12

Microclimatic Factors Affecting the Growth of House Dust Mites in Home and its Relation with Homemakers Health

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Introduction

It is estimated that people spent 90 percent of their time in indoors, often at home, breathing clean indoor air which have important impact on health (Robert et. al., 1992). Insanitary and unhygienic conditions of houses causes dust accumulation in the household furnishings, upholstered furniture, flooring and kitchen corners etc. This accumulated (settle) dust is the major source of HDMs in indoors. HDMs are one of the major risk factor that we got from indoor environmental dust which primarily lives on dead skin cells, which are commonly called dander, which shed regularly form humans and their animal pets (Barbogg, 2003). HDMs proliferation depends on the microclimatic conditions of indoors. HDMs are higher in number in areas where there is high humidity and lower light intensity. They just love to live in higher humidity of 70-80 percent and temperatures of 20-30°C in which there development and food consumption increases (Hart et al., 1998). Apart from this high air flow rate also increases HDMs concentration in indoors.

Most of the inmates are not aware of these HDMs as indoor pollutants and unconsciously easily become victim of its health hazards. Estimates are that dust mites may be a factor in 50 to 80 percent asthmatics (Crowther et al., 2001). More recently, causal links have been proven between immunity to HDMs and allergic disorders, including asthma, rhinitis, dermatitis and conjunctivitis (Hewitt et al., 1995). HDMs are the major cause of year round complaints of stuffy nose, sneezing and watery eyes what some people describe as a 'permanent cold' (Little, 2003). Hence, the objectives of present paper are:

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- To ascertain the micro climatic factors which affect the HDMs concentration in indoors i.e. temperature, humidity, air flow rate and light intensity.
- To examine respondents health status in relation to HDMs complications.

Methodology

The study was conducted in Udaipur city urban area, which comes under the sub- humid southern plains surrounded by Aravalli hills in Rajasthan. The climate of Udaipur is tropical. Lakes, fountains, parks and hills surround Udaipur and its climatic conditions create a suitable environment for the growth of HDMs. A survey of 120 households was conducted to gather information regarding respondents' family background and health complications faced due to HDMs. During summer reason rainy period (July to September, 2008) observation of indoor microclimatic conditions like temperature, RH, AFR and LI were made with the help of 4 in 1 environmental tester which affect the HDMs concentration in indoors. Apart from this emphasis was also made to compare the impact of different human activities based on respondents livelihood pattern in different zones viz. residential (RZ), commercial (CZ) and industrial zone (IZ).The incidences of health problems faced by respondents were gathered through interview schedule by the investigator. Two gram of settled dust was collected from four different areas of furniture and furnishings of living, dining, bed rooms and kitchen of the house through electric vacuum cleaner. The dust samples were collected in separate polythene bags, sealed and taken to laboratory within 24 hours to count HDMs under binocular microscope. On the basis mean ± SD of HDMs counts, all the households were divided into three categories as low (L), moderate (M) and high (H) HDMs. Linear regression model was administered to analyse the microclimatic factor affecting indoor HDMs concentration.

Findings of the Study

The findings of the study are presented as under:

Family Background Information

Family background information of the respondents was collected to analyse the respondents association with housing factors. Less than two third (60.83 per cent) of the respondents belongs to joint families and rest of them (39.17 per cent) to nuclear families. The average size of the respondents families were five members (SD=1.44).The average age of respondents was 45.22 years. One fourth of the respondents were graduates. More than half of the respondents were working (52.05 per cent) in teaching in government and private schools. To assess the socio-economic status of the respondents' families the worth of the respondents' household assets was calculated. The average worth of respondents household assets was 19,52,452.00 rupees (SD=15,96,698.00). Data shows that average annual income of the respondents household was rupees 4,82,158.43 (SD=2,26,173.14).

Micro Climatic Factors

The mite concentration depends on the ecological requirements like temperature, RH, AFR and light during summers in different areas of the house viz. living, dining, bed room and kitchen which are the prime requisite for successful growth and multiplication of HDMs (Crowther et al,.2000; Modak and Saha, 2002).

Temperature

Changing weather conditions play vital role in the growth of HDMs (Blythe et al., 1974; Abbott et al., 1981; Hart and Whitehead, 1990; Warner et al., 1993; Saha, 1997). To observe the impact of seasonal variation on HDM growth temperature of respondents' house different rooms was recorded in rainy season.

