the onset of rain (Vinod and Sabu 2009). They escape from the wet floors of rubber leaves to drier indoor spaces, where they can form huge aggregations. Mupli beetles are mostly attracted to tile-roofed and palm-frond thatched spaces which hold higher humidity than concrete tops (Vinod and Sabu 2009). This connects the dampness with the presence of beetles in indoor spaces.

Ants, which were the most common allergy- inducing insects in this study (Fig. 2- B), usually inflict painful stings introducing formic acid to the skin (Touchard et al. 2016). We found that their presence was higher in households with illnesses, although this effect was not statistically significant (Fig. 3-C). Mosquitoes, the third most common insect pest in this study, can cause nuisance by biting but also cause serious illness and even death in people (Prudêncio 2020) and some animals (IDPH 2017) by vectoring pathogens. Although in our study, we found no impact on the level of household illnesses. Probably because they just caused itching/ acute allergies due to biting, but no serious issues were reported during the survey (Fig. 3-B). The fourth and fifth most common allergic insects- bees (Wehbe et al. 2019) and wasps (Lee et al. 2016), respectively, are known to sting and inject a chemical cocktail when disturbed. Nevertheless, the second most allergic insect, the mupli beetle (Fig. 2-B), which neither stings nor bites, is the only insect that causes indirect irritation through its defensive phenolic secretions. When disturbed it releases an odoriferous volatile substance and causes skin irritation (Sabu et al. 2008) and keratoconjunctivitis (Susan et al. 2010).

Almost 78% of the total indoor spaces surveyed recorded the presence of beetles. Though free from direct stings and bites, the Mupli beetle was still reported as an allergic insect and, although not statistically significant they were found to be slightly more common in indoor spaces with members reporting allergy symptoms, which could suggest a minor impact of the chemicals released by them (Fig. 2-B). The lack of a significant effect of the beetles in this study, is possibly because they are only found around certain types of vegetations and during particular seasons, outside of which their effects are likely to be negligible. This survey, which was conducted from September 2020 to March 2021,

recorded data mostly during the inactive season with the seasonal aggregation occurring after 9 months in an inactive dormancy phase after summer rain, usually towards the end of March (Sabu et al. 2008). Huge aggregations occur close to indoor spaces in rubber plantations, where the beetles (particularly larval instars, pupae and teneral adults) feed on tender rubber leaves high in nitrogen and moisture content; a crucial factor for the growth and survival of the next generation (Sabu and Vinod 2009a , b). Mosquitoes, on the other hand, are constantly active nuisance pest present throughout the year, particularly in the tropics (Reinhold et al. 2018). Similarly in the tropics, ants are also abundant in terrestrial ecosystems throughout the year (Touchard et al. 2016). An increase in the number of indoor spaces reporting moulds synchronizing with an increase in the number of insect pests should also be taken into consideration (Fig. 3-D). In such circumstances, the most common indoor allergic symptoms such as cold, cough, sneezing etc recorded as a part of this work (Fig. 2-C) can be categorised as insect-related allergy symptoms (AAFA 2022, ACAAI 2022). Although not clinically proven, headaches, watery eyes and exhaustion, other usual hay fever symptoms (Fig. 1) (AAAAI 2022) may also be influenced by the presence of insects.

Conclusion:

The evident increase in the indoor air pollution statistics of India and the supporting morbidity and mortality data of this tropical country (LPH 2021) coinciding with a higher diversity of indoor insect pests, calls for more detailed studies into the possible link between indoor insects and public health. Indoor volatile releases from insects and the increased amount of time spent indoors by individuals during the COVID-19 pandemic along with its long-term effects are likely to be important. The impact of these small, but ubiquitous animals, on indoor air quality is a matter of serious concern. Information on the exact causes that impact on indoor air quality will help decrease the risk of indoor health disorders (US EPA 2019). However, detailed studies into the individual components of the defensive chemicals released by the nuisance insect pests identified in this study are also required. Studying the extent of the allergenicity of the defensive volatiles using immunoglobulin and skin prick tests can further help the development of better treatments and prevention.

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Declaration of interest:

The authors report there are no competing interests to declare.

