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CHARACTERIZATION OF INDOOR AND OUTDOOR AIR QUALITY RELATIONSHIPS IN CHENNAI, TAMILNAU, INDIA.

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ABSTRACT

The important finding of the present study is that a major portion of SPM concentration is in the form of finer particulate matters (< 0.7μm). Similar is the trend of the variation of the heavy metal concentrations with size of the particles, i.e. Most of the metal mass is concentrated in the fine particle size interval (i.e. < 0. 7 μm). The size distribution of both SPM and metals is found to be highly skewed towards the larger pat1icles. The only assumptions are size distributions relating to Ca and Cu are the only expectations. While, Cu is more abundant in fine particulate mode (< 0.7 μm), its presence is also important in size intervals 5.4- 1.6 and 1.6- 0.7 is also significant. However, in case of Ca there is no definite pattern in its distribution with size of particles. The seasonally averaged PM_{10} concentration is approximately 86.40% of TSP, and is 90.18%, 81.41% and 86.40% of TSP for winter, summer and monsoon seasons respectively. There is an unmistakable connection among PM_{10} and fine particles, and between PM_{10} and $PM_{2.5}$. This suggests the variety in PM_{10} can be represented by the variance in $PM_{2.5}$. Likewise, a consistent relationship between fine fraction and $PM_{2.5}$ also indicates that the difference in the in fine fraction concentration is due in essence to the variance in $PM_{2.5}$. Thus, present study reveals that PM_{10} can adequately act as surrogate for both fine fractions as well as $PM_{2.5}$. The fine fraction can also act as surrogate for $PM_{2.5}$.

INTRODUCTION

Air quality, with its scientific, socio-economic, political and international dimensions has attracted a great deal of attention for scientists, policy makers, town planners, industry managers, governmental and non-governmental organizations in different parts of the world. Cities are by nature concentrations of humans, materials and activities. They therefore exhibit both the highest levels of air pollution and the largest targets of impacts. Air contamination is, anyway established on all geological and temporal scales,

ranging: from "here and now" issues identified with human health, visibility and material harm, over regional phenomena like acidification and deforestation with a period skyline of decades, to worldwide phenomena (environmental change, ozone depletion), which throughout the following hundreds of years can change the conditions for man and nature over the whole globe. All the previously mentioned studies significance the importance of understanding the relationship between indoor and outdoor air quality.

As of late some significant examinations have additionally been led on indoor air contamination and on analyzing indoor and outdoor relationships. For instances Colome *et al*. (1992), examined the Indoor and Outdoor relationships for PM_{10} in the home of asthmatics. Phillips *et al*. (1992), considered the Indoor and Outdoor relationships in four naturally ventilated workplaces in the United Kingdom. Li *et al*.,(1996), contemplated on the indoor and outdoor air contamination in Tokyo and Beijing. Baek *et al*.,(1996), studied the Indoor and Outdoor air quality connections in Korean urban areas. Lee *et al*., (1997), found that, outdoor air contributed from 50 to 100% of indoor contamination during the summer season in Korea. Jones, (1999) has restored the present status of our compreshension of indoor air quality and related health aspects. Jones *et al*., (2000), considered the Indoor and Outdoor connections in some residential homes with road side in UK. Koponen *et al*., (2001), have evaluated the impact of outdoor air contamination on indoor air in Finland.

Air quality studies propose the significance of understanding the relationship among indoor and outdoor air quality. As far as anyone is concerned, no study on analyzing this relationship has been embraced in the Indian context. Moreover, the studies of the particle shape, size distribution and possible correlations between different size fractions are lacking. These contemplations have prompted the present study with the follow determination of indoor outdoor air quality connections at different sites in Chennai, determination of size distribution of aerosols and correlation between various size fractions over Chennai and Characterization of SPM using scanning electron microscope.