- **Living Room:** Average temperature of the respondent's living room was 24.71˚C (SD=3.07 ˚C). In RZ respondents' living room temperature (25.59 ˚C) was found to be higher than the average as compared to IZ (25.34˚ C) and CZ (23.21˚C). Intra zonal variation showed higher temperature of respondents' living room in moderate HDMs category of RZ (25.86˚ C) and CZ (23.82˚ C).
- **Dining Room:** The average temperature in respondent's dining room was 25.29˚ C (SD=2.48˚C) in summer. Not much variation was found in all the three zones dining room temperature (RZ=25.58˚C, CZ=24.42˚C and IZ= 25.89˚C) in summer season. Respondents having higher than the average temperature of dining room fall in moderate HDM category of RZ (25.77˚ C) and of CZ (25.50˚C) and higher HDM category of IZ (25.93˚C).

Table 1: Average Indoor Temperature of Respondents' Different Rooms

S. No.	Temperature of rooms (˚C)	RZ				CZ				IZ				Grand Total N=120
		L n=10	M n=27	H n=3	Total N=40	L n=9	M n=25	H n=6	Total N=40	L n=4	M n=31	H n=5	Total N=40	
1.	Temperature													
a.	Living room													
	Mean	25.26	25.86	24.20	25.59	22.44	23.82	21.85	23.21	25.77	25.26	25.48	23.34	24.71
	SD	1.70	1.80	0.72	1.76	4.90	3.96	5.36	4.35	2.43	1.89	0.32	1.80	3.07
b.	Dining room													
	Mean	25.46	25.77	24.33	25.58	24.37	25.50	24.41	27.22	25.70	25.70	25.98	25.89	25.29
	SD	1.45	1.82	1.15	1.70	3.66	3.10	1.64	3.05	2.03	2.41	1.72	2.30	2.48

c.	**Bed Room**													
	Mean	25.30	26.00	23.66	25.65	24.00	24.16	24.83	24.72	27.77	26.09	24.42	26.30	25.39
	SD	2.33	3.64	3.21	3.38	2.82	2.82	1.72	2.68	1.13	1.79	0.90	1.70	2.79
d.	**Kitchen**													
	Mean	25.91	26.12	25.66	26.03	25.11	24.01	24.36	24.31	26.25	25.5	24.90	25.51	25.28
	SD	2.13	2.30	4.04	2.33	2.57	2.87	2.89	2.77	2.06	1.58	1.10	1.57	2.37

- **Bedroom:** Table 1 shows that the average temperature of respondents' bedroom was 25.39˚ C (SD=2.79˚C) in summer season. Inter zonal variation highlighted higher than the average temperature of bedroom in IZ (26.30˚ C) and RZ (25.65˚ C) as compared to CZ (24.72˚ C). Moreover, respondents having higher than the average bed room temperature belonged to moderate HDM category of RZ (26.00˚C) and lower HDM category of IZ (27.77˚C). However, in CZ respondents belonging to higher HDM category had lower than the average bedroom temperature (24.83˚ C)
- **Kitchen**: Data in the Table 1 revealed that the average temperature of respondents kitchen in summers was 25.28˚ C (SD= 2.37). Inter zonal variation showed higher than the average temperature of respondents' kitchen in RZ (26.03˚C) and IZ (25.51˚C) than CZ (24.31˚C). Respondents having higher than the average temperature of their kitchen belonged to lower HDM category of CZ (25.11˚C) and IZ (26.25˚C) and moderate HDM category of RZ (26.12˚C). On the contrary the lowest temperature of respondents' kitchen was in high HDM category of RZ (25.66˚C) and IZ (24.90˚C).

Thus in the rainy season temperature of respondents' different rooms was ranging from 24.71 ˚C to 25.39 ˚C which is an ideal condition for HDMs growth. Several studies also reported that in summer season the most suitable temperature for mites survival is in between from 20-30˚C (Hart, 1998; Barbogg, 2003).

Humidity

In microbial culture, survival of mites depends upon the RH. There is a significant association between RH and presence of live HDMs (Charpin and Vervloet, 1990). An increase in RH leads to an increase in average development time of HDMs at all stages of life cycle (Arlian et al. 1983, Colloff, 1987). Indoor RH of respondents' houses was taken to identify its effect on HDMs growth.