Data availability statement:

The data that support the findings of this study are openly available in Mendeley Data at Mohammed, Sajidha (2022), Data set used for paper titled- A Comparative Analysis of Indoor Insect Pests and Illnesses of Inhabitants in Malappuram, Kerala, India, Mendeley Data, V1, doi: 10.17632/jh3rgs47mj.1

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Figures:

Figure1:

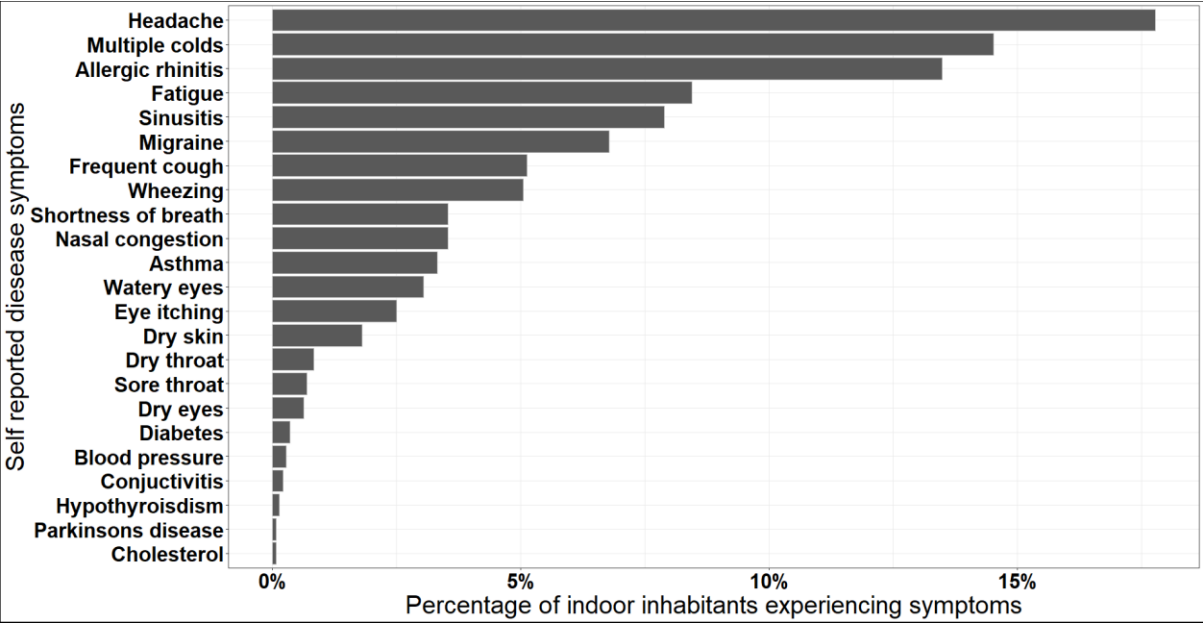


Figure 1. The percentage of indoor inhabitants reporting disease symptoms. This information was analysed from 1147 symptoms recorded from 403 indoor spaces to check the influence of the presence of insects on the health of inhabitants. All symptoms were self-reported and not confirmed by medical evaluation.

Figure 2:

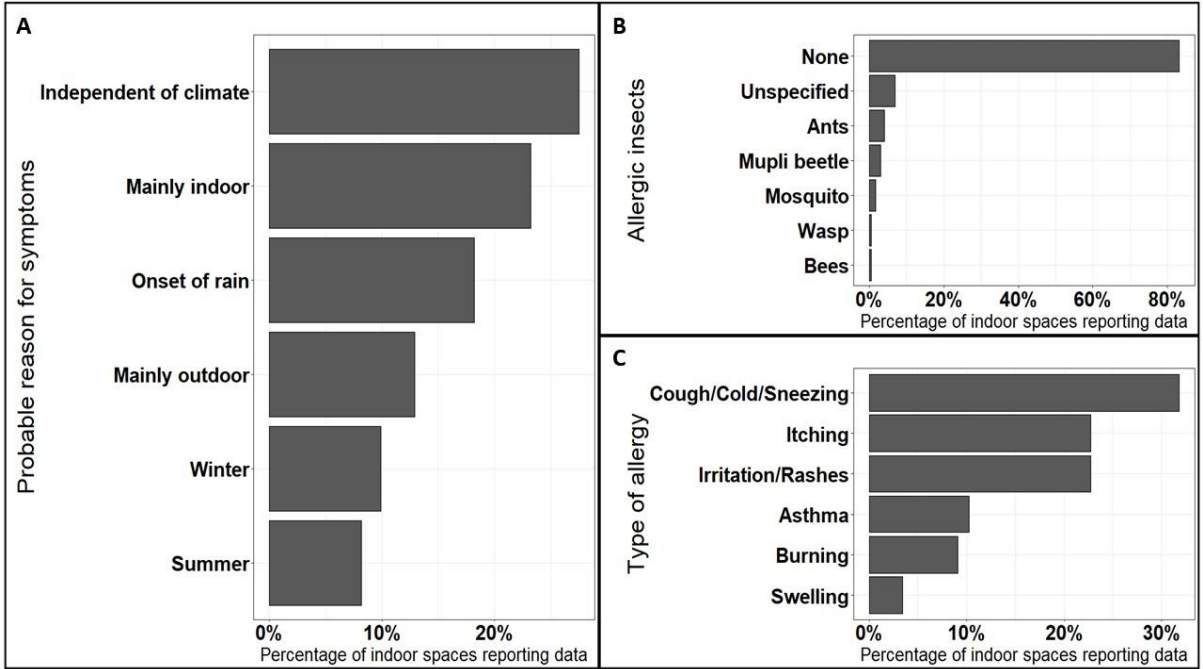


Figure 2: A- Represents the probable reasons for the appearance of the negative health symptoms as observed by the inhabitants. This information is analysed from 698 responses collected from 403 indoor spaces. B- Represents the kinds of allergic insects

from 417 responses recorded from 403 surveyed indoors. Here insects were termed as allergic when people experienced allergic issues during their presence, bites or sting. C- Represents 88 responses from 67 indoor spaces that have been experiencing negative health issues during the presence of insects or when they come in direct contact with the insects. Most of them were not medically confirmed, though some severe symptoms were treated medically.

Figure 3:

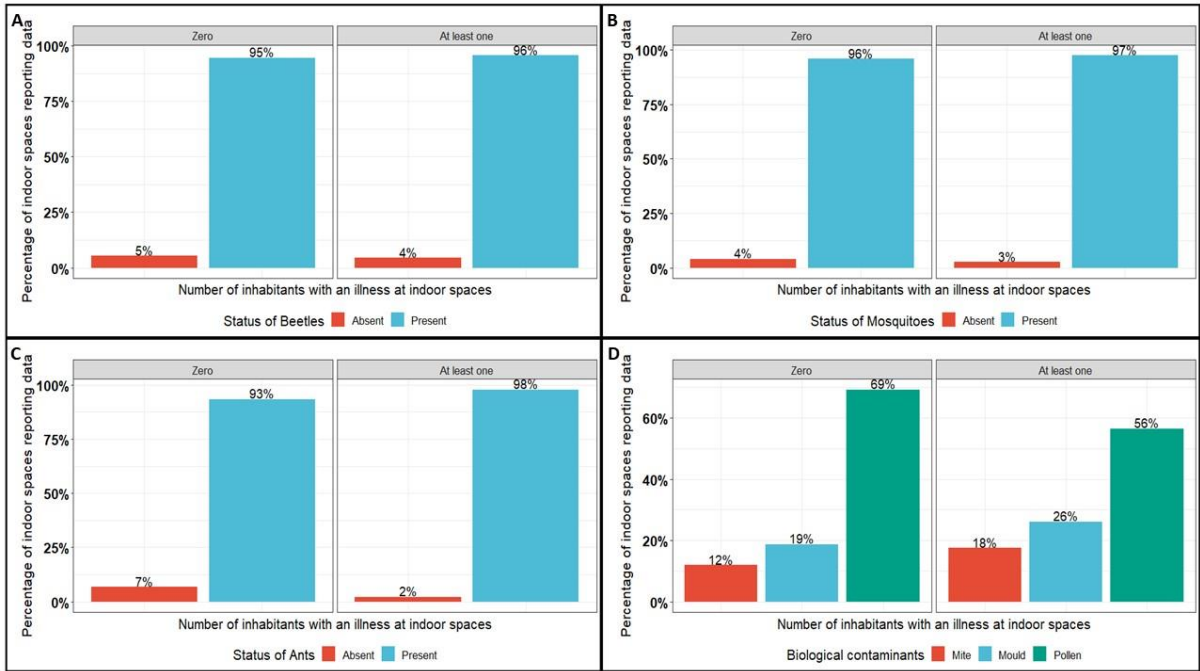


Figure 3: The self-reported households with illnesses (314 indoor spaces) and without illnesses (89 indoor spaces) in the presence or absence of specific insects (as reported by the respondents). A- Effect of mupli beetles. B- Effect of mosquitoes. C- Effect of ants. D- Comparison of biological contaminants of 563 responses collected from 403 indoor spaces. Multiple responses were recorded from most of the indoor spaces. The presence of biological contaminants was confirmed by the respondents. The inhabitants with an illness included only those with medically confirmed allergic issues.

