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IMPACT OF METEOROLOGICAL FACTORS ON MICROBIAL LOAD PRESENT IN THE AMBIENT AIR OF TEXTILE MARKETS LOCATED IN SURAT, GUJARAT.

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Abstract: Day-by-day, aeromicrobiology is gaining importance due to recent increase in allergic reactions. The massive increase in microbial infections has led to reduced productivity and increased absenteeism in individuals involved in occupation. Thus, this indoor air quality (IAQ) study focuses on the effect of environmental as well as microbial factors affecting the human health. The environmental factors include temperature; relative humidity etc. while microbial includes bacterial, fungal communities prevailing in textile markets. The study correlates the environmental factors with microbial populations and their effect on occupants' health. This can result in diseases like asthma, pneumonia etc. Hence, indoor air quality is an important factor affecting the progress and development of occupants.

Index Terms **-** Microbial load, Volatile Organic Compounds, Sick Building Syndrome, Indoor Air Quality, Occupational Health Hazards.

I. INTRODUCTION

Besides being a vital source of environment; air is also dominant in contaminants [1]. It contains a mixture of biological and non-biological sources of contaminants like dust, suspended particulate matter, Volatile Organic Compounds (VOCs) and microbes. The biological contaminants occupy a special space in elevating the indoor air pollution level. They can be pathogenic or may produce allergic reactions either inhaled or ingested and can cause adverse health effects [2, 3, 4, 5]. There are various sources of biological pollutants present in the indoor air. For example, the fabrics, yarn, textile material kept in textile markets are manufactured with various chemical which emits volatile organic compounds in the environment.

India is bestowed with enormous resources for vast manufacturing and production of textile. Gujarat is known as textile hub of India while Surat is known for its versatile textile industry. The major activities involved in textile processing are scouring, bleaching, neutralizing, dyeing, desizing, mercerizing, printing and finishing. These markets generate all three kind of waste .i.e. liquid, solid and gaseous. The major reason behind this gaseous emission is the use of chemicals in manufacturing of these textile materials. They are exposed to dyes and colours which under the effect of temperature and humidity releases several chemicals. These chemicals when suspends in air acts as a carrier for microbes to settle down and proliferate. The growth of microbes is responsible for increasing microbial load in the indoor air of textile markets.

The viable counts of bacterial and fungal biological contaminants may be culturable or non-culturable [6]. There are process like diffusion, accumulation and concentration contributing for exposure of air to enormous microbial pollutants. As people spend 80-90% of their time indoors, the indoor air pollution causes several health issues [7, 8].

Epidemiology is the study of health of occupants exposed to the polluted environment persisting during their occupation. These are also known as Occupational Health Hazards. It has been observed in various studies that dust particles, Total Volatile Organic Compounds (TVOCs), large nucleated organic compounds and even gram negative bacteria may cause serious infection and allergies. They may cause nasal, optical, physiological changes in the body. The sensory symptoms involve irritation, slugginess, sleepiness, headache and even r educes the ability to concentrate [9, 10]. Especially bacteria and fungi are those organisms whose presence creates problem in the indoor air quality [11].

Microbial pollution involves hundreds of species of bacteria and fungi which grow indoors only when optimum temperature and humidity is available. The workers involved in occupation when exposed to this environment may clinically associate with allergies, asthma, immunological reactions and respiratory disorders. Excess amount of moisture in all indoor material leads to the growth of microbes, such as mould, fungi, bacteria and VOCs compound in the air as per the WHO guidelines for indoor air.

Indoor air pollution depends on number of factors including type of sources used in Indoors, ventilation conditions as well as outdoor pollution. People in India and abroad both spend a substantial portion of their time in indoors 2-3. Indoor environment, improper maintenance, poor building designing or occupant activities often result in a condition called as ‘‘Sick Building Syndrome’’ (SBS), where occupants experience adverse health effects that appears to linked with the time spent in a building. According to WHO report, half of the world’s population and 90% of developing countries such as India still rely on unprocessed biomass which is responsible for death of 3 to 4 million peoples due to combustion of unprocessed solid biomass which are used by the rural and poor people of urban areas of country. Unprocessed biomass released 50 times more noxious pollutants like particulate matter, carbon monoxide, nitrogen dioxide, sulphur dioxide, formaldehyde and carcinogens such as benzo (a) pyrene and benzene.

