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Air Quality Effects of Pollutant Gases from Brick Kilns near Chennai

John Presin Kumar A, Ravikumar Solomon G, Sivakumar S, Balaji R, Mukesh Nadarajan, Ashish Selokar

Abstract: Brick kiln industries are commonly found in most of the regions in our country. Many private sectors consider this type of industry more as a business rather than giving importance to hygiene and health aspects. This work has focused on the air pollutants emitted from brick kiln industries near Chennai and its environmental effects. Majority of pollutants emitted were found to be oxides of nitrogen (NO_x), carbon dioxide (CO_2) and oxides of sulphur (SO_x). Generally all these gases have adverse bad effects on the well health of human community. Workers in brick kiln industries are directly inhaling toxic pollutant gases and suffer with various health complexities. Sampling sites were chosen based on last five years historical data. Experimental survey was done in the chosen sampling sites to observe the severity of pollution around the place. Time bound study and observation was conducted to know the pollution effects in various months ranging from October 2018 to February 2019. Air Quality Index (AQI) was calculated and remedial measures were suggested.

Index Terms: Brick Kilns, Emission, Air pollutants, Oxides of Sulphur, Oxides of Nitrogen

I INTRODUCTION

Brick production is commonly found in many parts of South Asia for its very necessity. India is the second highest brick producer after China in the world. India has larger sector for this Brick related works. Considering the case of small scale industries, the brick kiln industry is a developing industry because of increase in demand of bricks. The main raw materials used in brick production are materials which are rich in fine particles like clay or river sediments. Burning of coal produces high level of oxides of sulphur, oxides of nitrogen and carbon.

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* Correspondence Author
John Presin Kumar A, Department of Mechanical Engineering, Hindustan Institute of Technology and Science, Chennai, India
Ravikumar Solomon G, Department of Mechanical Engineering, Hindustan Institute of Technology and Science, Chennai, India
Sivakumar S, Department of Mechanical Engineering, Hindustan Institute of Technology and Science, Chennai, India
Balaji R, Department of Mechanical Engineering, Hindustan Institute of Technology and Science, Chennai, India
Mukesh Nadarajan, Department of Mechanical Engineering, Hindustan Institute of Technology and Science, Chennai, India
Ashish Selokar, Accendere, CL Educate India Ltd., New Delhi, India

Around 4.5 million metric tonnes of coal are produced each year in India in which fire clay bricks are produced in around 42000 small scale brick kilns which operate normally that is without using electricity. This means that around 100 million tons of coal is utilized without counting the electricity used for producing 1,000 billion bricks per annum [1]. It is thus an established fact that these small scale industries are one of the major contributors to atmospheric pollution in environment.

In this work, the Brick Kilns operated near Chennai, Tamilnadu, India was chosen as the place of study where lots of industries especially many small scale industries are available. Everyday these industries reject lot of pollutant gases affecting the society surrounding causing pollution. For this study, the most affected areas were selected by means of analyzing last 5 years historical data pertaining to the locality. Three different zones were chosen for sampling study as industrial area, residential area and hospital areas. Time bound observation was made by surveying for the last five months starting from October 2018 to February 2019. Air Quality Index (AQI) was calculated for all these months and analyzed.

Fig 1. Steps involved in a brick kiln process

Bricks fabricating as depicted in figure 1 is the quickest developing mechanical division and among the best three areas, alongside vehicle exhaust and resuspended street dust, adding to the air contamination and health issues in Chennai. The bricks fabricating approximately 1,000 block furnaces spread crosswise over bigger zone are restricted to the winter season from October to March as trending developments and flow advances do not permit creation amid the monsoon [2].

The complete discharges are assessed at 15,500 t of sulphur dioxide (SO_x) and 302,000 t of oxides of nitrogen (NO_x). 1.8 million tons of SO_x outflows from these bunches, to create 3.5 billion bricks for each year, utilizing vitality in effective fixed stack bull channel furnace innovation and dominatingly utilizing coal and rural waste as fuel. The related wellbeing impacts to a great extent fall on the thickly populated area using the Atmospheric Transport Modelling Framework scattering model, the effect of block furnace discharges was evaluated over Chennai.

