International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 - 5161
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Available at http://inpressco.com/category/ijcet

Research Article

Assessment on Particulate Pollution in Sindri after closure of Sindri Unit of Fertilizer Corporation of India/ (FCI)

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Accepted 20 February 2014, Available online 25 February 2014, **Vol.4, No.1 (February 2014)**

Abstract

The air quality of Sindri after closure of FCI has been assessed with respect to Particluate Matters. The SPM has been found to vary between 99 ug/m3 to 174 ug/m3, PM_{10} between 60 to 74.5ug/m3 and $PM_{2.5}$ between 35 to 48 ug/m3. The Air Quality Index has been computed based on the standard break-point definitions and as per CPCB guidelines. The quality index has been assessed for PM_{10} and $PM_{2.5}$. On scale 1-10, the Air Quality Index(AQI) has been found in the range of 8 to 10 for PM_{10} and for $PM_{2.5}$ the air quality index corresponds to 3. The Air Quality Index on scale 1 to 100 has been found between 41 to 52 for $PM_{2.5}$. Similarly, on scale 0-500, the AQI with respect to PM_{10} has been found in the range of 53 to 61 and for $PM_{2.5}$, AQI has been found in the range of 99 to 132. As per CPCB guidelines, the air quality has been assessed by calculating exceedence factor. The exceedence factor has been found to vary between 0.6 to 0.7 for PM_{10} and between 0.58 to 0.80 for $PM_{2.5}$. The Air Quality Index falls under moderate to un-healthy quality of air. A long/ chronic exposure may impart ill-health effect. The need, justification and objective of the paper has been highlighted through a review of literature presented in the introductory part of the paper. Major portion of the study is based on literature survey through standard hand books, journals, Google, Google Medline and Google scholar and information available from the records of Government and non-government organizations with the use of following key words.

Keywords: *Air Quality Index (AQI), Air Quality Health Index (AQHI), SPM, PM_{10}, $PM_{2.5}$.*

Introduction

The recent epidemiological research has demonstrated adverse health effect on short term fluctuation in ambient air pollution leading to daily non-accidental mortality, cardio-respiratory death, hospitalization and emergency room visit *(Delfino RJ et al: Burnnet RT et al: Analitis A et al: Le Terte A et al: Zanobetti A et al*). References have been also recorded that certain group of people are at higher risk, among them are elderly people (above 65 years of age), children (below 5 years of age) and physically impaired group of people are at higher risk due to short exposure *(Goldberg MS et al)*. The increase in concentration of pollutant (<PM_{10}) may cause congestive heart failure, diabetes and cardio-vascular diseases *(Bunette RT et al)*. The repeated exposure to air pollutants over a prolonged period of time i.e., in years may increase the risk of cardio-vascular diseases, respiratory diseases and even lung cancer among the healthy individual (*Pope CA3 et al)*. Air pollution now ranks the eight leading causes of death.

Particulate Matter is one of the important criteria pollutants. It is a mixture of tiny pieces of solid and liquid droplets with wide distribution of size and mass. They are suspended in the atmosphere and commonly known as Aerosols. The paper presents an assessment of Aerosols / Particulate Matter (SPM, PM_{10} and $PM_{2.5}$ after closure of Sindri Fertilizer Complex of FCI. The paper is limited to the aerosols which is present in the environment in solid or liquid form in which the individual aggregate is larger than the smallest molecules. It may be in the range of 0.0002 micron to 500 micron. However, in this paper SPM has been considered as Particulate Matter less than 100 micron with an average of 30 to 40 micron. The Respirable Particulates have been considered with size less than 10 micron. Fine particles have been considered equivalent to or less than 2.5 microns. The paper also presents the distribution pattern of the atmospheric aerosols with respect to SPM (<100 microns), RPM (<10 micron), Coarse particulate (PM_{10} to $PM_{2.5}$) and fine particulates (<2.5 microns).