When there occurs fault in plumbing, the indoor wall dampness increases. This forms the ideal condition for growth of fungi like Alternaria, Aspergillus, Cladosporium and Penicillium. Along with it, gram positive and gram negative bacteria breeds like Streptococcus, Micrococcus, Staphylococcus, Mycobacterium, Nocardia, and Streptomyces. These fungal spores and bacterial particulates emit mycotoxins and endotoxin contributes to a huge variety of household air pollutants. There are Genera-producing fungi associated with wet buildings, such as Aspergillus versicolor, Fusarium verticillioides, Penicillium aiurantiorisen, and S. chartarum, can produce potent toxins [12].

These micro-organisms are divided into two major categories according to their Gram’s stain reaction. The most common Gram-positive types originate from the mouth, nose, nasopharynx and skin, namely, Staphylococcus epidermidis, S. aureus and species of Aerococcus, Micrococcus and Streptococcus. Gram-negative bacteria are generally not abundant, but occasionally Actinetobacter, Aeromonas, Flavobacterium and especially Pseudomonas species may be prominent. Thus this paper is focussed to study the relationship between the effect of temperature and humidity on the microbial communities prevailing in the indoor of textile markets of Surat city.

II. MATERIAL AND METHODS

2.1Population and Sample

The sampling was done quarterly from November, 2017 to November, 2018. In each season 20 textile markets located near Ring road were sampled. So, summering the one year data we got 60 markets reading along with three different seasons.

2.2 Data and Sources of Data

The on-site sampling involved the two sectors.

First the environmental sampling with the help of Aeoss VOC PM2.5 and PM 10 Detector Air monitor Indoor Hygro/Thermometer RH humidity monitor with humidity sensor. With the help of this instrument temperature and humidity were recorded.

Second the microbial sampling with the Sedimentation plate method. For this Nutrient Agar, Potato Dextrose Agar and Martin’s Rose Bengal Agar plates were used.

2.3 Method and duration of sampling

For temperature and humidity, the instrument was kept on site for half an hour. Bacterial colony were collected on nutrient agar plates while fungal colonies on Martin’s Rose Bengal Agar and Potato Dextrose Agar. For microbial collection, the three media plates were exposed for 30 minutes at 1 meter height to escape the breathing zone. After that they were carried and preserved in refrigerator for further procedures. The method used for this was passive sampling method. In this we used air sampling by Settle/ Sedimentation plate method [13, 14].

2.4 Theoretical framework

The bacterial colonies were isolated from NA plates and their morphological characteristics had been noted. The bacterial isolates were sent for 16srRNA sequencing and fungal isolates undergone for 23srRNA sequencing. Once colony forming units (CFU) were enumerated with the help of colony counter, CFU/m3 were determined, taking into account the following equation described by Omeliansky [13];

$$N= 5a \times 104 (b\ t)-1$$

Where;
N= microbial CFU/m3 of indoor air;
a= number of colonies per Petri dish;
b= dish surface (cm2); t= exposure time (min).

