Statistical Analysis Of Role Of Meteorological, Environmental, Chemical And Microbial Attributes On Indoor Air Quality Of Ambient Air Of Textile Markets Of Surat City, Gujarat

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Abstract

Air is a mixture of gas acting as a suitable medium for dispersion of all kind of pollutants. The pollutants with long residence time affect the well-being of people. The primary pollutants may not always cause harm but on undergoing further chemical changes they gets convert into secondary pollutants and results as a harmful substance. Many factors prevailing indoors also worsen the action and effect of already existing pollutants. Hence, this paper focuses on the cumulative effect of parameters like temperature, relative humidity, PM 2.5, PM 10, TVOCs, HCHO, bacterial and fungal loads in the indoor air. These pollutants are ingested or inhaled by the workers when exposed for large duration of time. The help of statistical analysis have been taken for proving significance of these variables in indoor air.

Keywords: Total Volatile Organic Compounds, Formaldehyde (HCHO), Sick Building Syndromes (SBS), Heating, Ventilation and Air-conditioning Systems (HVACs), Principal Component Analysis (PCA).

1. Introduction

India is a major leading producer of textiles in the world after China [1]. It manufacture textile in two sectors. In India, Gujarat is renowned as Hub of textile in India with Surat as one of the famous textile industry in India. Gujarat produces man-made filament fabric and man-made fiber in the country. The textile industry of Surat divided into two sectors. First sector involves the traditional methods and small scale manufacturing. They encompass handloom, handicrafts and silviculture. The second one is regarded as organized sector. It involves power looms, embroidery units, fabric processing plants, Texturizing plants on huge scale. Surat is dealing with 150 textile markets, 45000 traders and about 1.4 million employees [1]. These workers are daily exposed to several indoor air pollutants. They spend a lot of time in these indoor for their whole life.

Indoor air contains a huge variety of pollutants like organic, inorganic components, particulate matter and microbes. The indoor environment of these textile markets act as a microenvironment. The office buildings are well equipped with heating, ventilation and air conditioning systems. There are enormous factors contributing to indoor concentrations like applied material, processing, climatic parameters and living behavior also. It can be easily seen in the **figure 1.1** given below.

The most common pollutants persist in indoor environment are Total Volatile Organic Compounds TVOCs, Formaldehyde HCHO and biological contaminants. It is suspected that TVOCs are responsible for Sick Building Syndrome (SBS) to some extent. Let discuss the parameters which affects the indoor air quality.

The most common TVOCs are methyl naphthalene, chlorotoluene, trichlorobenzene, perchloroethylene, butyl benzoate, ortho dichlorobenzene, methyl ester of cresotinic acid, biphenyl etc. In the processes like dyeing and finishing operations, solvent vapours are released with varying amount of toxic chemicals like acetaldehyde, p-dichlorobenzene, chlorobenzene, hexane, chlorofluorocarbons, ethylacetate, styrene etc. Major components released amongst them are acetic acid and formaldehyde as airborne VOC. When exposed to formaldehyde acute symptoms occur like eye, nose and throat irritation and also lower airway and pulmonary effects [2].

