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Determination of Respirable Suspended Particulate Matter, non Respirable Suspended Particulate Matter and total Suspended Particulate Matter in Piduguralla Industrial Area India

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Abstract

Respirable Suspended Particulate Matter (RSPM), Non Respirable Suspended Particulate Matter (NRSPM) AND Total Suspended Particulate Matter (TSPM) were estimated in Piduguralla industrial area with the help of PM10 sampler (Respirable Dust Sampler). The PM10 sampler shell dram the air sampler into sampler inlet through the filter at a uniform face velocity. Discharge exhaust air at a sufficient discharge from the sample inlet to minimize the sampling of exhaust air. After the estimation TSPM is 656.01 µg /m3 height in summer season and 422.45 µg /m3) Lowest in Monsoon. It is more than permissible limit as per EPA.

Keywords: Respirable suspended particulate matter, non respirable suspended particulate matter, total suspended particulate matter, air pollution, dust particle.

Introduction

Man is making use of great strides in science and technology to provide him with better creature comforts. In the process, he is tampering with the ecosystem which of course includes him-self. Despite the long history of environmental problems and interest in the environment, environmental health and toxicology are relatively new and have emerged because of the deterioration of the environment in a highly technological and affluent society. On one hand sophisticated new drugs, medical techniques and many modern equipment have made human life comfortable and has extended the life expectancy and made several items necessities which were once luxurious. On the other hand, greater life expectancy has resulted in an ever increasing famine and disease and greater technology that has lead to a multitude of toxic substances contaminating the environment and assailing the health of either working people or the people in the surrounding areas and in few instances the entire population. It is believed that approximately 80% of newly reported cases of cancer and cardiovascular diseases are environmentally induced[1-7]. The effect of pollutants on the health of human beings is a complex question. It depends on a) the pollutant in question b) the group of individuals involved c) the organ considered d) the concentration of pollutant and its time of exposure.

Different types of pollution which includes Air, Water, Noise, Soil. Particulate Matter (PM) is one of the pollutant present in all pollution and the most important in terms of adverse effects on human health. The Clean Air Act requires EPA to set National Ambient Air Quality Standards for six common air pollutants. They are particle pollution (often referred to as particulate matter), ground-level ozone, carbon monoxide, sulfur oxides, nitrogen oxides, and lead. These pollutants can harm human health and the environment.

In 1971, the United States Environmental Protection Agency (EPA) established the first PM National Ambient Air Quality Standard. The original PM standard was total suspended Particulate (TSP). This standard was replaced in 1987 with particulate matter less than 10 µm in aerodynamic diameter (PM10) and specified an annual average concentration of 50 µg/m3 and a 24-h maximum of 150µg/m3, based on the highest value over 3-year period. In 1997, after reviewing scientific studies, the EPA concluded that particles with aerodynamic diameter less than 2.5 µm (PM 2.5) had a greater association with mortality and morbidity rates than PM10. On these bases, the EPA established an annual PM2.5 standard level of 15µg/m^3 and a 24-h PM2.5 standard level of 65µg/m^3. Also, the EPA established the Pollutant Standard Index (PSI) as an air pollution alert system to communicate to the general public information about the health risks of PM and other pollutants. Particulate matter (PM) is the term used for a mixture of solid particles and liquid droplets suspended in the air. These particles originate from a variety of sources, such as power plants, industrial processes, and diesel trucks, and they are formed in the atmosphere by transformation of gaseous emissions. Their chemical and physical compositions depending of location, time of year, and weather. Particulate matter is composed of both coarse and fine particles. Coarse particles (PM10) have an aerodynamic diameter between 2.5 µm and 10 µm. They are formed by mechanical disruption (e.g. crushing, grinding, abrasion of surfaces); evaporation of sprays, and suspension of dust. PM10 is composed of aluminosilicate and other oxides of crustal elements, and major sources including fugitive dust from roads, industry, agriculture, construction and demolition, and fly ash from fossil fuel combustion. The lifetime of PM10 is from minutes to hours, and its travel distance varies from <1km to 10 km. Fine particles have an aerodynamic diameter less than 2.5 µm (PM2.5). They differ from PM10 in origin and chemistry. These particles are formed from gas and condensation of high-temperature vapors during combustion, and they are composed of various combinations of sulfate compounds, nitrate compounds, carbon compounds, ammonium, hydrogen ion, organic compounds, metals (Pb, Cd, V, Ni, Cu, Zn, Mn, and Fe), and particle bound water. The major sources of PM2.5 are fossil fuel combustion, vegetation burning, and the smelting and processing of metals. Their lifetime is from days to weeks and travel distance ranges from 100s to >1000s km. In addition, fine particles are associated with decreased visibility (haze) impairment in many cities of the U.S.