2.5 Statistical tools and Sampled Data

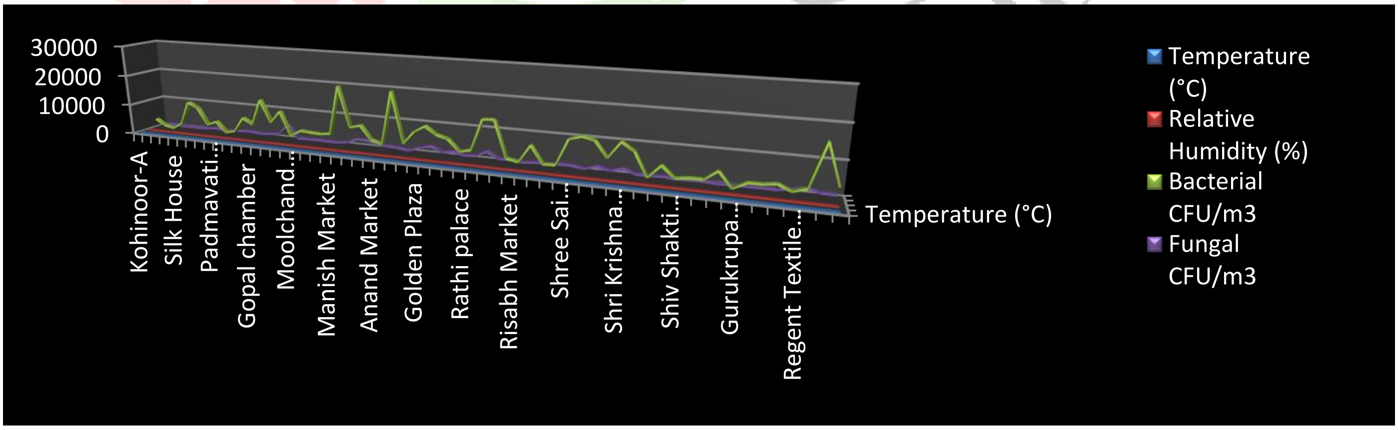
The data collected from sampling having five variables. They are temperature, relative humidity, bacterial CFU/m3, fungal CFU/m3 and total microbial load. The statistical analysis of these variables is done with the help of MINITAB 19 software.

Table 1.1 Sampling data of 60 markets sampled from 4/11/2017 to 5/7/18

Sr. No.	Name of Textile market	Latitude	Longitude	Temperature (°C)	Relative Humidity (%)	Bacterial CFU/m^3	Fungal CFU/m^3	Total microbial load CFU/m^3
1.	Kohinoor-A	21.1884	72.8377	29	66	3148.13	586.4	3734.53
2.	Kohinoor-B	21.1865	72.8348	30	61	1203.7	679	1882.7
3.	Universal-2	21.1894	72.8414	33	41	524.69	401.2	925.89
4.	Millennium-1	21.1882	72.8423	29	50	2623.44	246.9	2870.34
5.	Silk House	21.1892	72.8444	31	62	10246.8	308.6	10555.4
6.	Abhishek Market	21.1891	72.844	31	64	8703.6	432.1	9135.7
7.	Hariom Market	21.1859	72.8358	30	66	3148.1	987.6	4135.7
8.	Jagdamba Market	21.1879	72.8437	31	51	4444.4	401.2	4845.6
9.	Padmavati Textile Market	21.1872	72.8433	26	34	1018.5	709.8	1728.3
10.	Shubham Textile Market	21.1862	72.836	30	48	1851.8	925.9	2777.7
11.	Reshamwala Textile Market	21.185	72.8356	30	53	6635.7	1018.5	7654.2
12.	Hari krupa	21.1848	72.8567	33	41	4845.6	648.1	5493.7
13.	Gopal chamber	21.189	72.845	30	50	13394.9	987.6	14382.5
14.	Shiv Darshan	21.1857	72.837	31	46	6111.1	1203.6	7314.7
15.	Krishna Market	21.1895	72.8449	31	50	10154.2	4629.6	14783.8
16.	Mahavir Market	21.1709	72.8500	26	34	2314.72	370.356	2685.076
17.	Moolchand Market	21.19109	72.84182	31	37	4320.82	524.67	4845.47
18.	Vardhaman Market	21.19174	72.84001	31	51	4073.91	555.53	4629.21
19.	Universal Textile Market	21.1944	72.5487	31	50	3919.60	432.08	4351.68
20.	Jash textile market	21.1929	72.8438	31	64	4382.54	493.80	4876.34
21.	Manish Market	21.19227	72.84167	24	39	20154.19	901.21	21055.4
22.	Jaylaxmi Market	21.1939	72.8403	24	38	7191.312	2314.8	9506.112
23.	Adinath Market	21.1913	72.8403	22	44	8117.23	2191.34	10308.57
24.	Astha Market	21.1910	72.8401	26	37	3672.81	1388.88	5061.69
25.	Anand Market	21.1891	72.8457	27	37	2685.16	987.64	3672.8
26.	Sagar Market	21.1864	72.8463	23	39	19876.41	771.6	20648.01
27.	Kuberji House	21°11'16.00	72°53'16.00	24	38	3641.95	370.36	4012.31
28.	Shree Kuberji Textile Park	21.20001	72.83767	27	36	7808.59	1666.65	9475.24
29.	Golden Plaza	21.1868	72.8374	27	36	9907.34	2530.84	12438.18
30.	Raghunandan Market	21.1872	72.8390	23	38	7499.95	987.64	8487.59
31.	Abhilasha Textile Market	21.19111	72.84084	26	38	6543.16	1450.60	7993.76
32.	Ekta Textile Market	21.1934	72.8405	23	40	2962.94	648.14	3611.08
33.	Rathi palace	21.1944	72.5487	24	36	3796.27	925.92	4722.19
34.	New Textile Market	21.1881	72.8401	28	38	13641.88	2777.76	16419.64
35.	RKTM	21.1935	72.8420	25	34	13857.93	709.87	14567.8
36.	Shreeji Market	21.1893	72.8453	24	41	2314.8	895.05	3209.85
37.	Risabh Market	21.18988	72.84504	25	50	1635.79	432.096	2067.886
38.	Radhey Market	21.1911	72.8444	26	56	7191.312	802.464	7993.776
39.	Abhinandan Market	21.1914	72.8433	24	40	1759.24	833.32	2592.56
40.	451 textile Market	21.1874	72.8401	27	38	1913.56	1141.96	3055.52
41.	Shree Sai Darshan Textile Market	21.1876	72.8438	27	78	10123.06	1049.34	11172.4