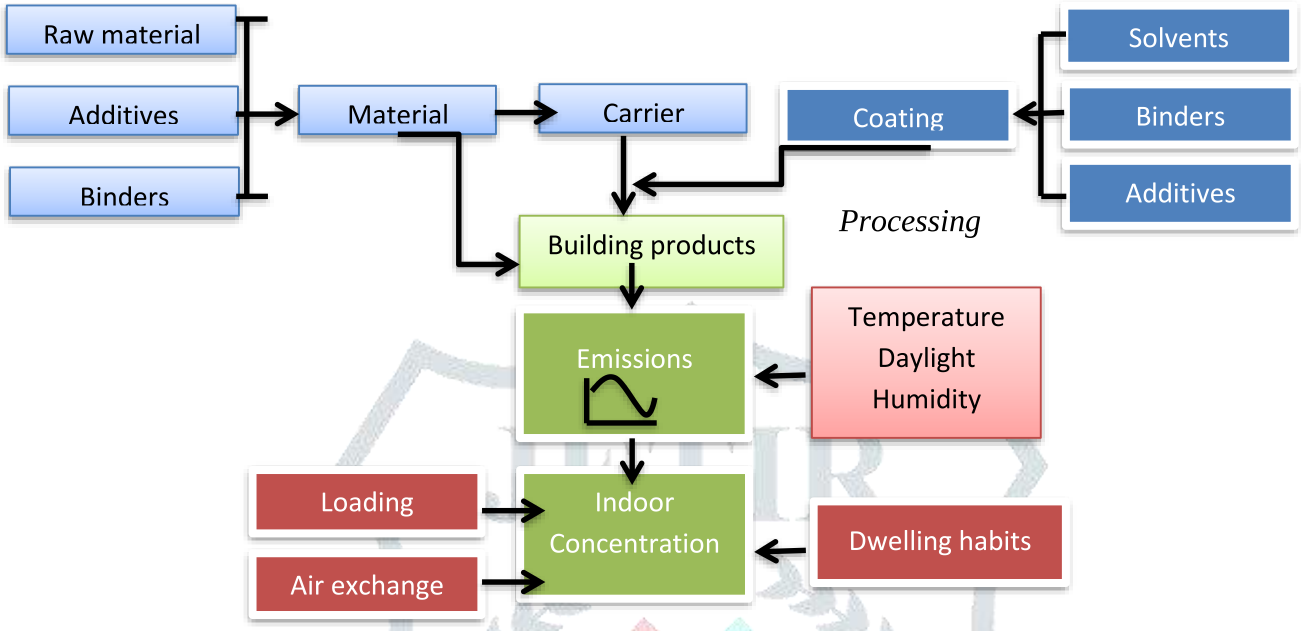


Fig 1.1 Influence of various activities on indoor air concentrations

Bioaerosol contaminants are those diverse varieties of agents from biological sources found in the indoor environment. These include viruses, bacteria, also endotoxins produced by them. Apart from them allergens dust, mite and animal dander also plays a major role. It has been proved that the rate of respiratory diseases caused by virus increases as the ventilation and other building characteristics decreases [3]. When people are exposed to mold spores in indoor environment they gets subjected to allergies with symptoms like runny nose, watery eyes, cough, fever and sneezing. The water leakage in the buildings results in growth of molds from genera *Aspergillus*, *Alternaria*, and *Cladosporium*. The suspended particulate matter present in the indoors act as a parachute for microbial communities to settle at the surface.

1. Material and Methods

2.1 Collection of Samples: 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.

2.2 Method and duration of sampling: For temperature and humidity, the instrument was kept on site for half an hour. For microbial sampling, the method used is passive sampling method. In this we used air sampling by Settle/ Sedimentation plate method [4, 5]. 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.

2.3 Isolation of Microbial Samples: The bacterial colonies were isolated from NA plates and their morphological characteristics had been noted.

2.4 Calculation of Colony Forming Unit (CFU/m3): Once colony forming units (CFU) were enumerated with the help of colony counter, CFU/m^3 were determined, taking into account the following equation described by Omeliansky [6];

$$N = 5a \times 10^4 (b\ t)^{-1}$$

Where;
N= microbial CFU/m^3 of indoor air;
a= number of colonies per Petri dish;
b= dish surface (cm^2); t= exposure time (min).

2.4 Molecular identification of Microbial Colonies: The bacterial isolates were sent for 16srRNA sequencing and fungal isolates undergone for 23srRNA sequencing.