Atmospheric reactions are strongly affected by the number of SPM. The particles supply surface on which the atmospheric reactions can occur and acts as a catalyst (*Environmental Engineering. Hand Book Page: 262,263*). Thus, they are responsible for climate change on the earth by changing the amount of incoming short wave solar radiation and outgoing terrestrial long wave radiations *(Haw wood et al: Twomey S et al)).* The climate change is one of the biggest sources of uncertainty in future climatic predictions. An increase in number of clouds droplets due to increase in introduction of fine aerosols there is

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reduction in cloud size. The water droplets are divided into more number of droplets which may suppress precipitation and may increase the cloud life in the atmosphere. This phenomenon has an adverse impact on hydrological cycle of the locality (*Forster Piers et al: Charlson RJ et al).*

The increase in level of fine particulates in the environment has been estimated to cause 22,000 to 52,000 deaths per year in USA *(Mokdad Ali H et al)* and 370,000 pre-matured deaths per year since 2005 in USA *(Spatial Assessment of PM10 and ozone concentration in Europe 2005)*. The New York Times (2[nd] February, 2014) reported that India has a highest death rate because of chronic respiratory disease. In December, 2013, the former Health Minister of China, Professor of Medicines, reported that air pollution was killing 500,000 people in China per year. Particulate matters in the order of less than 10 microns can penetrate deepest part of the lungs such as bronchioles *(Region 4: Laboratory and Field Operations - PM2.5 (2008)* larger particles are generally filtered through nose and throat via cilia or mucous. PM_{10} can settle at bronchioles and lungs and may cause health problem. $PM_{2.5}$ tends to penetrate into the gas exchange region of the lungs and very small particulates (<0.1 micron) may pass through lungs to the other organs of human body. $PM_{2.5}$ leads to high plaque deposit in arteries causing vascular inflammation and atherosclerosis hardening of arteries leading to heart attack and other cardio-vascular problems (*Pope, C Arden; et al)*. The particulate matters of less 0.1 micron passes through cell membrane and migrates to the other organs including brain and can cause Alzheimer type of problem. Particulate matter may cause more damage to the cardio-vascular system. Particulate matter from Diesl engine, recently known as DPM (Diesel Particulate Matter), carries carcinogenic compounds like benzo-pyrene absorbed on the solid particles is one of the recent problems of great concern.

Particulate matter has been found to produce adverse impact on vegetation by clogging of stomatal opening of the plants, which is responsible for deactivation of photosynthesis process leading to stunting of growth and mortality of plants *(Hogan, C. Michael -2010-Abiotic factor)*

US EPA has regulated particulate pollution since 1971. The agency has revised the standards several times to ensure they continue to protect public health and welfare. (http:/www.epa.gov/ttm/naaqs/standards/pm/spm history. html). North Carolina: US EPA Office of Air Quality Planning and Standards, 2013. Since September, 2013, almost all countries of the world has agreed to add up the break point definition of USEPA as per Federal Regulation Part 58 Appendix G for calculation of AQ Index and Air Quality Health Index.

The air quality of Sindri has been assessed by different standards for PM_{10} and $PM_{2.5}$. Based on Air Quality Index, the health index has also been assessed. The distribution patterns of particulate matters have been presented graphically.

Experimental Set-up

A monitoring station was setup on CIFT Building of PDIL at Sindri to assess the air quality of Sindri with respect to SPM, PM_{10} and $PM_{2.5}$. Sindri is located in Dhanbad district (Coal Capital of India) in the state of Jharkhand. The location has been presented in Fig.I. Geographically, Sindri is located at 23^0 39’ 58.15 N latitude and 86^0 29’ 24.26 E Longitude at an altitude of about 160 m from mean sea level (MSL). The air quality monitoring station has been selected in consideration of the following points:

- Representation of the area
- Approach to sampling station
- Security
- Availability of power (electricity)
- Location closer to the closed industrial activity (FCI)