The PSI does not describe specific health effects and cautionary statements for these PM10 concentrations. However, numerous studies have demonstrated an association between PM10 exposure at10µg/m³ and increased daily mortality for cardio respiratory diseases. The risk is higher in individuals over 65 years old of age[8-10]. Another study conducted in the U.S. demonstrated that for each 10 µg/m³ rise in PM10 post neonatal general mortality, sudden infant death syndrome and post neonatal respiratory mortality increased 4%, 12%, and 20% respectively[11]. Other studies observed a relationship between PM10 exposure at 20 µm/m³ and changes in PEFR in children with chronic symptoms or asthmatics[12,13]; between PM10 levels of 30 µg/m³ and increased total mortality (4.6%), decreased peak expiratory flow (PEF) and increased symptoms and medication use in asthmatic children[14]; and between PM10 levels of 40 µg/³ an increased cardiovascular mortality in individuals under 65 years old and mortality by Sudden Infant Death Syndrome . In addition, several epidemiological studies observed with PM10 levels of 50 µg/m³ an increase in respiratory diseases such as pneumonia, chronic obstructive pulmonary disease (COPD), and asthma. Also, a reduction in pulmonary function, an increase in hospital admission, and increased cardio respiratory mortality were found at these PM10 concentrations.

Material and Methods

NAAQS: 55 TO 154 µG/M³ 24-H Air Quality Category: Moderate: In the EPA PSI no health effects are described in this range. However, in a study conducted in Coachella Valley, California, at PM10 levels of 57 µg/m³, deaths due to cardiovascular and respiratory diseases increased in individuals older than 50. Another study conducted in Coachella associated PM10 levels of 87 µg/m³ with an increase in hospital admissions of children with respiratory disease[15]. Health effects are aggravated with concentrations approaching 100 µg/m³. Schwartz et al quoted that 100 µg/m³.

PM10 concentrations increased the relative risk (1.07, 95% CI: 1.02, 1.12) for ischemic heart disease admissions[16]. Other studies have shown a relationship between 100µg/m³ PM10 and hospital admissions for respiratory diseases including pneumonia, COPD and asthma in all ages. Children report cough, wheeze and asthma medication use. Also, smokers with mild to moderate COPD demonstrated a decline in FEV1 and PEF[17-19]. PM10 exposure to 100 µg/m³ is also associated with a 16% increase in deaths per day, primarily respiratory death and cardiovascular death. In a study conducted in Utah Valley, elevated PM10 levels (150µg/m³) were associated with a statistically significant reduction in lung function measured by reduction in peak expiratory flow (PEF) and increased symptoms of respiratory disease[20-22]. In addition, another study found PM10 association with a 26% increase in upper respiratory symptoms; a 50% increase in lower respiratory symptoms and 217% increase in the use of asthma medication and bronchodilator.

NAAQS: 155 TO 254 µg/m³ 24-H Air Quality Category: Unhealthy For Sensitive Group: In this range, in a study conducted in Mexico demonstrated a relationship between PM10 exposure to 166 µg/m³ and cough and difficulty breathing in children. In another study, Pope et al found an association between 195µg/m³ PM10, reduction in EF, and an increase in symptoms of respiratory disease and asthma medication use.

NAAQS: 255 TO 354 µg/m³ 24-H Air Quality Category: Unhealthy

NAAQS: 355 TO 424 µg/m³ 24-H Air Quality Category: Very Unhealthy

NAAQS Ranges and Health Effects: NAAQS: 0.0 TO 15.4 µg/m³ 24-H Air Quality Category: good

According to the NAAQS, at PM2.5 levels from 0.0 to 15.4 no health effects are expected. However the Six U.S. Cities study found a relationship between exposure to PM2.5 at 11 µg/m³ and daily mortality. A study conducted in Canada indicated that an increase of 10 µg/m³ in PM2.5 was associated with an 3.3% increase in respiratory and cardiac hospital admission[23].