Chennai (Urban)

The city of Chennai, popularly known as Madras, one among the four major metropolitan cities of India, located in the southern India lies between 12^{o} 09’, 80^{o} 12 NE and 13^{o} 09’, 80^{o} 19’NE. It is having population of 6.04 million in an area of 170.47 Sq.km. It is developing at a average of 25% per decade. The city is situated in a hot atmosphere zone, experiencing tropical maritime monsoons. The minimum temperature ranges from 21^{o} C to 24^{o} C in the month of December to February and the average daily maximum temperature is 37^{o} C during the month of May. The minimum monthly rainfall collections from 6mm to 10mm in the month of February and maximum rainfall of 320 mm has been recorded during the month of November. Chennai city does not have much of green space, except the Guindy National Park with an area of 270.57 hectares, which is under reserve forest category. This area has sparse vegetative cover.

Due to population growth the per capita vegetative area of the city declined to 0.00007 hectare from 0.00021 hectare between the years 1951-1991.

The Chennai city's landscape is more or less a level plain with dispersed hillocks, gently slanting towards Bay of Bengal in the east. The city has two kinds of metamorphic rocks, namely, the rocks consisting mainly of gneiss and rocks consisting mostly of laterite in various stages of formation. The Chennai city's soils type is comprehensively characterized into red loamy soil (in the inland), sandy soil (along the coastal belt), clayey soil (along low lying zones) and lateritic soil (on some barren lands). The city is crossed by two streams, the Cooum and the Adyar. The two waterways are streaming west to east, among the Cooum River, separates the city into equal parts. Kortalayar is another stream characterizes the northern boundary of the metropolitan area. Buckingham canal once navigable goes directly through the metropolitan region, parallel to the sea coast. The red slopes lake and Cholavaram Lake are situated in the north-west from which the city gets its water supply.

Chennai, originally known as Madras Patnam, was situated in the territory of Tondaimandalam, a zone lying between Pennar waterways of Nellore and the Pennar stream of Cuddalore. The capital of the area was Kancheepuram. Tondaimandalam was managed in the second century A.D. by Tondaiman Ilam Tiraiyan, who was an agent of the Chola family at Kanchipuram. It is accepted that Ilam Tiraiyan probably quelled Kurumbas, the first occupants of the region and set up his standard over Tondaimandalam. The more established territory called the Madraspatnam lay toward its north. Later on, the intervening space between the more established northern locals of Madraspatnam came to be immediately worked over with places of the new settlers (as the two extended) and that the two villages turned out to be for all intents one town. While the official centre of the settlement was assigned Fort St. George, the British applied the name Madras Patnam to the combined town. Golkonda forces under General Mir Jumla vanquished Madras in 1646 and brought Chennai and its prompt environmental factors under his control. On the fall of Golkonda in 1687, the region went under the standard of the Mughal Emperors of Delhi. After this region to create in new buildings development is extremely high. So Chennai is a good example of urban territory.