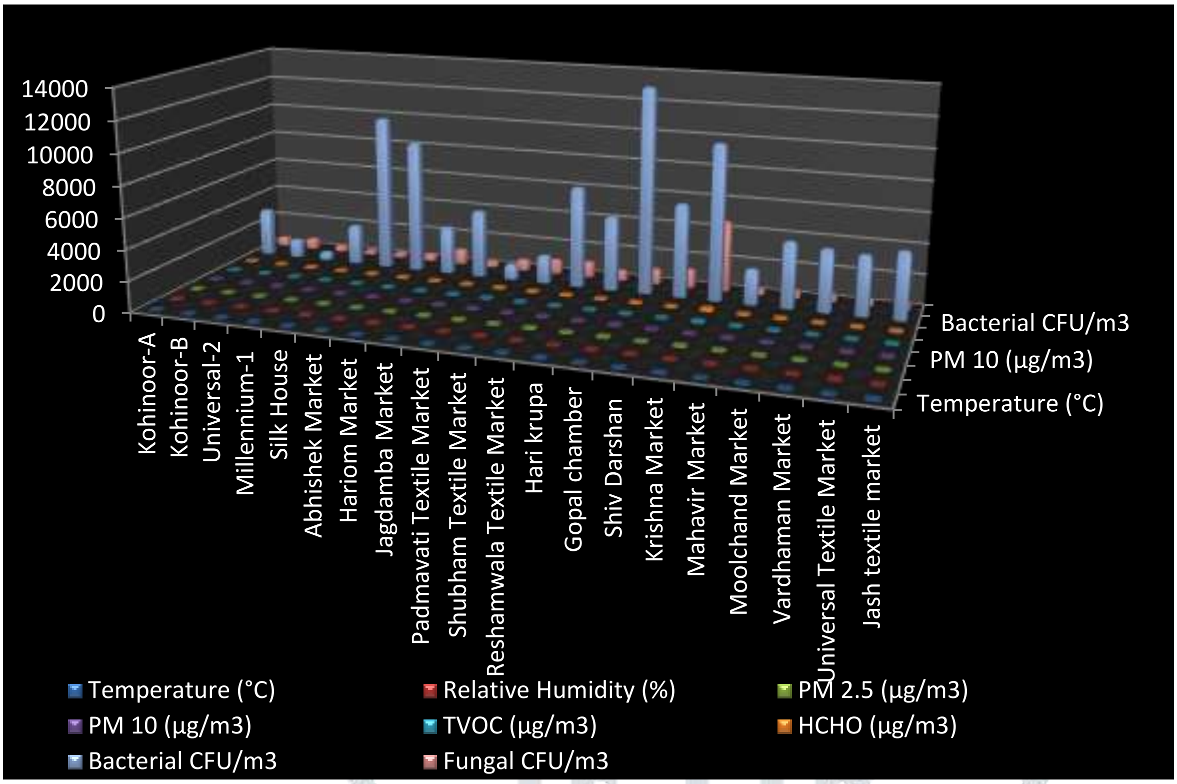
3. Result and Discussion

The sampling of textile markets is tabulated with temperature, relative humidity, PM 2.5, PM 10, TVOC, HCHO, bacterial and fungal CFU/m^3.

Table 1.1 Microbial and environmental parameters of textile markets.

Sr. No.	Textile Market Name	Temperature (°C)	Relative Humidity (%)	PM 2.5 (µg/m3)	PM 10 (µg/m3)	TVOC (µg/m3)	HCHO (µg/m3)	Bacterial CFU/m3	Fungal CFU/m3
1.	Kohinoor-A	29	66	39	64	38	70	3148.13	586.4
2.	Kohinoor-B	30	61	26	69	30	49	1203.7	679
3.	Universal-2	33	41	39	84	37	77	524.69	401.2
4.	Millennium-1	29	50	31	50	33	55	2623.44	246.9
5.	Silk House	31	62	41	61	40	70	10246.8	308.6
6.	Abhishek Market	31	64	40	67	38	72	8703.6	432.1
7.	Hariom Market	30	66	42	64	34	58	3148.1	987.6
8.	Jagdamba Market	31	51	65	99	48	88	4444.4	401.2
9.	Padmavati Textile Market	26	34	61	102	46	88	1018.5	709.8
10.	Shubham Textile Market	30	48	59	62	43	75	1851.8	925.9