APPENDIX

QUESTIONNAIRE

Name: _____ Contact : _____

1. Place :
2. Village/Municipality :
3. Age of building : 2yrs ☐ 5yrs ☐ 10yrs ☐
4. Structure of building : House ☐ Apartment ☐ Commercial ☐
5. Ventilation Status : Good ☐ Average ☐ Bad ☐
6. Roof Type : Traditional ☐ Closed ☐
7. Number of Members :
8. Number of children below 12 years :
9. Number of adults above 60 years :
10. General Parameters :
 - a) Temperature :
 - b) Humidity :
 - c) SO₂ :
 - d) CO :
 - e) PM 2.5 :
 - f) PM 10 :
11. Number of diseased ones :
12. Disease diagnosis :

<input type="checkbox"/> Allergic rhinitis	<input type="checkbox"/> Wheezing
<input type="checkbox"/> Asthma	<input type="checkbox"/> Dry throat
<input type="checkbox"/> Conjunctivitis	<input type="checkbox"/> Shortness of breath
<input type="checkbox"/> Sinusitis	<input type="checkbox"/> Nasal congestion
<input type="checkbox"/> Migraine	<input type="checkbox"/> Sore throat
<input type="checkbox"/> Frequent cough	<input type="checkbox"/> Eye itching
<input type="checkbox"/> Dry skin	<input type="checkbox"/> Watery eyes
<input type="checkbox"/> Dry eyes	<input type="checkbox"/> Headache
<input type="checkbox"/> Exhaustion	<input type="checkbox"/> Multiple colds
<input type="checkbox"/> Others _____	
13. If you suffered from any of the above,

Did these symptoms occur :

<input type="checkbox"/> Mainly outdoor	<input type="checkbox"/> Winter
<input type="checkbox"/> Mainly indoor	<input type="checkbox"/> Independent of environmental conditions
<input type="checkbox"/> Onset of Rain	
<input type="checkbox"/> Summer	
14. Do you experience any problems occurring frequently during any specific season of the year
 - a) Problem :
 - b) Season :
15. Qualitative survey-Surrounding plot :

<input type="checkbox"/> Tree _____	<input type="checkbox"/> Water body _____
<input type="checkbox"/> Shrub _____	<input type="checkbox"/> Houses _____
<input type="checkbox"/> Herb _____	<input type="checkbox"/> Industrial area _____
Forest _____	

☐ Others _____

16. Biological contaminants observed :

☐ Animal Dander

☐ Moulds

☐ Pollen

☐ Mites

Entomological Survey

17. Common insects observed Indoor :

18. Quantitative survey - kinds of insects :

Sl.No	Insect	5-10	10-15	Above 15
1	Flies			
2	Mupli beetle			
3	Mosquito			
4	Cockroaches			
5	Ants			
6	Other _____ _____			

19. Signs of infestation -

☐ Swarming

☐ Frass

☐ Others _____

☐ Noises

☐ Nuisance

20. Do you think any particular landscape /

Practices causes an increase in their

Number

: Yes ☐ No ☐

21. If Yes, provide details : _____

22. Are the pests at your place controllable : Yes ☐ No ☐

23. Control measures taken :

☐ Sprayed _____

☐ Dusted _____

☐ Others _____

Non-Chemicals _____

☐ Baits _____

☐

24. Do these insects or infestations cause any allergy related issues : Yes ☐ No ☐
25. If yes, mention the type of allergy : _____
26. Are you allergic to insect bite/insect Sting : Yes ☐ No ☐
27. If yes, give details : _____
28. Have you been medically evaluated For Allergies : Yes ☐ No ☐
29. Are you currently taking medicines : Yes ☐ No ☐
30. If Yes, provide details : _____
31. Do you have a history of having asthma : Yes ☐ No ☐
32. If Yes, Age of onset (in years) : 1-2 ☐ 3-5 ☐ 5-10 ☐ > 10 ☐
33. Frequency of attacks :
☐ 2 or less times a week
☐ 3-6 times a week
☐ 3-4 times a month
☐ Throughout the day
☐ Occasionally
34. Details of Medicines to control asthma : _____
35. Do you experience night cough : Yes ☐ No ☐
36. Season it gets worse in : _____
37. Do you experience difficulties when you wake up in the morning : Yes ☐ No ☐
38. Season it gets worse in : _____
39. Surgery histories of sick ones : _____
40. Immunizations of sick ones up to date : Yes ☐ No ☐

Comments/ Suggestions: _____