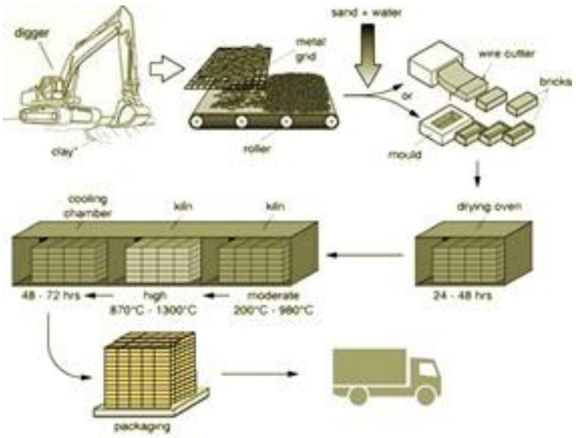

Fig 2. Sequence of processes in brick industries

Figure 2 above shows the sequences involved from raw material processing to finished bricks transport. A presentation of rising vertical shaft ignition innovation can give quicker advantages to open wellbeing and lessen atmosphere forerunner outflows by choosing the most persuasive bunches investigated in this paper. Bricks ovens are essentially connected with NO_x, SO_x, unpredictable natural mixes, nitrogen oxides, and overwhelming metals relying upon the kind of fuel consumed. In this contemplate, a mix of nearby studies also, late estimation battles are used to evaluate action based burning outflows. It is the primary arrangement of estimations in South Asia to measure the outflow factors for block ovens in the Indo-Gangetic fields [3]. While these variables can't be deciphered and utilized straightforwardly for the block furnaces in Dhaka, due to varieties in the fuel blend among India and Bangladesh, they do give a standard to examination given the innovations being used are comparable between the areas Brick ovens are believed to be a noteworthy wellspring of provincial and urban air contamination all through South Asia.

Barely any examinations have thoroughly dissected this issue and less have estimated the emanations factors as well as demonstrated their commitment to the surrounding particulate contamination levels in and around the urban areas in South Asia [4]. This examination marks one of the first to do as such in both mapping the oven bunches and demonstrating the particulate contamination The potential for joined advantages for wellbeing and atmosphere, by controlling the atmosphere antecedents like NO_x, CO_2 and SO_x is an rising science. Since anthropogenic environmental change is to a great extent driven by non-renewable energy source ignition, investigation of emanations likewise gives understanding into atmosphere compelling and connected relief methodologies With appropriate preparing and limit building to direct such examinations, in-nation usage of these procedures can make a profitable commitment to urban air quality administration and to the atmosphere arrangement network, given the potential for controlling the brief atmosphere forcers from sources like the block furnaces [5].

Fig 3. Brick kiln chimney emitting pollutant gases

Figure 3 above shows most of the disposal scenarios of pollutant gases from chimneys showcased in many places of brick kilns. All these pollutant gases especially oxides of sulphur and oxides of nitrogen has very detrimental effect on human health and also the environment. A common disposal policy is very much suggestible under these circumstances. Figure 4 below shows mainly the residential areas and hospital zone where people's living was mainly disturbed by the pollution caused by the pollutant gases from brick kiln chimneys. The importance of a time bound survey for pollution study is very well understandable from this.

Fig 4. Residential areas (Top two) and Hospital zone (Bottom two) in the locality

II MATERIALS AND METHODOLOGY

A Locality of study

A total area of 4000 square feet was being affected in this locality. Pollution effect had been happening since the last ten years. The sampling sites were selected based on the importance and severity of pollution control needed zones by analyzing the historical data as mentioned before and by survey. The sampling sites include Industrial estate where small scale Brick Kilns are available and in operating condition. There are residential areas where lots of apartments and state government built housing units were available.