The area falls in semi-arid region of India. It receives a rainfall of 1374 mm, Rel. Humidity ranges from 27% to 87%, Ambient Temperature ranges from 11^0C to 39^0C , dominant wind direction is SW to NE. The area is surrounded by Jharia Coalfield, a cement industry ACC is situated in NE direction at a distance of about 1 km. One Thermal Power Station at Santhaldih is situated in southern direction from the sampling point at a distance of about 10 km in the state of West Bengal. The area is surrounded by Open Cast Coal Mining Projects of Jharia Coalfield. A number of coke-oven plants and small industries are located within 10 km radius with respect to sampling location. The industrial activities stated above are the main source of particulate pollution in Sindri area. After closure of FCI, large patches of land are covered with vegetations in random fashion, which are considered to be scavenger for particulate matter and sources of biogenic particulate matters.

Material & Methods

The samples of SPM, PM_{10} & $PM_{2.5}$ were collected from the above sampling station during the period from Oct’ 11 to June’13 except the monsoon period (July’12 to Sept’12). 8 days per month sampling schedule was maintained during Oct’11 to Jun’12 and 7 days per month sampling schedule was maintained for a period between Oct’12 to June’13. PM_{10} & $PM_{2.5}$ samples were collected on GF/A and Teflon (Millipore) with the help of RDS sampler and ambient Fine Dust Sampler/ Dampler. The instrument RDS is based on simple design standardized by US EPA for monitoring of total dust or SPM. This instrument first separates the coarser particles larger than 10 micron from air stream before entering it on the filter GF/A of pore size 0.5 micron and allows to measure both TSPM & RPM of dia. less than 10 micron.

All the filter papers were pre-weighed on Metler analytical balance before sampling and desiccated for about 24 hrs. To avoid contamination pre-weighed filter papers were placed in filter holder cassette of PM2.5 and in poly bags with zipped lock provision before its use in the damplers and samplers. Before loading the filter papers in these instruments, the timer reading were adjusted / fixed for 24 hours. Later the filters were loaded as per direction of the instrument supplier and screwed properly. After completion of sampling period (24-hours), the loaded PM2.5 filter was removed with the help of forceps and placed properly in the cassette and wrapped in the aluminium foil. In case of PM10, the filter was wrapped in aluminium foil and put into the zip locked poly bags. Both the filters were conditioned in the laboratory and determined the mass concentration of PM10 and PM2.5.

Quality Control

The quality control for measurement of PM2.5 is highly warranted. PM2.5 dampler design is based on the process in which the particles are removed from 10 micron size to smaller size from the air stream by forcing the air to make a sharp bend of particles. The particles of size of greater than 2.5 micron possesses higher momentum and they are trapped in a system of damplers where they strike the surface leaving the smaller particles in the air stream. Thus, the fluctuation in the flow rate is one of the most important and critical point of consideration in Quality Control Program for collection of fine particles (<PM 2.5). During collection of fine particulate matter proper flow rate was maintained i.e. for RDS the flow rate was maintained @1± 0.1 m^3/min. and for FDS the flow rate was maintained @1±0.1 m^3/hr. The impaction filter was changed at regular interval. The impaction filter was also soaked with 3 to 4 drops of silicon oil daily.

Scope of Study

The present study is limited utterly to the measurement of concentrations of SPM, PM10 and PM2.5 with an aim to establish an Air Quality index and Air Quality Health Index on the basis of two years maximum minimum and average data. The study also presents the distribution pattern of Aerosol containing particulate matters between 10 to 100 micron, 2.5 to 10 micron and below 2.5 micron.

Air Quality Index has been computed with the help of equation derived on standard break-point definitions presented in Table-1 to Table-5.

(A) Air Quality Index and corresponding Health Risk Index on scale 1-10

The scale is most commonly used in UK & Canada as per recommendations made by Committee on medical effects of air pollutants (COMEAP).