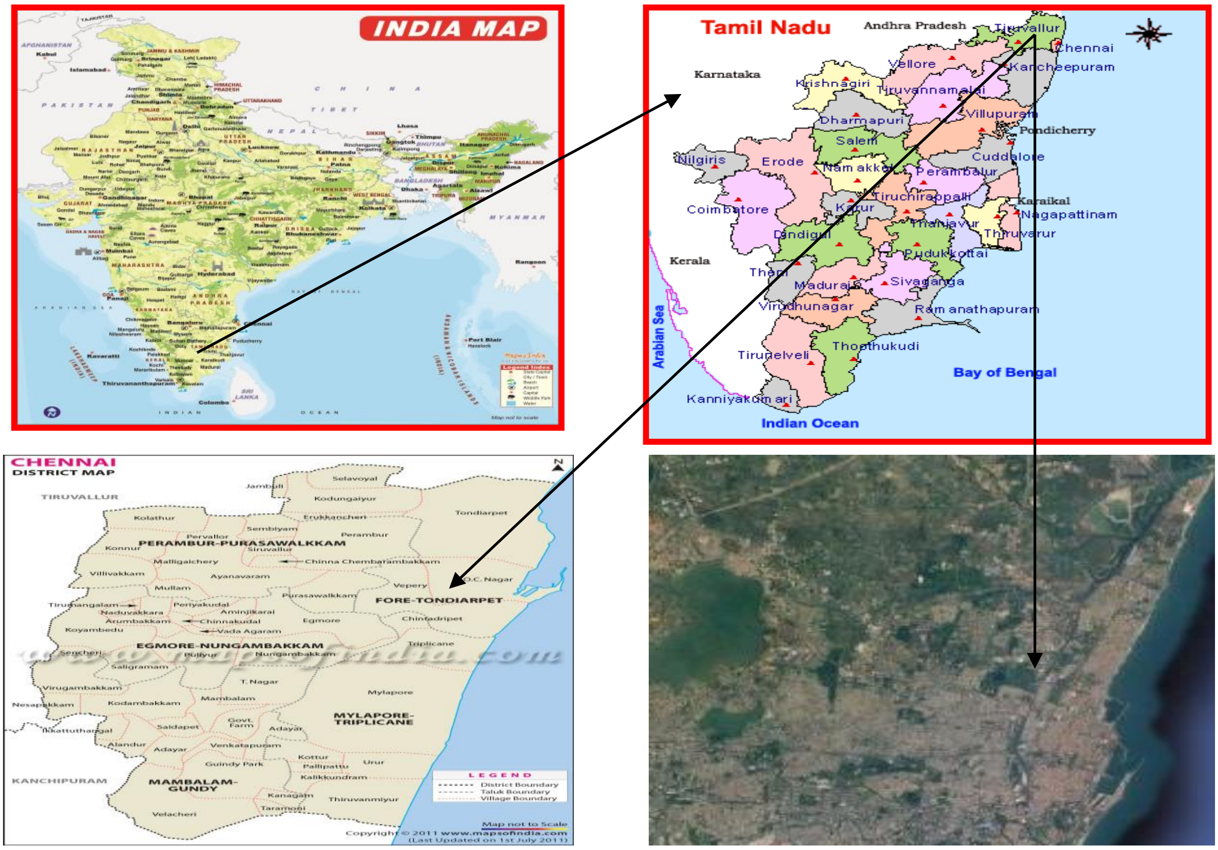

Fig. 1. Chennai (Urban)

METHODOLOGY

To evaluate the ambient air quality, station were recognized in the populace thickness regions. Calibrated Respirable Dust Samplers (Enviro tech APM 460) with stream rate ranging between 1.2 - 1.45 m^3/min were utilized for observing of SPM and RPM. Gaseous samples were gathered by coordinated gas sampling get together (Envirotech APM 411). A tapping gave in the container of the sampler was used for inspecting of SO_2, NO_X and CO, with appropriate stream controller and a stream 1.0l/min. Envirotech Organic Vapour Sampler (APM 850) and a digital imported personnel sampler Drager Multiwarm II BD were utilized for checking CO. The contaminations were observed on 24 hourly basis in twice in month or season wise. Calibrated Respirable Dust Sampler is used with Whatman GF/A microfibre filter paper for the determination of PM_{10}. PM_{10} is a measure of particulate matter having size <10 microns. Respirable Dust Sampler (RDS) is attached with a cyclone. Air enters a vertical chamber with swirling (Vortex) motion and molecule bigger than design cut-off are kept on the on the inner surface of the chamber, whereas particles undernath 10 microns are stored on the Whatman GF/A microfibre filter paper. PM_{10} was determined by taking the contrast among initial and final

weight of the filter paper and separating volume of the air sampled.

Scanning Electron Microscopy (SEM)

The Scanning Electron Microscope (SEM) is a powerful instrument, which permits the characterization of heterogeneous materials and surfaces on a local scale. In the present study, a computer controlled Philips XL-20 scanning electron microscope has been used. In SEM, the area to be examined is irradiated with a focused (10 nm spot size) electron beam, which may be static, or swept in raster across the surface of specimen. The types of signals which are produced when the focused electron beam impinges on a specimen surface, include secondary electrons, back scattered electrons, characteristic X-rays, Auger electrons, and photons of various energies. They are obtained from specific emission volumes within the sample and are used to measure many characteristics of the sample (composition, surface topography, crystallography, magnetic and electric fields, light emitting properties, etc.). Electron micrographs were taken on SONY (ll0mm x 20mm) high speed printing films.