People in these places live in families going to offices on daily basis either in their own vehicles or by government buses. There are also government hospitals, where patients were the majority. Whatever be the location, everywhere there were people who were of the main concern and importance regarding pollution and all the safety measures and surveys were conducted for the people's safety and wellbeing. In this work, these three areas were chosen as the sampling sites and air pollution survey was done for five months starting from october 2018 to february 2019 using the pollution monitoring device called High Volume Air Sampler [6].

Fig 5. Brick Kiln Industries

Figure 5 above shows the brick kiln industries available serially along the roadside of the chosen locality. In this locality, only less importance was given to better control of exhaust gases from chimney. The exhaust gas production and its disposal were completely dependent on the particular industry's own methodologies with less number of proper guidelines [7].

B Sampling site selection

Six locations were initially considered in the locality near brick kilns for analysis based on historical data for the last 5 years with regard to National Ambient Air Quality Standards (NAAQS) [8]. Table-I shown below depicts the details of Air Quality Index (AQI) data for the six locations indicating which were all crossing the AQI limits prescribed by the above mentioned standards.

Table-I. Historical data analysis

	2018						2017						2016						2015						2014					
Locations	L 1	L 2	L 3	L 4	L 5	L 6	L 1	L 2	L 3	L 4	L 5	L 6	L 1	L 2	L 3	L 4	L 5	L 6	L 1	L 2	L 3	L 4	L 5	L 6	L 1	L 2	L 3	L 4	L 5	L 6
Average AQI value limit Crossed (C) or Not Crossed (NC)	NC	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC	NC	NC	C	NC	C	NC	C	NC	NC	NC	C	NC	C	NC	C	NC	C

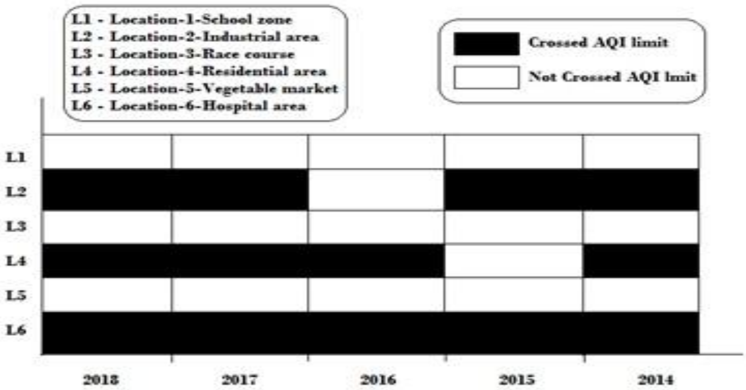

Fig 6. Plot for AQI limit checking based on historical data

Figure 6 as shown above clearly depicts the nature of AQI limits for the six locations near brick kiln, whether or not the NAAQS limits were crossed or not. It was observed that the locations L2, L4 and L6 were crossing the limits for most of the years. Based on this data, the three locations pertaining to L2, L3 and L4 referring respectively to industrial area, residential area and hospital area were selected as sampling sites for this experimental survey.

C High Volume Air Sampler

The air pollution monitoring equipment used in this survey in the chosen sampling sites of Industrial estate, Residential areas and School zones was high volume air sampler as shown in figure 7 below [9]. It is an electronic powered device with 0.9 to 1.7 cubic meter per minute airflow with a product dimension of 400 x 400 x 680 gabel roof of weight 25 Kg single phase model with a frequency of 50 Hz 230 VAC.

Fig 7. Survey in different sampling sites

D Consequences of inhaling Pollutant gases from Brick Industries

In present years, gases that pollute the environment are gradually increasing in amount and thereby affecting the environment. In this scenario, the impact of oxides of nitrogen (NO_x), carbon dioxide (CO_2) and oxides of sulphur (SO_x) emission especially from horticultural field, residential people and animals are high. Nitrogen dioxide poisoning is an illness caused from the toxic effect of nitrogen dioxide (NO_2) [10]. It occurs by the inhalation of the gas beyond a threshold limitation. Nitrogen dioxide is reddish-brown in color with very bad smell at high concentrations. It is colorless and also odorless at lower concentration but still remains harmful. Nitrogen dioxide poisoning always depends on the duration of its exposure, frequency, and intensity of exposure [11]. Nitrogen dioxide is an irritant of the another membrane linked with an air pollutant that usually causes pulmonary diseases such as asthma, chronic obstructive pulmonary disease and sometimes in fatal cases resulting in deaths. Its poor solubility nature in water enhances its easy passage and capability to pass through the moist oral portion of the respiratory tract. Like most of the toxic gases, the dose of this gas inhaled determines the toxicity on the respiratory tract area. Occupational exposures always constitute the highest risk of toxicity and domestic exposure is very uncommon.