NAAQS: 15.5 TO 65.4 µg/m³ 24-H Air Quality Category: Moderate

In contrast with PM10, in this range the PSI includes a PM2.5 health effect cautionary statement where it mentions the possibility of aggravation of heart or lung disease among persons with cardiopulmonary disease and the elderly. A few epidemiological studies found that PM2.5 exposure from 18 µg/m³ to 30 µg/m³ increased daily mortality due to cardio-respiratory mortality in the elderly and persons with cardiovascular and respiratory disease. [24, 25 and 26]. In addition, other studies demonstrated a relationship between 45 µg/m³ and increased hospital admission and chronic bronchitis.

NAAQS: 65.5 TO 100.4 µg/m³ 24-h air quality category: Unhealth for sensitive group moderate

NAAQS: 100.5 TO 150.4 µg/m³ 24-h Air Quality Category: Unhealthy

NAAQS: 150 TO 250.4 µg/m³ 24-h Air Quality Category: Very Unhealthy

NAAQS: 250.5 TO 500.4 µg/m³ 24-h Air Quality Category: Hazardous

Study Area: Geography and Physiography: Piduguralla is a town in Guntur District in Andhra Pradesh state. It is famous for white Cement and Lime Lime Stone Industries, Cotton and Mirchi farming fields. Natural limestone is found in abundance and is the source of the town's nickname 'Lime city' or 'Mini USA'. Piduguralla is located in the part of "PALNADU" around 70 km from Guntur and 240 km from Hyderabad. It is Located on the Hyderabad - Chennai National Highway. The mandal is rich with minerals and also surrounding villages are very green with paddy fields. Most of the people depend on agriculture with fertile lands having abundant water from the Nagarjunasagar canals. Piduguralla is well connected by buses from Guntur, Vijayawada, Miryalguda, Tirupathi, Karimnagar, Suryapet, Kodad, Warangal, Hyderabad, Narasaraopet and Macherla. It has a well established bus depot that connects villages around the town.

Physical Environment of the Climate: The climate is characterized by a summer and is generally dry expect during the monsoon. There are four seasons - summer (from March to May), monsoon season (from June to September), Post monsoon season (October and November) & winter (from December to February).

The annual temperature in the project region ranges between 20^0C - 44^0C. May is the hottest month with a mean max of 44^0C. Winds are light to moderate with some strengthening in the period from May to August. The general dominant flow pattern is westerly during monsoon while the flow pattern is easterly in the post-monsoon and winter seasons.

Temperature: The annual temperature in the study area ranges between 20^0C - 44^0C. May is the hottest month with an average maximum temperature of 44^0C. With the advance of south west monsoon into the area, by the middle of June, day temperature drop is observed. By about the first week of October the monsoon, the temperature drops to about 18^0C. The monthly temperature range is smallest in August because of overcast conditions and largest in March on the contrary.

Wind: Winds are light to moderate with some strengthening in the period from May to August. During the post-monsoon and cold season, winds blow mostly from the east or north-east. By March, south westerlies and westerlies start blowing and continue during the rest of summer. The sought west monsoon season winds are mostly from directions between south-west and North West. The general dominant flow pattern is westerly during monsoon while the flow pattern is easterly in the post-monsoon and winter seasons.

Rainfall: The actual annual rainfall in the study area varies from the months of June and September receiving the most. The bulk of the annual rainfall is received during the southwest monsoon.

Evaporation of Water: A steep increase in evaporation is observed from January through May followed by an equally steep fall during the first half of the southwest monsoon season. During the rest of the year, the monthly variation is minimal

Experimental methods for Air Quality Instruments: Respirable Dust Sampler: Respirable dust sampler (RDS) , manufactured by Envirotech Pvt Ltd., (India) model No. APM411TE was used for the sampling of respirable particulate matter (RSPM).The basic components; of this instrument are programmable timer, time totaliser, voltage stabilizer, impinger assembly, etc. Using this instrument, which is equipped with a cyclone separator, particulate matter of respirable size (0.1µm to 10µm) can be collected. Ambient air with suspended particulate matter enters the system through the inlet pipe. As the air passes through the cyclone separator, coarse and respirable particulate matter is separated from the air stream by centrifugal forces acting on the solid particles. The separated coarse particulate matter falls through the cyclone's conical hopper and is collected in the sampling cone placed under the hopper. The fine dust (RSPM) forming the respirable fraction of the total dust (TSPM) [27] passes through the cyclone and is carried by the air stream to the filter paper (Whatmann GF/A 20.3 x 25.4 cm filter papers were used) clipped between the air tight top cover and filter adopter assembly. The Respirable dust sampler (RDS), APM411TE uses a modern blower which does not require carbon brushes. Air sampling has been taken up continuous by for 24 hours. As this instrument generates only 65 – 75 decibels (dB) it can be used without any problem during nights also.