RESULTS AND DISCUSSION

In order to quantitatively assess how outside levels impact indoor air quality in Chennai, the data were statistically analyzed. In Chennai, most of the people usually open their windows to get cool air, especially in summer and monsoon seasons. Therefore concentrations of indoor contaminants can be assumed to be substantially related to those outdoors. Day time (3hrs mean) SPM concentrations indoors and outdoors at all the sampling sites selected. The magnitudes of concentrations indoors are appreciable, and in some situations even more in comparison to concentration outdoors. Therefore the quantitative assessment of the impact of outdoor pollution on the indoor air quality is worth the study.

Relationships between Indoor and Outdoor Air Quality in Chennai

Indoor condition has slowly pulled into more influential consideration in recent years, as a large number of people spend 80-90% of their energy inside. A few people, the old, the extremely youthful and decrepit, who are generally defenseless with the impacts of contaminations, may invest all their energy inside. Therefore, an indoor air quality assessment is typically critical to understanding the impact of air pollution on human wellbeing.

The information was measurably broke down to decide quantitatively

how open air levels influence indoor air quality in Chennai. In Chennai, the majority of the individuals normally open their windows to get cool air, particularly in summer and rainstorm seasons. Along these lines, it is not out of the ordinary that indoor toxin fixations might be essentially identified with those outside.

In the tracheal bronchiolar district, air speed and directional changes diminishes. The streamlined distance across go supported for testimony right now from 1 to 5 μm. The littler particles are spread all over the alveolar parts of respiratory tract. As the speed diminishes to for all intents and purposes zero, additional time is accessible for sedimentation to happen, bringing about less and less particles arriving at the alveoli.

Gravity turns out to be less significant as the particles become littler, hence particles, generally littler than 1μm, are stored on alveolar dividers for the most part by dissemination. All things considered, communication between particles and cells is based upon where the particles store in the respiratory tract. For instance, particles saved in the alveoli require a larger number of components for evacuation than particles that store in the upper respiratory tract. In any case, the bit obtained by the person depends on the particle dissolvability and alternative perspectives, similar to the location of the oath. The important aspects of the assessment and the findings are covered in the segment on moving.

Table :1. Description of the sampling period and duration

Season	**Period**	**Duration(Hours)**
Winter	2019	24
Summer	2019	24
Monsoon	2019	24

TABLE :2. Sampling characteristics of the Cascade particle sampler (CPS-105 Kimoto)

Stage	Nozzle width(mm)	Flow speed (m/s)	Sampling size (μm)
1	5.5	3.6	Max-10.9
2	3.0	8.0	10.9-5.4
3	1.0	29.9	5.4-1.6

TABLE :3. Sampling characteristics of the Outdoor Air quality in Chennai region (μg/m^3)

Month (2019)	**PM_{10}** (Mean value)	**PM_{100}** (Mean value)	**$PM_{2.5}$** (Mean value)	**SO_2** (Mean value)	**NO_2** (Mean value)	**CO** (Mean value)
January	85	120	43	10.8	21.8	215
February	95	145	36	11.4	24.6	423
March	90	135	40	9.6	24.8	420
April	104	114	65	10.5	34.4	918
May	106	161	51	8.3	26.8	654
June	64	163	31	8.8	18.8	914
July	66	148	20	9.3	29.4	420
August	109	175	61	10.6	34.7	765
September	104	148	32	9.4	28.3	320
October	85	162	65	8.6	25.6	235
November	100	189	68	7.4	28.9	214
December	98	186	65	8.9	26.1	258

TABLE :4. Sampling characteristics of the Indoor Air quality in Chennai region (μg/m^3)