- **Living Room:** In summer season average RH of respondents living room was 66.54 per cent (SD=1.70). RH was found to be higher in IZ (67.15 per cent) as compared to other zones (RZ=66.02 per cent and CZ=66.45 per cent). Higher than the average living room RH (67.66 per cent) was observed in high HDM category of CZ. In RZ respondents falling in high HDM category had higher than average RH of living room (66.33 per cent). In IZ the lower HDM category respondents' houses had higher than average RH (68.25 per cent) of living room. Several researchers also reported that HDM grows well in the dust at 45 -80 per cent of RH (Shivpuri and Dua 1974; Shivpuri, 1977).
- **Dining Room**: Average RH of respondents dining room was 65.87 per cent (SD=1.31). Among all the three zones average RH was higher in IZ (66.25 per cent) and CZ (65.87 per cent) as compared to RZ (65.50 per cent). In high HDM category of RZ (65.66 per cent) and CZ (66.33 per cent) average RH of respondents' dining room was found to be higher. Lower HDM category respondents had higher RH (66.50 per cent) in IZ.
- **Bedroom:** The average RH of respondents' bedroom in summer season was 67.58 per cent (SD=2.36). Average RH of respondent's bedrooms was found higher in IZ (67.92 per cent) as compared to RZ (67.32 per cent) and CZ (67.50 per cent). Intra zonal variation revealed that in higher HDM category of CZ respondents' bed room had higher than the average RH (69.83 per). Thus it can be said that mattresses in the bedroom retain moisture for longer periods therefore, provide a more suitable habitat for HDM. In RZ respondents of moderate HDM category had higher than the average RH (67.92 per cent) in bedroom. Warner et al. (1999) also found a significant association between the maximal mite count and RH of bedrooms.

Table 2: Average Indoor RH of Respondents' Different Rooms

S. No.	RH of rooms(in per cent)	RZ				CZ				IZ				Grand Total N=120
		L n=10	M n=27	H n=3	Total N=40	L n=9	M n=25	H n=6	Total N=40	L n=4	M n=31	H n=5	Total N=40	
1	**Humidity**													
a.	**Living room**													
	Mean	65.20	66.29	66.33	66.02	66.33	66.20	67.66	66.45	68.25	66.96	67.40	67.15	66.54
	SD	1.48	1.56	2.30	1.62	1.32	1.41	2.16	1.56	2.36	1.74	1.51	1.77	1.70

b.	**Dining room**													
	Mean	65.10	65.62	65.66	65.50	65.55	65.88	66.33	65.87	66.50	66.19	66.40	66.25	65.87
	SD	1.20	1.11	1.15	1.14	1.01	1.30	1.75	1.30	1.73	1.40	1.67	1.42	1.31
c.	**Bed room**													
	Mean	65.60	67.92	67.66	67.32	67.66	66.88	69.83	67.50	68.50	67.90	67.60	67.92	67.58
	SD	1.57	2.23	3.05	2.32	2.73	2.16	2.31	2.49	2.64	2.38	1.81	2.30	2.36
d.	**Kitchen**													
	Mean	64.90	66.92	67.00	66.42	66.88	66.60	69.16	67.05	68.25	67.29	67.40	67.40	66.95
	SD	0.56	2.03	2.64	1.99	1.69	1.82	2.31	2.03	2.36	1.98	1.51	1.94	2.01

- **Kitchen:** Average RH of respondents kitchen in summer season was 66.95 per cent (SD= 2.01). Inter zonal variation revealed that respondents kitchen RH was more than average in CZ (67.05 per cent) and IZ (67.40 per cent) as compared to RZ (66.42 per cent). Intra zonal variation showed that respondents' kitchen RH was higher than the average in high HDM category of RZ (67.00 per cent) and CZ (69.16 per cent). It can be due to high water vapour content in kitchen air while cooking which increases the moisture and helps in the concentration of HDMs.

The RH of respondents' different rooms was in between 66.54 to 67.58 per cent. During favourable conditions of humidity and temperature HDMs osmoregulate from the surface cuticle (Layon, 2004). Corroborated inferences were also drawn by several researchers that HDM grows well in the dust at 45 -80 per cent of RH (Shivpuri and Dua1974; Blithe, 1976; Shivpuri, 1977; Carswell, 1982; Hunter, 1996; Lakshmi and Hao, 1999; Singh and Rao, 2001).

Air Flow Rate (AFR)

Dust accumulation in the house depends upon the AFR. It has been estimated that 20 per cent of the dust that comes in the house is accumulated through air flow. This settled dust is the main reason for the occurrence of HDMs the most common human habitat (Alan, 2003). The dust accumulation and resuspension is readily influenced by the air flow patterns and activities taking place in the area (Thatcher et al., 1995). During summer AFR was measured without fans so that the HDMs concentration due to natural AFR can be taken.