Procedure for Analyzing Various Parameters: Respirable Suspended Particulate Matter (RSPM): Particulate matter was collected on Whatman glass fiber filter paper (GF/A) of 20.3" x 25.4" size. The filter papers were dried by desiccation for 48 hours before use. The dried filter papers were weighed accurately and fixed on the filter holder of the respirable dust sampler such that the blistered surface was up sided. The initial air flow rate was noted. Since the actual flow through the filter paper would be reduced with time because of deposition of dust, the flow rate was noted after the completion of the sample collection. The filter paper was then removed from the air sampler RDS unit carefully and again desiccated for 48 hours and weighed accurately. The concentration of particulate matter (µg/m^3) was calculated from the difference in the weights of filter paper before and after sampling.

Non Respirable Suspended Particulate Matter (NRSPM): Coarse dust was collected in a cone which was weighed before and after sampling. After sampling, the dust box is thoroughly cleaned to remove the total dust in the cone. The difference in weight is divided by the volume of the air sampled and is expressed in µg/m^3 of non respirable suspended particulate matter.

Total Suspended Particulate Matter (TSPM): The total suspended particulate matter (TSPM) is the total of RSPM + NRSPM coarse dust in the cone for the same period. Finally both RSPM and NRSPM are represented as µg/m^3.

Results and Discussion

The air samples collected from the lime kilns at about 2 kms from Piduguralla town during different seasons were analyzed for their RSPM, NRSPM and TSPM as described in the experimental section in table-1 , table-2 and figure-1, figure-2, figure-3.

Table-1
Air samples collected data in different seasons

Season	RSPM (µg /m3)	NRSPMa	TSPM (µg /m3)
Monsoon	150.46	271.99	422.45
Post Monsoon	218.72	317.14	535.26
Winter	175.66	274.48	450.14
Summer	313.28	342.78	656.01

The results indicate that the Total Suspended Particulate Matter of the air at the lime kiln industry are exceeding the Central Pollution Control Board limits. Especially in the summer the Total Suspended Particulate Matter is getting higher than the rest of the all seasons. And in the monsoon the TSPM Concentration is getting lower and compared to the rest of the all seasons. Even in monsoon season, the particulate matter is more than the Central Pollution Control Board limits.

In Piduguralla, most of the lime kilns do not have the required stake height as prescribed by the Central Pollution Control Board. The raw materials and finished products are in generally being transported to and from the kiln site in open containers which are being carried into the air very easily. During the crushing of the raw materials, which is carried out in open air, also huge volume dust is being released into the air. The kiln management is not maintaining proper storage area for lime stone and coal. The huge particulate matter in air is damaging every sphere of life. Most of the residences of this area are suffering from some worst and life threatening diseases like silicosis, bronchitis, asthma and from many lung diseases.

Table-2
The conditions for the production of lime per the CPCB

Output	Height	Condition
Upto 5 Tons/Day	Stack Height	A Hood should be provided with a stack of 30Mts Height from the Ground Level (Including Kiln Height).
Above 5 Tons/Day	Stack Height	$H = 14(Q)^{0.3.}$ Where Q is the Emission rate of SO_2 in Kg/Hr, and H = Stack Height in Mts.
More than 5 Tons/Day and Upto 40 Tons/Day	Particulate Matter	150 µg/m^3
Above 40 Tons/Day	Particulate Matter	500 µg/m^3

Figure-1
Gurava Reddy Quarry

Figure-2
Lime Kilns in Piduguralla, India

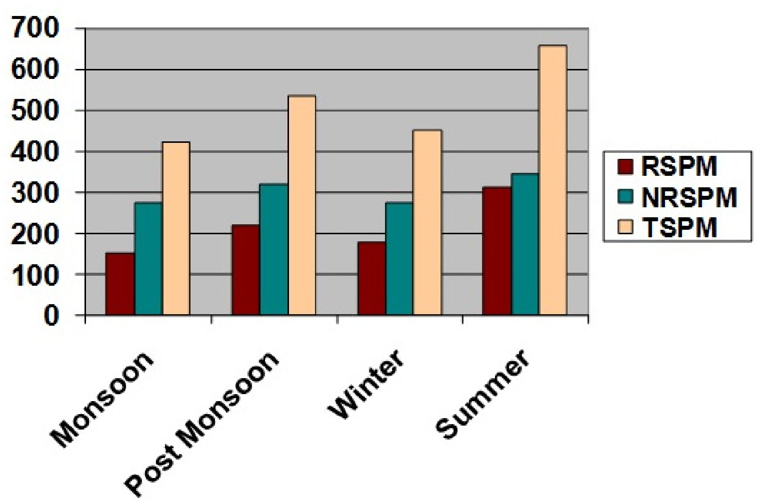

Figure-3
Seasonal variation (abscissa) of Concentration of Particulate matter in µg/m^3(Ordinate)