Table-1 Break-point definition for calculation of Air Quality Index for PM10 & PM2.5 on scale 1-10

Categories	Air Quality Index	PM10 (24-hrs mean value, µg/m3)	PM2.5 (24-hrs mean value, µg/m3)
Low	1	0-11	0-16
	2	12-23	17-33
	3	24-34	34-49
Moderate	4	35-41	50-58
	5	42-46	59-66
	6	47-52	67-74
High	7	53-58	75-83
	8	59-64	84-91
	9	65-69	92-99
	10	≥70	≥100

(B) Air Quality Index & Air Quality Health Risk Index on 0-100 scale

(*Indices definitions www. Airqualitynow-9th August, 2012)*

The following equations have been used for calculation of Air Quality Index & category of Health Risk associated with the indeed. The quality index with respect to particulate matter is limited to $PM_{2.5}$ only along with other gaseous pollutants. The equation is also based on piece-wise linear presentation of the pollutant concentration in the environment.

Table-2 Break Point for Calculation of Air Quality Index & Air Quality Health Risk on scale (0-100)

Air Quality Category for Health Risk	Concentration of $PM_{2.5}$ (µg/m^3, 24-hrs avg.)	Air Quality Index Equation
Very Good	<12	$1.364xPM_{2.5}+0$
Good	12-22	$1.500xPM_{2.5}-2.0$
Moderate	23-45	$0.7727xPM_{2.5}+14.228$
Poor	46-90	$1.113xPM_{2.5}-1.298$
Very Poor	>90	$1.100xPM_{2.5}+0$

Some of the countries follow the following categories on the basis of AQ Index as given below:

Table-3 Categorization of AQ Index

Pollution Load	Index No.
Very Low	0-25
Low	25-50
Medium	50-75
High	75-100
Very High	>100

(*C) Air Quality Index & Health Risk Assessment Based on USEPA on 0-500 scale*

(US EPA Office of Air Quality Planning & Standard, 2013) (Air Now, 9th August, 2012) (US Environmental Protection Agency (EPA), 14th December, 2012)

The Air Quality Index is a piece-wise linear function of pollutants concentration with a sharp boundary between the Air Quality Categories & Index. The index is calculated for individual pollutants and the highest index is considered as AQ Index of the area. The calculation is based on following mathematical expression and based on the mathematical expression. AQ index equation has been derived and presented. The break-point definition has been adopted by most of the Asian, European and American countries since 09.09.2013.

$$I = \frac{I_{high} - I_{low}}{C_{high} - C_{low}}(C - C_{low}) + I_{low}$$

where:

I = Air Quality index,

C = Pollutant concentration,

C_{low} = Concentration breakpoint that is $\leq C$,

C_{high} = Concentration breakpoint that is $\geq C$,
I_{low} = Index breakpoint corresponding to C_{low},
I_{high} = Index breakpoint corresponding to C_{high}.

Table-4 Equation for Determination of Air Quality Index for PM10 on 0-500 scale (USEPA)

Air Quality Index No.	Concentration of PM10 (μg/m3, 24-hrs avg.)	Equation for Calculation of Air Quality Index
0-50	0-54	$0.9259xPM_{10}+0$
51-100	55-154	$0.4949x(PM_{10}-55)+51$
101-150	155-254	$0.4949x(PM_{10}-155)+101$
151-200	255-354	$0.4949x(PM_{10}-255)+151$
201-300	355-424	$1.4347x(PM_{10}-355)+201$
301-400	425-504	$1.253x(PM_{10}-425)+301$
401-500	505-604	$1.0x(PM_{10}-505)+401$
>500	605-4999	$0.1x(PM_{10}-605)+500$*

Table-5 Equation for Determination of Air Quality Index for PM2.5 on 0-500 scale (USEPA