- **Living Room:** Data in the Table 3 explicitly showed that average AFR of respondents living room was 0.74 m/sec. (SD=0.56). The average AFR of respondents' living room was higher in IZ (0.80 m/sec.) as compared to RZ (0.75 m/sec.) and CZ (0.67 m/sec.). It can be ascribed to most of the houses in IZ were detach type and situated in open areas, due to which circulation of air was more. Increased AFR was observed in higher HDM categories of RZ (0.80 m/sec.) and IZ (0.90 m/sec.) of respondents' living room.
- **Dining Room:** Average AFR of respondents dining room was 0.83 m/sec. (SD=0.64). Respondents of IZ were found to have higher than the average AFR (1.00 m/sec.) of dining room as compared to other zones (CZ=0.64 m/sec. and RZ=0.84 m/sec.). The dining room AFR was found to be higher in higher HDM categories of RZ (1.06 m/sec.) and IZ (1.04 m/sec.). It can be said that higher AFR increases the HDMs concentration in home. However, increased AFR of dining room was observed in lower HDM category of CZ (0.75 m/sec.).
- **Bedroom:** During summer average AFR in respondents' bedroom was 0.77 m/sec. (SD=0.51). Inter zonal variation revealed increased average AFR of respondents bedroom (0.93 m/sec.) in RZ than other zones (IZ=0.71 m/sec. and CZ=0.68 m/sec.). Intra zonal variation highlighted that in all the three zones increased AFR of respondents bedroom was observed in high HDM categories of all the three zones (RZ= 1.30 m/sec. , CZ= 0.73 m/sec. and IZ= 1.22 m/sec.). It can be concluded that high AFR encourages HDMs growth in the bedroom.
- **Kitchen**: The overall average AFR of respondents' kitchen was 0.90 m/sec. (SD=0.53). Increased average AFR of respondents kitchen was observed in IZ (1.04 m/sec.) as compared to other zones (RZ= 0.94 m/sec., CZ=0.74 m/sec.). Intra zonal variation reflected higher AFR (0.90 m/sec.) in respondents' kitchen of higher HDM category in CZ. Furthermore, in IZ moderate HDM category respondents had higher AFR (1.10 m/sec.) in their kitchens.

The AFR of the respondent's houses depends upon the outer air flow pattern (Warner et al., 1999). The increased AFR brings more dust in indoors which increases HDMs in settled dust. At the same time HDMs flow from one place to another also increases.

Table 3: Average Indoor AFR of Respondents' Different Rooms

S. No	AFR (in m/sec.)	RZ				CZ				IZ				Grand Total N=120
		L n=10	M n=27	H n=3	Total N=40	L n=9	M n=25	H n=6	Total N=40	L n=4	M n=31	H n=5	Total N=40	
	Indoors													
1	**Air flow rate**													
a.	**Living room**													
	Mean	0.68	0.76	0.80	0.75	0.20	0.72	0.68	0.67	0.72	0.82	0.90	0.80	0.74
	SD	0.58	0.59	0.65	0.58	0	0.59	0.65	0.58	0.54	0.52	0.60	0.52	0.56
b.	**Dining room**													
	Mean	0.78	0.80	1.06	0.84	0.75	0.60	0.70	0.64	0.92	1.00	1.04	1.00	0.83
	SD	0.67	0.68	0.67	0.66	0.64	0.59	0.69	0.60	0.72	0.61	0.76	0.62	0.64
c.	**Bed room**													
	Mean	1.04	0.85	1.30	0.93	0.68	0.67	0.73	0.68	0.35	0.68	1.22	0.71	0.77
	SD	0.55	0.59	0.17	0.56	0.48	0.48	0.51	0.47	0.17	0.46	0.40	0.47	0.51
d.	**Kitchen**													
	Mean	1.01	0.92	0.93	0.94	0.85	0.68	0.90	0.74	0.82	1.10	0.82	1.04	0.90
	SD	0.50	0.54	0.51	0.52	0.56	0.54	0.60	0.54	0.73	0.48	0.56	0.51	0.53

Light Intensity

HDMs prefer dark and shady places in the house. Light intensity is one of the main limiting factors for the HDMs growth. Indoor light intensity of respondents' different rooms was measured to examine its affect on HDMs growth.

- **Living Room**: During summer average light intensity of respondents living room was 45.72 Lux (SD=17.56). Inter zonal variation showed that in CZ respondents living room had lower light intensity (31.90 Lux) as compared to RZ (41.06 Lux) and IZ (64.21 Lux). Intra zonal variation showed that lower HDM category respondents had lesser light intensity of' living room in RZ (36.75 Lux)). Conversely, higher light intensity was observed in lowers HDM category of respondents' living room in CZ (33.20 Lux).