Month (2019)	**PM_{10}** (Mean value)	**PM_{100}** (Mean value)	**$PM_{2.5}$** (Mean value)	**SO_2** (Mean value)	**NO_2** (Mean value)	**CO** (Mean value)
January	55	80	23	8.9	11.9	186
February	41	91	16	9.6	11.6	325
March	45	85	20	9.1	14.8	365
April	49	90	35	8.6	15.9	715
May	56	96	38	8.0	13.8	435
June	25	95	19	7.6	16.8	735
July	24	89	15	7.9	19.6	236
August	65	98	42	8.5	21.3	512

September	60	84	21	6.3	16.7	196
October	38	79	36	6.9	22.3	186
November	42	78	41	5.6	20.1	165
December	40	76	40	6.9	18.3	198

It has been discovered that the open air SPM fixations do without a doubt influence the indoor SPM focuses in shifting degrees. The degree of the impact of the outside SPM on indoor SPM has been seen as reliant on the idea of the site. The connection among's indoor and outside SPM is seen as most extreme for business/overwhelming traffic zone (~ 85%) trailed by private/delicate zone (~ 39%) and the reference site of Chennai (~ 30%).

Table: 5. Indoor and outdoor concentration ratios for SPM and different metals at three zones

Species	**Indoor/Outdoor ratio at Industrial zone**	**Indoor/Outdoor ratio at Residential zone**	**Indoor/Outdoor ratio at Sensitive zone**
SPM	1.59	0.95	0.88
Mg	1.00	1.07	0.97
Ca	0.93	1.35	0.73
Cu	1.16	0.92	0.98
Cd	0.91	1.03	0.98
Pb	0.88	1.01	0.96
Cr	0.95	0.96	0.96
Mn	1.09	1.02	0.97
Fe	0.76	1.03	0.98
Ni	0.82	1.02	0.97

The normal TSP at all the three locales in three unique seasons is given in Table 3-5. It might be noticed that TSP is fluctuating between 100 to 384 $\mu g/m^3$ aside from at Residential zone in summer season where it is near 600 $\mu g/m^{3.}$ The TSP levels are moderately high in winter and summer seasons at Sensitive zone, which isn't unforeseen since it is a modern zone. The fairly exorbitant focus in summer at Residential zone can be ascribed to visit dust storms during the coarse of testing.

The division (%) of TSP which lies in the 5-size interims of the effect or is appeared for the separate locales in Table 3 to 5. An assessment of these size dispersed portions, obviously show the predominance of better particles (>0.7 μm) at all the destinations for all seasons aside from at Residential zone, where there is some peculiarity in storm seasons. In every one of the staying four phases, the portion is ~ 20%. The striking component of all these mass size dispersions is their uni-modular nature. These conveyances seem to observe either Junge's capacity law or Log-Normal appropriation and is slanted towards bigger size particles (Harrison *et al.,* 1998).

Particle Characterization Using Scanning Electron Microscope

The utilization of SEM for the individual molecule investigation is imperative to get morphological information and to quantify physical qualities of the particles to uncover the source data, which can't be resolved through mass compound and physical portrayal. The pictures acquired by SEM are especially helpful in recognizing circular particles (generally demonstrative of ignition) from non-round particles. Dust and spores can likewise be distinguished through a manual audit of pictures.

The SEM is an advanced framework outfitted with optional and backscattered electron finders. The example organize is balanced both physically and through the PC in X and Y - bearings. The Z-hub is physically flexible and is commonly set at the ideal separation for X-beam obtaining.

The SEM is outfitted with programming which empowers investigation to be directed in the PC controlled mode once the underlying conditions are set. This instrument can be utilized for assurance of different parameters viz. amplification, number of particles, molecule size, shape, basic creation and molecule pictures (Conner *et al.*,2001).