Air Quality Index No.	Concentration of PM10 (μg/m3, 24-hrs avg.)	Equation for Calculation of Air Quality Index
0-50	0-12	$4.1666xPM_{2.5}+0$
51-100	12.1-35.4	$2.1030x(PM_{2.5}-12.1)+51$
101-150	35.5-55.4	$2.4623x(PM_{2.5}-35.5)+101$
151-200	55.5-150.4	$0.5163x(PM_{2.5}-55.5)+151$
201-300	150.5-250.4	$0.9909x(PM_{2.5}-150.5)+201$
301-400	250.5-350.4	$0.9909x(PM_{2.5}-250.5)+301$
401-500	350.5-500.4	$0.9909X(PM_{2.5}-350.5)+401$
>500	-	$0.999xPM_{2.5}$

The scale >500 has been introduced since 09.09.2013 and considered as a critical hazardous category and this concept has been introduced in almost all European & Asian countries. The scale is simply a modification of 14th December, 2012 scale.

(D)Characterization based on CPCB (MoEF), Govt. of India.

The characterization is based on exceedence factor with reference to standard of December, 2009. The exceedence factor defined as follows:

EF = (Concentration of Pollutant)/Air Quality Standard
Where,
EF = Exceedence factor
The air quality has been divided into four categories:
Low Pollution = EF <0.5
Moderate Pollution = EF = 0.5-1.0
High Pollution = EF = 1.0-1.5
Critical Pollution = EF = >1.5
The risk has been also categorized in four categories. The risk has been determined on the basis of surrogate number exposure factor (SNLF).

SNLF = No. of samples exceeding the standard / Total no. of samples under study X EF

Low Risk = SNLF = 0
Moderate Risk = SNLF = <0.25
High Risk = SNLF = 0.25-0.5
Critical Risk = SNLF = >0.5

The interpretation of the results have been made on the basis of the key words like Air Quality Index (AQI) and Air Quality Health Index (AQHI) with special reference to the terms like air pollution, ambient air quality, particulate matter, aerosol and health out-comes with the key words like respiratory diseases, cardio-vascular disease, cancer, asthma, hospital admission, non-accidental death, emergency department visit, mortality. Search has been made through standard books, journals, Google, Google Medeline and Google scholar. Various reports through websites of government and non-government organizations like Environmental Canada, US EPA, World Health Organization, Canadian Council of Ministers of the Environment, the Ontario Ministry of Environment, the British Columbia Ministry of Environment, and the Committee on The Medical Effects of Air Pollutants (UK) etc. have been utilized.

Result & Discussion

The result and discussion is based on the statistically analyzed analytical results presented in Table-6 with respect to Total Suspended Particulate Matter SPM, PM10, PM2.5 & PM10-PM2.5 commonly known as coarse respiratory particles (RSPM).

The table presents minimum, maximum and average values of the above parameters and also includes the ratio of PM10/TSPM, CPM/SPM. The results in the table are based on 135 samples collected on the basis of 24-hrs sampling program. The minimum, maximum and average values of PM10 and PM2.5 have been considered for calculation of Air Quality Index as per different practices and standards of the world. The findings can be presented in Table-7.

On the basis of Air Quality Index, Air Quality Health Risk, messages have been estimated as discussed above. The results of AQ Index based on the above equation and break-point definitions have been presented in the Table 8. The air quality index of Sindri based on two years data presented in Table-6 with respect to PM_{10} on scale 1 to 10 reveals that the degree of pollution is high and the index ranges from 8 to 10. The health message corresponds to high health risk with message to general public and suggests a reduction in streneous activity outdoors for children and elders and public who experience symptom such as coughing and throat irritation should restrict their strenuous outdoor activities. Most of the standards does not consider the health problem due to PM_{10}. The AQ Index with respect to $PM_{2.5}$ on a scale of 1-10 have been calculated equivalent to 3 with a message that it is an ideal environment for outdoor activities.