42.	Adarsh 2 market	21.1906	72.8414	27	78	11295.85	555.534	11851.38
43.	Shinya Textile	21.1798	72.8258	27	77	10493.42	1604.87	12098.29
44.	Belgium Square	21.2006	72.8402	27	77	5740.51	802.43	6542.94
45.	Shri Krishna market	21.1860	72.8365	27	77	10740.32	1820.91	12561.23
46.	Someshwar textile market	21.1868	72.8436	31	78	8394.73	524.67	8919.4
47.	M.G. Textile market	21.1893	72.8412	31	70	1203.65	401.21	1604.86
48.	extilTower Market	21.19151	72.8449	30	66	5123.25	709.84	5833.09
49.	Shiv Shakti Market	21.18954	72.84398	28	61	1790.05	370.356	2160.406
50.	Vankar Textile Market	21.19253	72.84241	30	67	2283.86	462.94	2746.8
51.	Ambaji Textile Market	21.18812	72.83888	31	65	2314.72	555.53	2870.25
52.	Anmol Textile Market	21.18663	72.84409	30	64	5215.84	277.76	5493.6
53.	Gurukrupa Market	21.18978	72.84514	30	62	678.98	432.08	1111.06
54.	Arihant Textile Market	21.19183	72.84362	31	67	2685.08	432.08	3117.16
55.	Anupam Textile market	21.18748	72.84493	29	58	2746.80	493.80	3240.6
56.	Raghukul Textile Market	21.18577	72.84582	26	55	3302.34	432.08	3734.42
57.	Regent Textile Market	21.1892	72.83791	29	56	1666.60	1111.06	2777.66
58.	Hira Panna Textile Market	21.19269	72.84178	31	71	2870.25	1820.91	4691.16
59.	Tirupati Textile Market	21.19216	72.84139	30	68	16017.89	833.30	16851.19
60.	Pashupati Market	21.19229	72.83918	29	68	4289.95	740.71	5030.66

2.5.1 Graphical Representation of Data



Graph 1.1 Depicting the microbial load with respect to temperature and humidity

Above graph represents the distribution of variable temperature, relative humidity, Bacterial and fungal CFU/m^3 in 60 textile markets found near Ring road of Surat city.