Table 4: Average light intensity of respondents different rooms

S. No.	Light intensity of rooms (in Lux)	RZ L n=10	RZ M n=27	RZ H n=3	RZ Total N=40	CZ L n=9	CZ M n=25	CZ H n=6	CZ Total N=40	IZ L n=4	IZ M n=31	IZ H n=5	IZ Total N=40	Grand Total N=120
1	**Light intensity**													
a	**Living room**													
	Mean	36.75	42.05	38.40	41.06	33.20	31.74	29.00	31.90	56.22	66.57	66.33	64.21	45.72
	SD	1.30	11.95	1.34	10.67	4.51	4.77	3.46	4.65	19.18	13.61	14.86	15.39	17.56
b	**Dining room**													
	Mean	32.30	32.51	39.66	32.32	34.75	30.16	35.00	30.92	49.24	45.37	47.7.3	46.60	36.61
	SD	7.57	2.29	6.65	7.15	3.94	3.89	0	3.94	18.10	16.89	16.13	16.70	12.80
c	**Bedroom**													
	Mean	39.20	38.40	37.00	38.50	37.88	37.20	37.00	37.32	52.50	59.48	57.60	58.55	44.79
	SD	11.34	11.80	13.45	11.49	8.32	7.88	7.74	7.76	15.60	11.56	15.05	12.22	14.41
d	**Kitchen**													
	Mean	42.80	43.11	41.66	42.92	37.88	37.20	37.00	37.32	52.50	59.48	57.60	58.55	46.26
	SD	10.52	11.53	14.57	11.19	8.32	7.88	7.74	7.76	15.60	11.56	75.05	12.22	13.82

- **Dining Room:** The overall average light intensity of respondents dining room was 36.61 (SD=12.80 Lux). Light intensity of respondents dining room was found to be lower in CZ (30.92 Lux) and RZ (32.32 Lux) as compared with IZ (46.60 Lux). Inter zonal variation revealed that in lower HDM category of RZ (32.30 Lux) and moderate HDM category of CZ (30.16 Lux) had low light intensity of dining room.
- **Bedroom:** During summer average light intensity of respondents bedroom was 44.79 Lux (SD=14.41). Inter zonal variation showed that respondents of RZ (38.50 Lux) and CZ (37.32 Lux) had less than average light intensity of

bedroom as compared to IZ (58.55 Lux). Intra zonal variation showed that respondents of lower HDM category in RZ (39.20 Lux) and CZ (37.88 Lux) had intense light.

- **Kitchen**: Average light intensity of respondents' kitchen in summer was 46.26 Lux (SD=13.82). Lower than the average light intensity of RZ (42.92 Lux) and CZ (37.32 Lux) was observed in the respondents kitchen as compared to IZ (58.55 Lux). Respondents having low intensity of kitchen light belonged to high HDM categories in RZ (41.66 Lux) and CZ (37.00 Lux).

The data reflected that in summer's rainy period kitchen and dining rooms' light intensity was higher than the other rooms. The lower light intensity encourages HDMs to develop whereas intense light lowers HDMs (Lakshmi and Haq, 1999).

The microclimate of different rooms postulated that temperature, RH, AFR and light intensity was higher in IZ which can be related to houses situation in open areas. Apart from this industrial houses had more open areas. Higher AFR in this area brings more dust inside the house. High humidity of IZ can be attributed to nearby water reservoir (UdaiSagar). High humidity in CZ can be related to congested ill ventilated houses and low light intensity which creates ideal conditions for the HDMs growth.

Relationship of Microclimatic factors and HDMs

To test the correlation between seasonal variation in HDMs concentration with different microclimatic factors (temperature, RH, AFR and light) leaner regression equation (Y=a+b1x1+b2x2+b3x3+b4x4) was used.

The regression equation highlighted a significant difference between the HDMs concentration with temperature (t= 2.14, sig. level 0.05), RH (t= 2.02, sig. level 0.05) and light intensity (t=2.95, sig. level 0.01) during summer season. Regression coefficient value explains 75.00 per cent of variation in HDMs due to four independent variables i.e. temperature, RH, AFR and light intensity collectively and rest (36.00 per cent) of the variation could not explained by these variables.

Table 5: Regression equation for HDMs concentration with various microclimatic factors

S No.	Coefficients	Unstandardized Coefficients		Standardized Coefficients	t value
		B	Std. Error	Beta	
	Season				
1	Light	0.256	0.087	0.276	2.95**
2	Temperature	0.397	0.123	0.187	2.14*
3	Humidity	0.147	0.073	0.182	2.02*
4	Air flow rate	0.201	1.609	0.011	0.12NS

NS: Non Significant

* Significant at 0.05 level of probability

** Significant at 0.01 level of probability

This may be attributed to the rainy period in which temperature becomes low, high humidity and low light intensity which creates favorable environment for high HDMs concentration. Several researchers also substantiate these findings that favorable temperature and RH is an important factor in the development of mites at all stages. HDMs hide in dark places so light intensity is also important factor in their growth. (Hart, 1998; Custonic et al., 1998; Lakshmi and Haq, 1999; Crowther et al, 2001).Statistical test results showed that micro climatic factors like temperature, humidity and light intensity affect HDMS concentration during summer rainy period. It was observed that in rainy period micro climatic conditions favoured HDMs proliferation in indoors.