Table-6 SPM Distribution Pattern at Sindri from October 2011 to June 2013 on 24-hrs basis (Except July, Aug, Sep' 2012)
(Results are express in µg/m^3 of Ambient Air unless otherwise stated)

Period	SPM			PM_{10}			CPM			FPM			PM_{10} / SPM x 10^{-3}			CPM/FPM x 10^{-3}		
	Max	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max	Min	Avg.
Oct-11	132	102	118	70	52	61	21	16	19	49	36	42	534	500	516	474	417	441
Nov-11	144	99	121	74	50	60	30	20	25	44	30	35	532	471	497	867	625	730
Dec-11	165	117	141	76	56	68	28	20	25	49	36	43	500	461	483	610	510	567
Jan-12	162	121	145	76	60	70	24	18	22	52	42	48	496	469	479	500	417	458
Feb-12	173	132	150	78	66	71	26	23	24	52	43	48	530	451	477	535	462	496
Mar-12	167	135	152	76	70	72	28	22	25	49	44	48	533	449	478	636	458	525
Apr-12	162	125	145	78	60	71	38	22	29	46	38	42	518	430	488	950	579	695
May-12	174	132	153	80	68	75	36	26	30	49	40	45	515	460	488	818	583	677
Jun-12	153	110	135	75	60	62	33	20	25	46	40	44	545	490	462	786	478	577
Oct-12	139	101	120	70	54	61	28	20	22	43	34	39	535	504	515	700	512	563
Nov-12	136	109	123	70	56	63	28	20	24	42	36	39	526	500	515	737	538	606
Dec-12	134	109	124	68	59	63	28	20	24	40	32	37	520	496	507	700	556	649
Jan-13	142	112	127	70	60	65	28	20	24	43	36	40	536	493	510	667	524	605
Feb-13	134	108	124	66	58	63	24	20	22	43	38	40	537	493	507	600	512	548
Mar-13	143	114	127	70	58	63	28	20	23	42	38	40	509	484	495	667	526	574
Apr-13	164	118	138	72	65	68	34	24	29	42	37	39	551	415	497	895	571	746
May-13	153	121	140	76	66	70	36	22	30	44	40	42	545	496	507	857	500	709
Jun-13	156	108	135	74	56	67	32	26	27	42	30	40	519	474	498	867	619	697

Table-7 Minimum, maximum and average values of PM10 and PM2.5

Category	PM10	PM2.5
Minimum	60	35
Maximum	74.5	48
Average	68	42.4

Table-8 Air Quality Index for PM_{10} & $PM_{2.5}$ on different scales

AQ Parameters	Statistical Class	Scale 1-10	Scale 1-100	Scale 0-500	CPCB Scale based on EF	CPCB Scale based on SNLF
PM_{10}	Minimum	8	-	53	0.6	0
	Maximum	10	-	61	0.7	0
	Average	9	-	57	0.68	0
$PM_{2.5}$	Minimum	3	41	99	0.58	0
	Maximum	3	52	132	0.8	0
	Average	3	47	117	0.7	0

The scale of 0-100, AQ Index is generally assessed for PM $_{2.5}$ and it does not consider any significant change in Air Quality Health Index due to PM_{10}. The assessment on this scale reveals that the AQ Index of Sindri falls between 41 to 52 with an average value corresponding to AQ Index of 47. The average value corresponds to the health message as *People with some respiratory disease are at risk for outdoor activities.*

On US EPA scale 0-500 the AQ Index of Sindri has been estimated in the range of 53 to 61 with an average value equivalent to 47. The AQI of Sindri as per this standard falls in the moderate class of air quality with following health message *May have some impact on patients in case of chronic exposure and non for general public.*

AQI of Sindri with respect to $PM_{2.5}$ has been found in the range of 99 to 132 with an average index of 117. The evaluation with respect to PM2.5 as per US EPA scale of 0-500 falls in unhealthy category corresponding to health message as *May have harmful impact in case of chronic exposure.*

Index Categorization as Per CPCB

Exceedence factor (EF) calculated for Sindri with respect to PM_{10} falls in the range of 0.6-0.7 with average value of 0.68. The class as per standard practice is moderate. Similarly the value of EF for $PM_{2.5}$ falls in the range 0.58 to 0.8 with an average value of 0.7. The level of pollution may be considered as moderate.