Sulphur dioxide looks colourless gas usually with a pungent smell and generally comes from the burning of coal and oil [12]. In the air, it can be readilyconverted into sulphuric acid, sulphur trioxide, and sulphates. Exposure to very high values of sulphur dioxide can be a life threatening risk. An exposure to 100 parts of sulphur dioxide per million parts of air that is 100 ppm is considered immediately dangerous to human life and health. This causes burning of the nose and throat, breathing difficulties. Severe airway obstructions had occurred in miner people who breathed sulphur dioxide which was released as a result of an explosion in a copper mine. Long-term exposure to consistent levels of sulphur dioxide can affect the human health. Lung function irregulaities may be noticed in industrial workers exposed to low levels of sulphur dioxide for almost 20 years or more. Asthmatics have also been identified to be sensitive to the respiratory effects of even low concentrations of sulphur dioxide. Studies on animals also have shown respiratory related effects from breathing sulphur dioxide. Animals exposed to high concentrations of sulphur dioxide have shown decreased respiration, inflammation of the airways in lungs, and destruction in the areas of the lung.

E Air quality categories

Air Quality Index (AQI) is defined as the measure of ratio of the pollutant concentration in ambient air to the national standards of the pollutants [13]. National Air Quality Monitoring Program has begun just in 1984 in India. Utilizing AQI for pollution monitoring results in better results. This is an observed fact from the pollution monitoring history in our country. Despite the fact that in Nagpur, monitoring work begun observing system in 10 urban areas in 1978 and Bombay Municipal Corporation even previously in the same year, steps were not made to utilize AQI for information understanding and open telecom. Several committees inspected accessible AQIs and thought about Air Quality status of the city of Mumbai with its rural areas. In spite of the fact that plenty of specialized papers proposing explicit records showed up in global writing, no confirmative investigation was attempted to utilize an index in India. An ongoing report to characterize Air Quality Index in India has been taken up by private initiatives which incorporates air quality anticipating and named the framework as System of Air Quality-Weather Forecasting and Research [14]. This investigation considered interlinking examination of long haul air quality information of various poisons and wellbeing information for two urban areas, like Chennai and Delhi. The weakness of this investigation was that it accounted only the well-being information just for two urban areas only though for a perfect AQI agent of a nation, it is needed to account the well-being information for whatever number urban communities and towns possible.

Table-II. Category of air quality

Type	AQI
Clean air	0-50
Satisfactory	51-100
Moderate pollution	101-250
Poor	251-300
Very poor	301-400
Severe	401-500

Table-II above shows different types of air quality such as clean air, Satisfactory, Moderate pollution, Poor, Very poor and Severe based on their respective range of API as 0-50, 51-100 and 101-250, 251-300, 301-400 and 401-500 [15].

AQI was calculated for this sampling study based on the average value of polluting gas in $\mu g/m^3$ [15] for the three selected sampling sites like industrial estate, residential area and school zone. This is shown in equation (1) below.

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$$AQI = \frac{\text{Polluting gas quantity in } \mu g/m^3 \text{ for (Industrial estate + Residential area + Hospital area)}}{3} \quad \text{—— (1)}$$

III RESULTS AND DISCUSSIONS

Brick kiln industries were the main cause of pollution in the chosen area of sampling study. The levels of NO_x, CO_2 and SO_x were of main concern in this place. These pollution levels were not only a hazard to human welfare and health but also could adversely affect the environment surrounding.