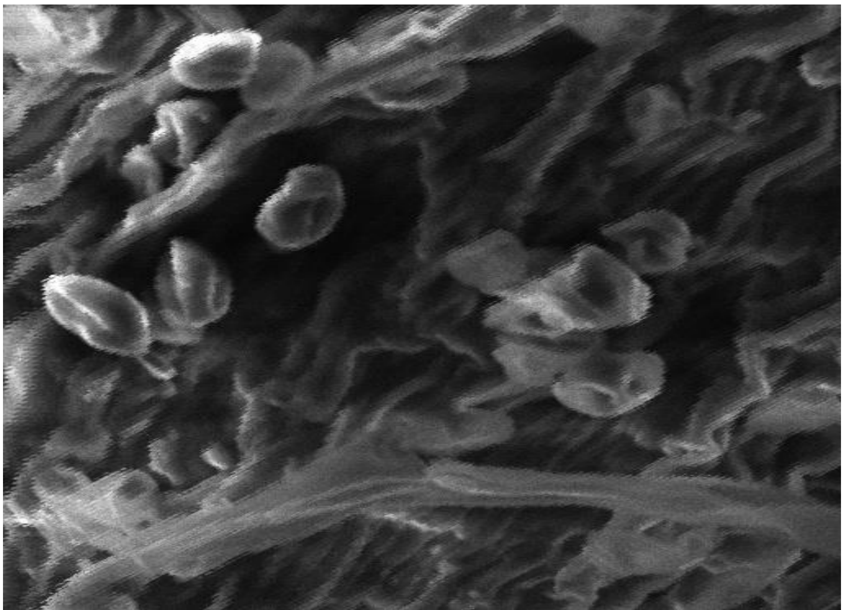

Fig.2. Electron Micrograph particles size at Chennai

CONCLUSIONS

It was discovered that the concentrations of outdoor SPM are likely to affect the concentration of indoor SPM in varying degrees. The degree of the impact of the outdoor SPM on indoor SPM has been seen a reliant on the idea of the site. The correlation between indoor and outdoor SPM is seen as most extreme for commercial and substantial traffic zone (~ 85%) trailed by private and sensitive zone (~ 39%) and the reference site Industrial zone (~ 30%). In the event of metals, Cu, Cr, Cd and Ni excellent connection among the indoor and outdoor concentrations is observed irrespective of the nature of the site. For the most of the metals Mg, Mn, Fe, Cu, Cd, Cr and Ni apart from Ca and Pb, residential and vulnerable areas have a strong li nk between indoor and outdoor concentrations. Commercial and heavy traffic zone areas show great connection between indoor and outdoor environments for Cu, Cd, Cr, Ni, Mn, Fe and Pb aside from Mg and Ca. At the reference site Industrial zone, aside from Cu, Cd, Cr and Ni, no relationship was found to exist among indoor and outdoor concentrations of Mg, Mn, Ca, Pb and Fe. The significant finding of the present investigation is that a major portion of SPM concentration is in the form of finer particulate matters (< 0.7μm).

The distribution of the range of heavy metal concentrations is similar to disproportionate metal focuses with particle size, e.g. the vast majority of metal mass is concentrated in the small particle size interval (e.g. < 0.7 μm). The size appropriation of both SPM and metals is seen to be highly skewed towards the bigger pat1icles. The main special cases are the size disseminations relating to Cu and Ca. However, Cu is more abundant in fine particulate mode (< 0.7 μm), its presence in size intervals 5.4- 1.6 and 1.6- 0.7 is additionally noteworthy. Be that as it may, in the event of Ca there is no distinct example in its distribution with size of particles. The regularly found the middle value of PM10 concentration is approximately 86.40% of TSP, and is 90.18%, 81.41% and 86.40% of TSP for winter, summer and monsoon seasons individually.

The relationship between PM_{10} and fine particles is obvious and between PM_{10} and $PM_{2.5.}$ It indicates that the variation in PM_{10} can be explained by the difference in $PM_{2.5.}$ Likewise, a consistent relationship between fine fraction and $PM_{2.5}$ also indicates that the difference in fine fraction concentration is due in seen essence to the variance of $PM_{2.5}$. Therefore, the present study shows that both fine fractions as well as $PM_{2.5}$ can adequately serve as substitute for PM_{10}. Also the fine fraction can serve as a surrogate for $PM_{2.5.}$ Scanning electron micrographs show that silicate and soot particles predominate at most locations.

The residential sites are devoid of any particular type of particle or a group of particles being dominant.

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