III. RESULT AND DISCUSSION

3.1 Descriptive Statistics: Temperature (°C), Relative Humidity (%), Total microbial load

3.2 Discussion of Descriptive Statistics

From the Table1.2, it can be easily understood that number of observation are 60. The minima value of temperature is 22 while maxima is 33. The difference of 10 between them entails the minimum presence of outliers. Similarly in case of relative humidity there occurs only difference of 10 between maxima and minima values, thus indicating less outliers in our data. The value of standard deviation for temperature 2.848 which is less than 3 shows near about normal distribution of data. The spread of data around the mean revealed is low. The standard deviation approximately estimates the "average" distance of the individual observations from the mean. The value of skewness near to 0 which is actually 0.28 shows normal distribution ability in the data for the variable relative humidity. The temperature shows slightly negative skewness while total microbial count shows slightly positive skewness. The value of Kurtosis for total microbial load 0.76 is nearer to baseline value zero depicts that the data follows normal distribution curve.

Table 1.2 Basic Descriptive Statistics of data of Table 1.1

Variable	Total Count	Mean	StDev	Coef Var	Minimum	Median	Maximum	Range	Skewness	Kurtosis
Temperature (°C)	60	28.083	2.848	10.14	22.000	29.000	33.000	11.000	-0.37	-0.97
Relative Humidity (%)	60	52.92	14.17	26.78	34.00	50.50	78.00	44.00	0.28	-1.27
Total microbial load CFU/m^3	60	6815	4898	71.87	926	4861	21055	20130	1.17	0.76

3.3 Paired T-Test and CI: Temperature (°C), Relative Humidity (%)

Sample	N	Mean	StDev	SE Mean
Temperature (°C)	60	28.08	2.85	0.37
Relative Humidity (%)	60	52.92	14.17	1.83

3.4 Estimation for Paired Difference

Mean	StDev	SE Mean	95% CI for μ_difference
-24.83	13.15	1.70	(-28.23, -21.44)

μ_difference: mean of (Temperature (°C) - Relative Humidity (%))

3.5 Test

Null hypothesis	H_0: μ_difference = 0
Alternative hypothesis	H_1: μ_difference ≠ 0
T-Value	**P-Value**
-14.63	0.000

3.6 Discussion of 3.3, 3.4, 3.5

From above paired T-test data analysis, it can be stated that the value of P (0.000) which is less than 0.05. A significance level of 0.05 indicates a 5% risk of concluding that a difference exists when there is no actual difference. We can conclude that the difference between the population means does not equal the hypothesized difference. Thus, we can reject the null hypothesis and our data is statistically significant.

IV. CONCLUSION

It can be easily concluded from above mentioned work that aeroallergens can affect human health in many ways. Spores of fungi are mainly non-infectious, when inhaled it may show adverse effects on respiratory tract causing allergic rhinitis. Fungus like Alternaria, Aspergillus and Cladosporium cause diseases like asthma or cystic fibrosis which develop a chronic allergic reaction with cough. The lining bronchi and alveoli become inflamed severely reducing the capacity to inhale. A life threatening disease Allergic Bronchopulmonary Aspergillosis (ABPA) mostly caused due to Aspergillus. Immunotoxic disease caused by inflammation of small air way and the alveoli of the fungus due to mycotoxins and endotoxins produced by fungus and bacteria. The symptoms of this disease resemble those of influenza with high temperature shivering, nasal congestion, irritation of throat, headache and cough [14]. Thus, the occupational epidemics like tuberculosis, black lung disease, respiratory disorders can be easily predicted. From the above study, it can be concluded that temperature and humidity directly affects the microbial growth. . If a single person inhales an average of 10 m^3 of air every day [15]; then a worker working in textile market for 12 hours would be inhaling approximately 500 m^3 of air per hour. Hence, the air loaded with this huge quantity of bioaerosols and microbes would ultimately lead to occupational health hazards for those workers. So as to reduce these hazards, proper hygiene, aeration, ventilation, air conditioning should be availed for them in that scenario.

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