High volume air sampler was used to get the pollutant measurement readings of how much quantity in micro grams per unit cubic meter of a particular pollutant was available in the air during various periods of five consecutive months starting from October 2018 to February 2019 as shown in table-III below.

Table-III. Observed values of pollutants

Polluting gas	Sampling area	Oct 2018 ($\mu g/m^3$)	Nov 2018 ($\mu g/m^3$)	Dec 2018 ($\mu g/m^3$)	Jan 2019 ($\mu g/m^3$)	Feb 2019 ($\mu g/m^3$)
NO_x	Industrial estate	310	300	320	280	290
	Residential area	290	280	280	260	260
	Hospital zone	250	260	270	240	250
CO_2	Industrial estate	320	310	320	300	290
	Residential area	290	280	290	260	260
	Hospital zone	250	260	270	240	270
SO_x	Industrial estate	340	330	320	300	310
	Residential area	310	300	290	260	260
	Hospital zone	250	260	300	270	270

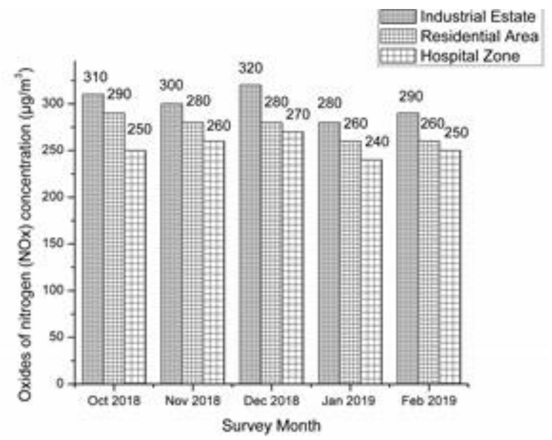

Fig 8. Pollution effect of NO_x gas

Pollution effect of oxides of nitrogen NO_x is illustrated in the figure 8 above for the five months of sampling study. During october 2018 the values of 310 $\mu g/m^3$, 290 $\mu g/m^3$ and 250 $\mu g/m^3$ were observed for the regions of industrial estate, residential area and hospital zone respectively. For november 2018, the values of 300 $\mu g/m^3$, 280 $\mu g/m^3$ and 260 $\mu g/m^3$ were observed for the regions of industrial estate, residential area and hopital zone respectively. For december 2018, the values observed were 320 $\mu g/m^3$, 280 $\mu g/m^3$ and 270 $\mu g/m^3$ respectively for these different regions. Similarly for the month of january 2019, the values came as 280 $\mu g/m^3$, 260 $\mu g/m^3$ and 240 $\mu g/m^3$ respectively. Finally for the month of february 2019, the values of 290 $\mu g/m^3$, 260 $\mu g/m^3$ and 250 $\mu g/m^3$ were observed respectively. A comparative decrease in pollution was observed for the last two months than the first three months.

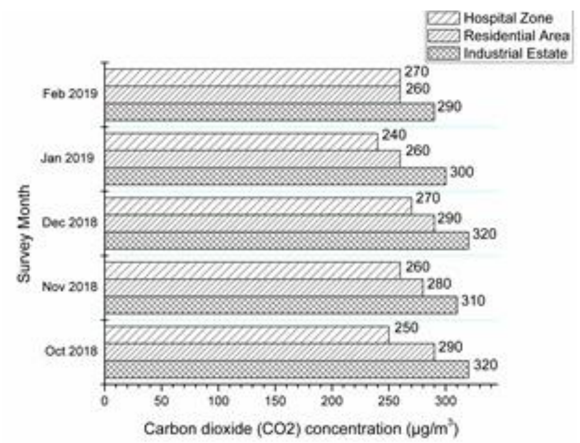

Fig 9. Pollution effect of CO_2 gas

Pollution effect of oxides of nitrogen CO_2 is illustrated in the figure 9 above for the five months of sampling study. During october 2018 the values of 320 $\mu g/m^3$, 290 $\mu g/m^3$ and 250 $\mu g/m^3$ were observed for the regions of industrial estate, residential area and hospital zone respectively. For november 2018, the values of 310 $\mu g/m^3$, 280 $\mu g/m^3$ and 260 $\mu g/m^3$ were observed for the regions of industrial estate, residential area and hospital zone respectively. For december 2018, the values observed were 320 $\mu g/m^3$, 290 $\mu g/m^3$ and 270 $\mu g/m^3$ respectively for these different regions. Similarly for the month of january 2019, the values came as 300 $\mu g/m^3$, 260 $\mu g/m^3$ and 240 $\mu g/m^3$ respectively.