Particulate Distribution Pattern & Seasonal Variation

The seasonal variation pattern with respect to SPM, PM_{10} and $PM_{2.5}$ has been presented graphically in Fig. 2. In Fig.2 from July 2012 to September 2012 represents monsoon period and data has been simply extraplotted. The presentation is not representative due to heavy precipitation of particulate matters. The concentration of particulate fraction has been found in the following order namely >SPM <PM_{10}<$PM_{2.5}$.

A photograph of $PM_{2.5}$ collected from fine dust sampler/dampler presents the predominancy of carbon particles as it appears black in colour. The photograph of $PM_{2.5}$ has been presented in Fig.3.

A high degree of consistency in PM has been recorded in Sindri township. A high degree of consistency for $PM_{2.5}$ has been recorded. The dominance of $PM_{2.5}$ may be attributed to the coal mines activities in this area and burning of coal for preparation of coke on random basis and due to the Coke Oven Plants in Sindri area. The coarse particles i.e., between $PM_{2.5}$to PM_{10} have been found less than the fine particles i.e., < $PM_{2.5}$. The average life time of coarser particles has been reported in literature equivalent to a few hours whereas the fine particles have average life time of 6 to 7 days (Encyclopedia of Process Technology).

The ratio of PM_{10} to SPM has been found in the range of 0.551 to 0.415 whereas the ratio of PM_{10}- $PM_{2.5}$/ $PM_{2.5}$ has been found in the range of 0.95 to 0.417.

Further, after closure of FCI random vegetations have grown up which contributes significant amount of Biogenic Aerosol which combines with their soot (carbon) and smoke generated from various local activities of coalfield area. The fine particles increases sharply after monsoon season due to release of some organic matters from plants and combine with NOx and SO_2 & forms smog. The spring smog in 2013 was a predominant phenomenon which was lasted over a week. This is one of the causes of consistency in the presence of fine particles in the area.

Conclusion

The particulate matter is one of the important criteria pollutants. The increased level of fine particulate matter in the environment is responsible for various epidemiological events which affect the health leading to various ill effect on human, animals & plants. It is one of the important causes of non-accidental death. The paper presents an assessment on the particulate matter comprising SPM having particle size less than 100 micron and averaging of 30 to 40 microns, PM_{10} and $PM_{2.5}$. The concentrations have been presented in µg/m^3 and 24-hrs mean value have been used for calculation of air quality index and associated health risks. The results of the concentration presented gravimetrically i.e., µg/m^3 have been assessed on four different methods of air quality characterization. The result of SPM has been found to vary between 99 to 174 µg/m^3. PM_{10} has been found to vary between 60 to 74.5 µg/m^3 and $PM_{2.5}$ found to vary between 35 to 48 µg/m^3. The paper is concerned only with $PM_{2.5}$ and $PM_{2.5}$ for calculation of Air Quality Index. On scale of 1-10, PM_{10} have been found in the range of 8 to 10 indicating a high degree of pollution. However, the AQ Index for $PM_{2.5}$ has been calculated equivalent to AQ Index 3. The air quality with respect to PM_{10} presents a high degree of pollution corresponding to high health risk whereas the AQ Index level with respect to $PM_{2.5}$ represents a good quality of air and an ideal environment for out-door activities. On scale of 0-100, $PM_{2.5}$ has been found in the range of 41 to 52 with an average value of 47 which corresponds to the health message as *People with some respiratory disease are at risk for outdoor activities.*

A major portion of elderly people of Sindri area have been found victim of diabetes. As per literature, the cause may be the presence and long time exposure of fine aerosols, beyond certain limit, in the ambient air of Sindri. The present assessment reveals that the Air Quality Index of Sindri area is 117, which corresponds to health message May have some harmful impact in case of chronic exposure.