11.	Reshamwala Textile Market	30	53	66	103	48	82	6635.7	1018.5
12.	Hari krupa	33	41	42	93	37	77	4845.6	648.1
13.	Gopal chamber	30	50	72	113	51	97	13394.9	987.6
14.	Shiv Darshan	31	46	44	65	40	71	6111.1	1203.6
15.	Krishna Market	31	50	68	84	137	241	10154.2	4629.6
16.	Mahavir Market	26	34	61	102	53	89	2314.72	370.356
17.	Moolchand Market	31	37	42	86	39	88	4320.82	524.67
18.	Vardhaman Market	31	51	38	93	38	75	4073.91	555.53
19.	Universal Textile Market	31	50	41	110	47	84	3919.6	432.08
20.	Jash textile market	31	64	47	107	44	91	4382.54	493.8



Graph 1.1 Graphical representation of textile markets data

3.1 Statistical Analysis of observed data

The statistical tool employed for analysis of observed data is Minitab 19. The Windows MS EXCEL has also been used for graphical representation of data collected.

Principal Component Analysis: Temperature (°C), Relative Humidity (%), PM 2.5 (µg/m3), PM 10 (µg/m3), TVOC (µg/m3), HCHO (µg/m3), Bacterial CFU/m3, Fungal CFU/m3

Table 1.2 Eigenanalysis of the Correlation Matrix

Eigenvalue	3.6305	1.7660	1.0331	0.8417	0.4289	0.2287	0.0635	0.0075
Proportion	0.454	0.221	0.129	0.105	0.054	0.029	0.008	0.001
Cumulative	0.454	0.675	0.804	0.909	0.963	0.991	0.999	1.000

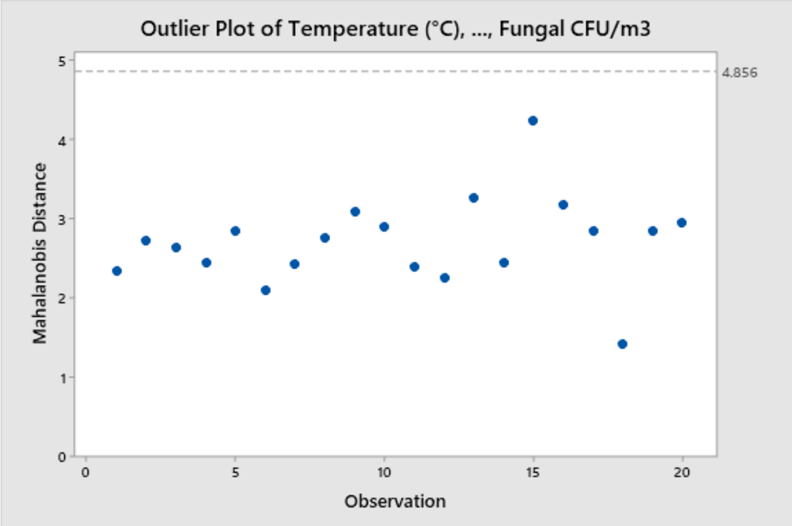
Table 1.3 Eigenvectors

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
Temperature (°C)	-0.003	0.462	-0.457	0.671	0.028	-0.347	-0.059	-0.055
Relative Humidity (%)	-0.108	0.563	-0.106	-0.515	-0.607	-0.148	-0.060	0.033
PM 2.5 (µg/m3)	0.388	-0.325	-0.203	-0.316	0.129	-0.761	-0.078	0.027
PM 10 (µg/m3)	0.203	-0.452	-0.566	0.113	-0.544	0.286	0.206	-0.038
TVOC (µg/m3)	0.500	0.094	0.220	0.063	-0.128	0.119	-0.355	-0.730
HCHO (µg/m3)	0.502	0.081	0.150	0.155	-0.132	0.164	-0.439	0.677
Bacterial CFU/m3	0.290	0.305	-0.503	-0.368	0.530	0.388	0.065	-0.005
Fungal CFU/m3	0.458	0.226	0.309	0.096	-0.063	-0.074	0.788	0.060