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Finally for the month of february 2019, the values of 290 μg/m^3, 260 μg/m^3 and 270 μg/m^3 were observed respectively.

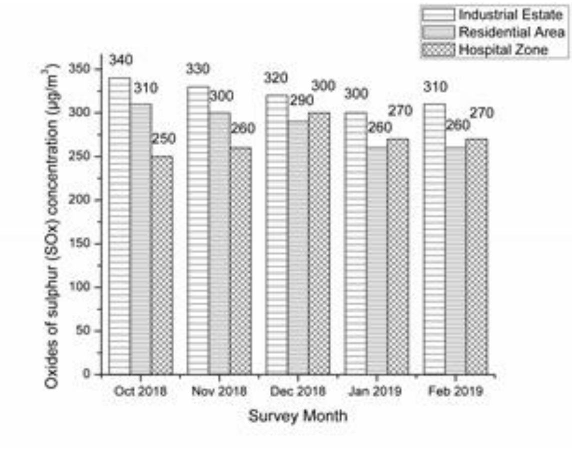

Fig 10. Pollution effect of SO_x gas

A comparative decrease in pollution was observed for the last two months than the first three months.

Pollution effect of oxides of nitrogen SO_x is illustrated in the figure 10 above for the five months of sampling study. During october 2018 the values of 340 μg/m^3, 310 μg/m^3 and 250 μg/m^3 were observed for the regions of industrial estate, residential area and hospital zone respectively. For november 2018, the values of 330 μg/m^3, 300 μg/m^3 and 260 μg/m^3 were observed for the regions of industrial estate, residential area and hopital zone respectively. For december 2018, the values observed were 320 μg/m^3, 290 μg/m^3 and 300 μg/m^3 respectively for these different regions. Similarly for the month of january 2019, the values came as 300 μg/m^3, 260 μg/m^3 and 270 μg/m^3 respectively. Finally for the month of february 2019, the values of 310 μg/m^3, 260 μg/m^3 and 270 μg/m^3 were observed respectively. A comparative decrease in pollution was observed for the last two months than the first three months.

Table-IV. Calculated AQI values

Pollutant	Oct 2018 (μg/m^3)	Nov 2018 (μg/m^3)	Dec 2018 (μg/m^3)	Jan 2019 (μg/m^3)	Feb 2019 (μg/m^3)
NO_x	283.33	280	290	260	266.66
CO_2	286.66	283.33	293.33	266.66	273.33
SO_x	300	296.66	303.33	276.66	280