Health Complications Due to HDMs

Different types of complications are faced by respondents through HDMs. These are:

- **Wheezing:** Wheezing is a high pitched whistling sound while breathing. Risk of wheezing also associated with HDMs allergens in indoors (Jedrychowski et al; 2007). Appraisal of the Table 6 reflected that near about two third of the respondents (67.50 per cent) faced the wheezing problem during high humidity. This problem was higher in IZ (85 per cent) as compared to other zones (RZ=47.50 per cent, CZ=70 per cent). Cent percent of the high HDM category respondents among all the three zones faced the wheezing problem during the high humidity conditions.
- **Coughing:** Coughing is the commonest reason that may trigger through HDMs (Little, 2003; Sharma, 2009). Near about two third of the respondents faced coughing problem seasonally in all the three zones (RZ=62.50 per cent, CZ=66 per cent and IZ=65 per cent). Respondents face coughing problem seasonally. Most of the high HDM category respondents (RZ=66.07 per cent, CZ=66.07 per cent, IZ=80 per cent) faced coughing problem. One third of the RZ respondents belonged to high HDM category faced the HDMs problem throughout the year.
- **Shortness of Breath:** This complicated HDMs respiratory problem, occurs mostly in high humid conditions (Jock et al., 1994). Shortness of breath was found seasonally by 70.83 per cent of the respondents. A small percentage of the respondents (17.5 per cent) faced it throughout the year and after rainfall. Higher HDM category respondents of IZ (100 per cent) and RZ (66.07 per cent) faced shortness of breath problem seasonally.
- **Shortness of Breath with Wheezing:** In severely affected HDMs conditions, complications may occur in lot of combinations i.e. shortness of breath with wheezing or coughing. Children in urban area exposed to HDMs suffered from shortness of breath with wheezing and woke up with respiratory symptoms

(Zock et al. (1994). Near about three fourth of the respondents (72.50 per cent) faced the problem of shortness of breath with wheezing after the rainfall. One third of the respondents' belonged to high HDM category had shortness of breath and wheezing problem when humidity is high. In IZ 60 per cent of high HDM category respondents, seasonally faced shortness of breath with wheezing problem.Asthma is more prevalent in underdeveloped urban area and among industrialized urban communities (Saha, 1997).

- **Wake up with Respiratory Problem:** HDMs can cause respiratory problems when they wake up in the morning due to difficulty in respiration. Higher percent of respondents in all the three zones (RZ=45 per cent, CZ=7.50 per cent and IZ=67.50 per cent) wake up with respiratory problems generally in high humidity. Respondents of high HDM category in CZ wake up with respiratory problem after the rainfall. Respiratory allergies are caused by the inhalation of dead or alive mites (Nadchatram, 2005).

Table 6: Distribution of respondents according to incidences of complications associated with HDMs

S. No.	Incidences of complications	RZ				CZ				IZ				Grand Total N=120
		L n=10	M n=27	H n=3	Total N=40	L n=9	M n=25	H n=6	Total N=40	L n=4	M n=31	H n=5	Total N=40	
1.	**Wheezing**													
	Throughout year	30.00	37.00	0	32.05	11.05	24.00	0	17.05	0	19.04	0	15.00	21.66
	After rainfall	20.00		0	5.00	22.2	4.00	0	7.50	0	0	0	0	4.16
	In high humidity	50.00	40.70	100	47.05	66.07	64.00	100	70.00	100	80.6	100	85	67.5
	Seasonally	0	22.20	0	15.00	0	8.00	0	5.00	0	0	0	0	6.66
2.	**Coughing**													
	Throughout year	40.00	25.90	33.30	30.00	11.01	8.00	0	7.50	25.00	12.09	0	12.50	16.66
	After rainfall	10.00	3.70	0	5.00	22.20	12.00	0	12.50	50.00	9.70	20.00	15.00	10.83
	In high humidity	0	3.70	0	2.50	44.40	0	33.30	15.00	25.00	6.50	0	7.50	8.33