3.2 Discussion of Statistical Analysis

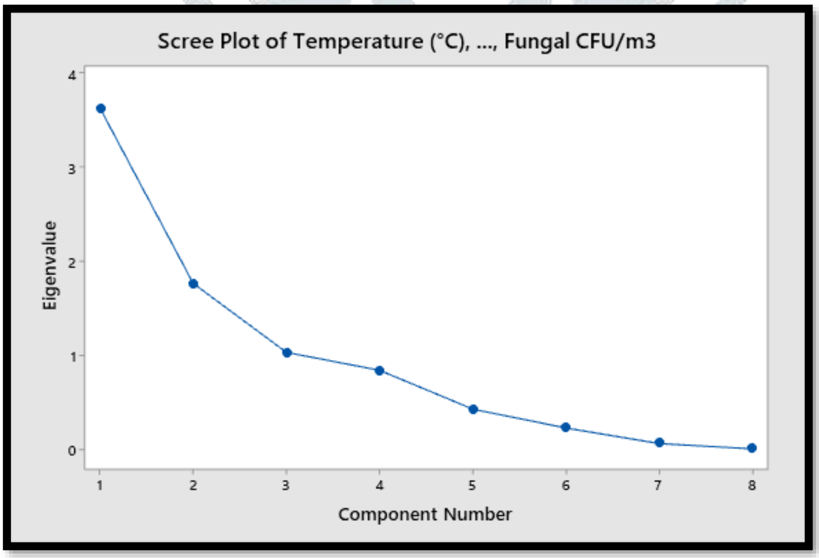
When in the analysis, we have to identify a small number of uncorrelated variables from a large set of data than those variables are known as principal components. The main aim of principal components analysis is to explain the maximum amount of variance with the fewest number of principal components. PCA is a type of multivariate analysis. With this analysis , we create new variables or principal components that are linear combinations of the observed variables. It is used to explain the maximum amount of variance with the fewest number of principal components. Now to interpret the PCA, to determine the amount of variance that the principal components explain. The components which explains an acceptable level of variance are retained. For descriptive analysis, 80% acceptance level is considered. Thus, from cumulative values, first four principal components explain 90.9% of the variation in the data. Therefore, these components are the most effective one.

The principal components can also be determined with the help of size of eigen values. The values which are greater than 1 are retained in this. Hence, first three eigen values are to be retained and act as principal components. In table 1.2 , the first eigen value possess highest proportion which is 45.4%. Thus in table 1.3, the variables which affects the PC1 more are TVOC, HCHO and Fungal CFU/m^3.Thus, PC1 is positively coorelated with all these three variables. It means when TVOC, HCHO and fungal CFU/m^3 increases the value of first principal component.