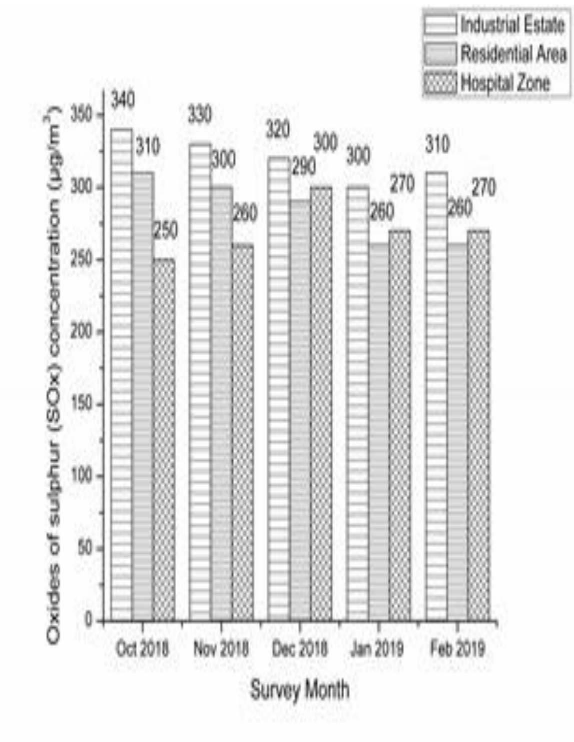

Fig 11. AQI values for the surveyed months

As per the air quality index (AQI), it was found that during the first three months of brick kiln industries the air quality was over polluted as shown in figure 8, compared to the remaining two month. In overall, the greater the AQI, the more is the pollution. Air pollution has also been associated with a variety of health problems to the humans. Every year approximately 8,000 people face illnesses like respiratory lung related diseases, caused by outdoor air pollution in Chennai and approximately 600 of these deaths are estimated to occur in the nearby zones of industries alone. A lower value of AQI, therefore, is welcome and beneficial for better human health and the overall safe environment.

IV CONCLUSION AND RECOMMENDATIONS

Production of brick results in environmental degradation due to emissions of significant quantities of gaseous pollutants through improper disposals of wastes.

- It is clearly visible that small scale brick kiln industries near Chennai, Tamilnadu, India are emitting measureable amount of air pollutants.
- The level of different air pollutants (gaseous and dust) in the ambient air was higher and noticeable during the sampling period of five months.

- This was considered as the major air pollution problem in the study area. The study area was selected as residential area and hospital zone in addition to the Industrial estate by conducting experimental survey for the area.
- On the basis of air quality index (AQI), all the three sites were turned to be severe air pollution sites.
- On the whole, the greater the AQI, the more is the pollution. A lower AQI therefore is beneficial for human health and the environment.
- The level of gaseous and dust pollutants may be reduced by providing the better quality leather raw materials such as good and uniform quality sand.
- The use of quality raw materials may facilitate better kiln firing process in overall. Development of green belt around the brick kiln industries may be an effective mitigation mechanism.
- Better gas adsorption filter filled masks could be developed through proper R&D and provided to the workers of the industry as well as the residential people nearby for safety measure.
- More environmental awareness programs should be organized in a year. In the absence of effective air quality management systems, air pollutant concentrations will increase in the future.
- Therefore it is highly necessary to develop and enforce of air quality standards in the sampling area of this small scale brick kiln industries near Chennai.

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AUTHORS PROFILE

Dr.A.John Presin Kumar has been in engineering teaching and engineering research field for the last 18 years. He has published 20 international journal papers so far. He is a member of WEO, ISEIS and IRED and presently doing research work in waste recycling, pollution control and soil fertility.

Dr.G.Ravikumar Solomon is the Professor and Head of the Department of Mechanical Engineering in Hindustan Institute of Technology & Science, Chennai. He has over 30 years of teaching experience and has published almost 25 research papers in the field of computational fluid dynamics, thermal engineering, heat transfer, energy, refrigeration & air conditioning, pollution control. He is a member of ISTE, IET.

Dr.S.Sivakumar has been in engineering teaching and engineering research field for the last 15 years. He has published 10 international journal papers so far. He is a member of SAE and IRED and presently doing research work in CAD/CAM, waste recycling, pollution control and soil fertility.

Mr.R.Balaji is presently pursuing his third year B.Tech in Mechanical Engineering at Hindustan Institute of Technology & Science, Chennai. He is presently doing project and research work in material science, waste recycling, pollution control and soil fertility.

Mr.Mukesh Nadarajan is presently pursuing his third year B.Tech in Mechanical Engineering at Hindustan Institute of Technology & Science, Chennai. He is presently doing project and research work in material science, waste recycling, pollution control and soil fertility.

Dr.Ashish Selokar is presently working in Accendere, CL Educate Pvt Ltd., New Delhi, India. He has done his Ph.D from IIT Roorkee. He has 6 years of research experience. His research interests include metallurgical science, pollution survey and analysis software in mechanical engineering. He has published several research papers in referred international journals and conferences.