	Seasonally	50.00	66.70	66.70	62.50	22.20	80.00	66.07	65.00	0	71.00	80.00	65.00	64.16
3.	**Shortness of breath**													
	Throughout year	40.00	14.80	33.30	22.50	0	16.00	50.00	17.50	25.00	12.90	0	12.50	17.50
	After rainfall	0	22.20	0	15.00	0	12.00	0	7.50	25.00	12.90	0	12.50	17.50
	Seasonally	60.00	63.00	66.70	62.50	100	72.00	50.00	75.00	50.00	74.20	100	75.00	70.83
4.	**Shortness of breath plus wheezing**													
	Throughout year	40.00	18.50	33.03	25.00	0	0	0	0	0	0	0	0	8.33
	After rainfall	40.00	77.80	33.03	65.00	77.08	88.08	66.07	82.05	50.00	77.04	40.00	70.00	72.05
	In high humidity	20.00	3.07	33.03	10.00	22.02	4.00	33.03	12.05	25.00	6.05	0	7.05	10.00
	Seasonally	0		0	0	0	8.00	0	5.00	25.00	16.01	60.00	22.05	9.16
5.	**Wake up with respiratory symptoms**													
	Throughout year	0	11.10	0	7.50	11.10	0	0	2.50	0	0	0	0	3.33
	After rainfall	10.00	7.04	33.03	10.00	0	24.00	0	15.00	0	22.60	20.00	20.00	15.00
	In high humidity	50.00	44.04	33.03	45.00	88.09	64.00	100	75.00	100	64.00	60.00	67.05	62.05
	Seasonally	40.00	37.00	33.03	37.05	0	12.00	0	7.05	0	12.09	20.00	12.05	19.16
6.	**Common cold**													
	Throughout year	40.00	55.06	0	47.05	100	92.00	66.07	90.00	75.00	80.06	60.00	77.50	71.66
	After rainfall	10.00	22.20	66.07	22.50	0	0	0	0	25.00	3.20	0	5.00	9.16

	In high humidity	30.00	14.08	0	17.05	0	4.00	16.07	5.00	0	12.09	20.00	12.50	11.66
	Seasonally	20.00	7.04	33.03	12.05	0	4.00	16.07	5.00	0	3.02	20.00	5.00	7.50
7.	**Harshness of voice**													
	After rainfall	0	22.20	0	0	0	12.00	16.07	10.00	25.00	12.09	0	12.50	7.50
	In high humidity	40.00	14.08	33.30	22.50	0	0	0	0	0	0	0	0	7.50
	Seasonally	60.00	63.00	66.07	62.07	100	88.00	83.03	90.00	75.00	87.01	100	87.05	80.00
8.	**Common fever and sweating**													
	Throughout year	40.00	18.50	33.03	25.00	0	0	0	0	0	0	0	0	8.33
	After rainfall	50.00	66.07	66.07	62.05	77.08	76.00	83.03	77.05	100	87.01	80.00	87.05	75.83
	In high humidity	10.00	14.08	0	12.05	22.02	24.00	16.07	22.05	0	9.07	20.00	10.00	15.00
	Seasonally	0	0	0	0	0	0	0	0	0	3.02	0	2.05	0.83
9.	**Itching**													
	Throughout year	40.00	18.50	33.03	25.00	0	8.00	0	5.00	25.00	6.50	0	7.50	12.50
	After rainfall	0	14.08	33.03	12.05	11.01	8.00	0	7.50	0	0	20.00	2.50	7.50
	In high humidity	60.00	66.07	33.03	62.05	88.09	84.00	100	87.05	75.00	93.05	80.00	90.00	80.00
10.	**Red rashes on skin**													
	Throughout year	40.00	18.05	33.03	25.00	0	8.00	0	5.00	25.00	6.50	0	7.50	12.50
	After rainfall	0	14.08	33.03	12.05	11.01	8.00	0	7.50	0	0	20.00	2.50	7.50

	In high humidity	60.00	66.07	33.03	62.05	88.09	84.00	100	87.05	75.00	93.05	80.00	90.00	80.00
11.	**Head aches**													
	Throughout year	50.00	59.03	100	60.00	55.06	72.00	66.07	67.05	50.00	71.00	100	72.05	66.66
	After rainfall	0	3.07	0	2.05	11.01	4.00	0	5.00	50.00	25.08	0	25.00	10.83
	In high humidity	30.00	14.08	0	17.05	22.02	20.02	0	17.05	0	3.02	0	2.05	12.05
	Seasonally	20.00	22.02	0	20.00	11.01	4.00	33.03	10.00	0	0	0	0	10.00
12.	**Fatigue**													
	Throughout year	50.00	48.01	33.03	47.05	88.09	84.00	66.07	82.05	75.00	87.01	80.00	85.00	71.66
	After rainfall	30.00	22.02	33.03	25.00	0	0	0	0	0	0	0	0	8.33
	In high humidity	0	11.10	33.03	10.00	0	12.00	0	7.50	0	6.50	20.00	7.50	8.33
	Seasonally	20.00	18.50	0	17.50	11.10	4.0	33.30	10.00	25.00	6.50	0	7.50	11.66
13.	**Watery eyes**													
	Throughout year	30.00	18.50	33.03	22.50	0	0	0	0	0	0	0	0	7.50
	After rainfall	0	3.07	0	2.50	22.02	12.00	0	12.05	0	16.01	20.00	15.00	10.00
	In high humidity	70.00	77.08	66.07	75.00	66.07	76.00	100	77.05	100	83.09	80.00	85.00	79.16
	Seasonally	0	0	0	0	11.01	12.00	0	10.00	0	0	0	0	3.33

Common Cold: The symptoms and signs of an allergic reaction to HDMs are similar to common cold or hay fever (www.indoor-allergies.suite 101.com). Cold was common problem in all the three zones. Most of the respondents in RZ (66.07 per cent) of high HDM category faced this problem after rainfall. Cent percent of low HDM category respondents in CZ and 80 per cent of moderate HDM category respondents of IZ faced cold problem throughout the year.