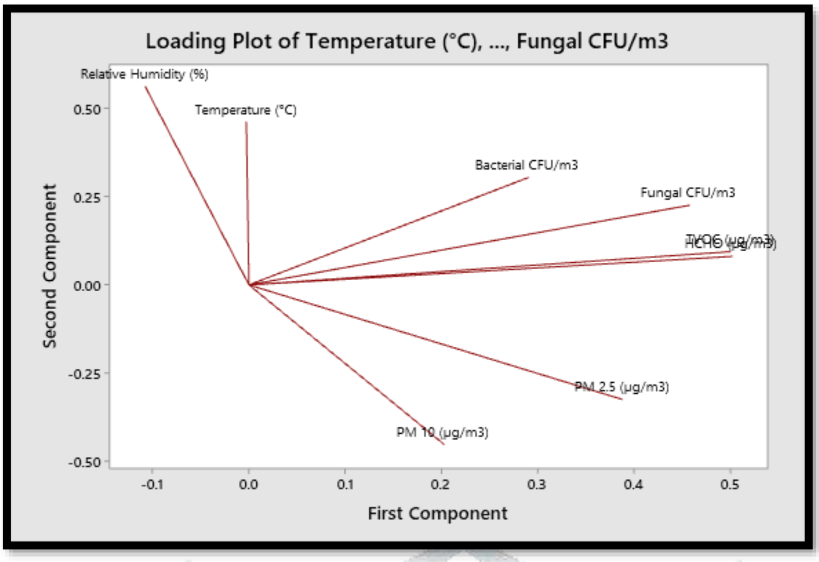
Graph 1.2 Outliers Plot

This **graph 1.2** illustrates that no point is found above the reference line. All the points are below the reference line so there is no outlier in our data. Hence, it shows the significance of the results.

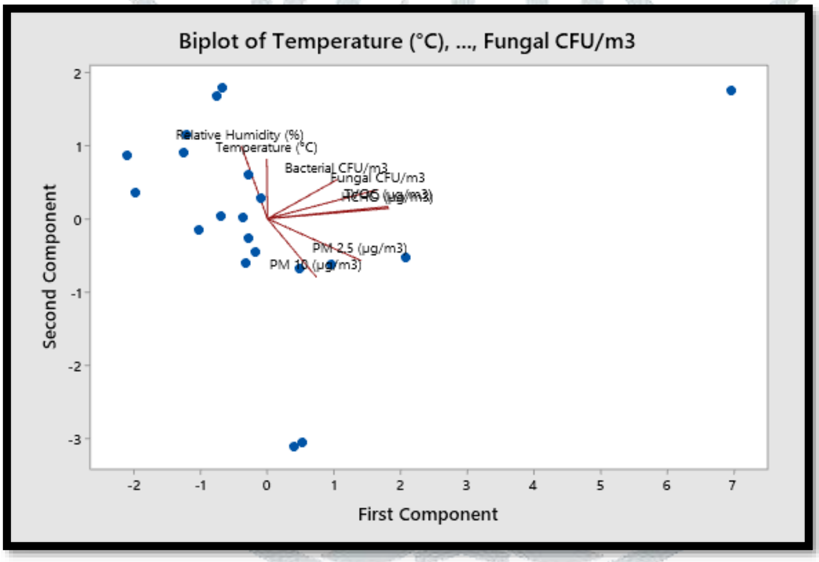


Graph 1.3 Scree Plot

This Scree plot Graph 1.3 shows that first three components are tending to form a straight line. Thus the remaining principal components account for a very small proportion of the variability (close to zero) and are probably unimportant.



Graph 1.4 Loading Plot



Graph 1.5 Biplot

The above loading plot and Biplot, **Graph 1.4 & 1.5** shows that the TVOC, HCHO, fungal and bacterial CFU/m^3 have large positive loading on component 1, so they measures the air quality more importantly as compared to PM 2.5, PM 10 shows negative loadings.

4. Conclusion

Major strategies have to made and implemented for combating this indoor air pollution and its detrimental effects on health. The research field is attempting to improve the situation through the new researches in this field. Ministry of Environment and Forestry (MOEF) along with Central Pollution Control Boards (CPCB) and state PCB's are continuously working in this field. They are preparing Ambient Air Quality guidelines and its implications through various awareness programmes. Although proper Heating, Ventilation and Air-conditioning system have been improvised for better results. The workers are being provided with safety measures from occupational health hazards. The above statistical analysis signifies that not only environmental factors are responsible for deterioration of indoor air but microbial parameter also contributes in it.

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