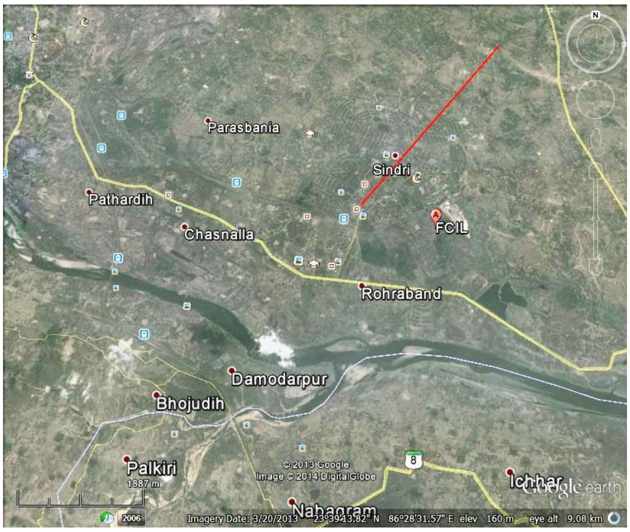

Fig.1 Location of Sampling Station

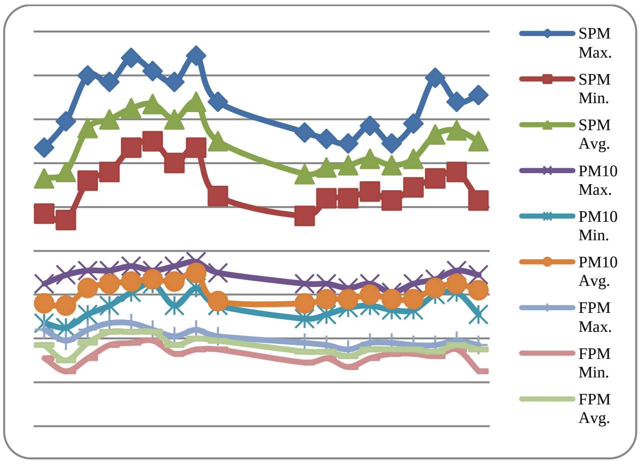

Fig.2 Seasonal Variation of Particulate Matters From Oct’11 to June’13

The air quality index on scale of 0-500 with respect to PM_{10} has been found to vary between 53 to 61 with an average value of 57. The air quality of Sindri is in moderate class with health message *May have some impact on patients in case of chronic exposure and non for* *general*. The AQ Index with respect to $PM_{2.5}$ has been found in the range of 99 to 132 with an average index value of 117 which corresponds to health message *May have some harmful impact in case of chronic exposure*. The quality characterization based on exceedence factor reveals that the air quality of Sindri area is in moderate category. The distribution pattern of particulate matter has been found in the following decreasing order >SPM<PM_{10}<$PM_{2.5}$. The ratio of PM_{10}/SPM has been found in the range of 0.551 to 0.415. PM2.5 has been found greater than PM_{10}-$PM_{2.5}$ i.e, coarse particulate matter. The observation of $PM_{2.5}$ filter papers appears black in colour indicating the maximum mass concentration due to elemental or organic carbon. The study reveals that FPM which is responsible for various epidemiological diseases is mainly due to the burning of coal in this area.

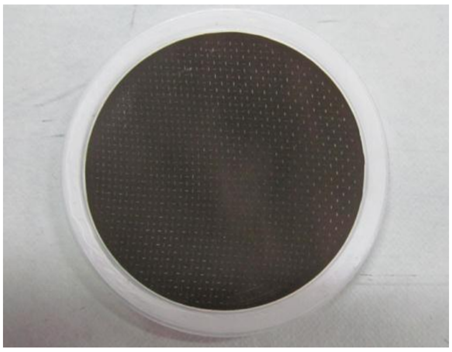

Fig.3 Photograph showing predominancy of elemental or organic carbon deposit on $PM_{2.5}$ Sampler/ Dampler

Acknowledgment

We are thankful to Md. Anwar Khan, Consultant, PDIL, Sindri for providing his sincere technical assistance for shaping the paper in presentable form.

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