Harshness of Voice: It refers to abnormally rough or harsh sounding voice caused by vocal abuse and allergy to substances like HDMs and pollens (www.nasal.net.com). Harshness of voice was faced by majority of the respondents in all three zones throughout the year (RZ=62.07 per cent, CZ =90 per cent and IZ=87.05 per cent). Cent percent of higher HDM category respondents in IZ and lower HDM respondents in CZ face harshness of voice problem during high humidity conditions.

Common Fever and Sweating: Common fever and sweating problem were high (75.83 per cent) among all the three zones respondents (RZ=62.05 per cent, CZ=77.05 per cent and IZ=87.05 per cent) after the rainfall. During high humidity higher HDM category respondents of RZ (66.07 per cent) and CZ (83.03 per cent) faced this problem.

Itching: Dirty skin may also become a perfect breeding place for skin diseases like itching, eczema etc. Moist body parts with perspiration give a preferable environment for the growth of tropical fungus and HDMs (Stella, 1974). Severity of skin diseases depend on the concentration HDMs in the dust (Beck et al., 1989). In high humidity itching problem was faced by most of the respondents in all the three zones (RZ=62.05 per cent, CZ=87.05 per cent and IZ=90 per cent). High HDM category respondents in CZ (100 per cent) and IZ (80 per cent) face itching problem during high humidity. One third of the respondents of high HDM category in RZ faced the itching problem after rainfall.

Red Rashes on Skin: Most of the respondents in IZ (90 per cent) faced red rashes problems as compared to other zones (RZ=62.05 per cent, CZ=87.05 per cent) during high humidity. Majority of the respondents of higher HDM category (CZ=100 per cent, IZ=80 per cent) faced red rashes problem during high humidity.

Headaches: Headaches, fatigue and depression are the signs of allergic reactions from HDMs (Lyon, 1991). Two third of the respondents had headache problem throughout the year and it was higher in IZ (72.05 per cent) as compared to RZ (60 per cent) and IZ (67.05 per cent). Moreover, two third of the respondents in CZ and cent percent in RZ and IZ belonged to high HDM category had headache throughout the year.

Fatigue: Majority of the respondents in IZ (85 per cent) and CZ (82.50 per cent) had fatigue problem throughout the year and this problem was more common among respondents' belonging to moderate HDM category in CZ (84 per cent) and IZ (87.10 per cent). Convergent results were also reported by Khatri (2006) that fatigue was faced by women during the time of low humidity (25 percent) and seasonal variation (20 percent).

Watery Eyes: When the surface of eyes is exposed to HDMs allergens an allergic reaction occurs causing red, itchy and watery eyes. Watery eyes are the commonest problem caused by HDMs that was faced by more than three fourth of the respondents (79.16 per cent) after the rainfall. In this period respondents of high HDM category in all three zones faced the watery eyes problem (RZ=77.08 per cent, CZ=77.50 per cent and IZ=85 per cent). One tenth of the respondents in CZ seasonally faced watery eyes problem. Several researchers also reported significant role of mites in the house dust responsible for health hazards such as respiratory allergy, nasobronchial, nasal and skin allergy in sensitive individuals (Shivpuri and Dua, 1974; Anand, 1981; Sharma et al., 2009). Respondents faced these complications throughout the year but the severity of these complications vary from individual to individual, as well as these symptoms are severe during high humidity rainy period. This can be related to the occurrence of seasonal rises in their population often reaching peak development during rainy season (Tilak and Jagdand; 1989). Significant correlation was also found by Sharma et al., (2009) between the severity of allergic diseases and indoor concentrations of mites.

Conclusion

Thus it can be concluded that with ideal microclimatic conditions like temperature, relative humidity, light intensity HDMs proliferate. These HDMs are harmful for human health. They are the causative factor of severe complications occur due to HDMs but homemakers are ignorant about these micro-organisms. Hence, policy framers architects, civil engineers should emphasize on proper planning of houses with emphasis on proper microclimatic factors which reduce HDMs proliferation. Awareness among homemakers should be generated regarding harmful effect of HDMs which will be helpful in reducing the incidences of health complications.

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