The mothers of infant children are suffering from different types of psychosis or psychosomatic diseases due to air pollution. People are becoming petulant and impatient. Thus sociological complications are being developed among the local people.

The PCB, after conducting inspections in March 2010, submitted the Ambient Air Quality Monitoring (AAQM) report to the Senior Environmental Engineer (Task Force), APPCB, which stated that the Suspended Particle Matter (SPM) levels at two places in the cluster was 616 microgram/m3 and 785.7 micrograms/m3, which were far above than the permissible SPM level of 200 microgram/m3

Conclusion

The Particulate Matter is evolved while in the Calcinating

Process. If the Calcinating Process is carried out in Shaft furnaces, rotary Kilns, then the particulate matter emission can be reduced, the production of lime can be increased, the consumption of coal for burning process also can be reduced.

Substitution of raw material or fuel has been used successfully in many cases for controlling atmospheric pollution. If the lime manufacturers use of low-volatile coals in place of high-volatile coals has proved quite effective in eliminating smoke and soot in lime industrial and commercial heating applications. Similarly, substitution of low-sulphur fuels has reduced considerable the sulphur dioxide discharge into the atmosphere. Another method of decreasing emission of air pollutants is substituting bauxite flux for fluorspar in an open hearth furnace.

Transportation and Storage: Materials handling techniques and automation have reduced air pollution from these operations. Loading and unloading, conveyor belt discharge and transfer, and stock filing operations can produce particulate matter emissions. Lack of attention to wind erosion of stock piles has often created an 'air pollution control paradox'. Gaseous emissions can be produced by evaporation of materials from storage piles. If we carry the lime stone and coal in closed containers while transport, we can prevent the falling of fine Particles on the Road. After Completion of the Calcinating process, if we maintain some closed storage area for Hydrated Lime, Un-Burnt Lime Stone, Clinkers, fine compound, then we can reduce some Particulate Matter.

Size reduction operations are commonly classified as either crushing or grinding according to the size range of feeds and the size reduction ratio achieved. Various types of crushes and grinders are usually operated in series to obtain desired size reduction. Dust is discharged from crusher and grinder inlet and outlet ports. For most effective dust control, crushers and grinders should be enclosed and provided with exhaust ventilation, discharging to a suitable collector. Although generally not as effective as local exhaust ventilation, wet sprays can be used in controlling dust emissions from crushing, grinding and other mineral production operations.

Scrubbers or wet collectors are devices which utilize a liquid to assist in the removal of particulates from the carrier gas stream. Generally, water is used as the scrubbing liquid. In a wet collector, the dust is agglomerated with water and then separated from the gas together with the water. Nature has used wet scrubbing as a method of cleaning the atmosphere since the world began. Every rainstorm scrubs the air producing that fresh air sensation we all experience. In industrial applications, it is necessary to force the stack gases to be cleaned by contact with the liquid which is going to do the scrubbing. This requires a lot of energy. As such, scrubbers are basically, 'cheap' to install but 'expensive' to operate. The operational range for particle removal by scrubbers includes material less than 0.2 μ in diameter to large particles which can be suspended in the gas phase. Four major steps are involved in collecting particles by wet scrubbing. The first of these is transport. The particles must be moved to the vicinity of the water droplets which are usually 10 to 1000 times larger. The second step is collision. The particle must collide with the droplet. The third step is adhesion. Adherence is promoted directly by the property surface tension. The fourth step is precipitation, or removal of the droplet containing the dust particle from the gas phase. In addition to removing entrained particulate matter, scrubbers can remove gases by absorption and or adsorption. This capability of scrubbers is not possessed by other types of particulate control equipment. If planned plantation of trees and scrubs surrounding the Lime Kilns, then may be some of particulate matter will be reduced. Water should be sprayed at regular intervals to prevent the Dust generation on the Roads

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