Original Article

# Measurement of Atmospheric Particulate Matter (PM 2.5 and PM10) Concentrations in Lahore and Their Possible Impact on Mental Illness in Adults and Children.

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**Objective:** To measured the particulate matter concentration in the atmosphere around different areas in Lahore and high lights the possible future concerns regarding its impact on the mental health of the people especially children who are directly exposed to it.

**Methods:** The particulate matter concentrations (PM2.5, PM10, PM1) were measured using a calibrated digital device. The results were tabulated.

**Results:** The highest concentration of the particles were measured in The Data Darbar area (90 µg/m3) while the lowest was found in the GOR-1 area (61 µg/m3). Even the lowest concentration found was much higher than what the WHO allows in a 24 hour period (24 µg/m3). Health problems including mental health problems start to appear above an annual mean level of PM2.5 of 10 µg/m3. It is foreseeable, the possible immense impact of particulate pollution on mental health in Lahore.Conclusions

**Conclusions:** The particulate matter concentrations in all areas in Lahore were beyond the acceptable WHO levels. Mental illness is strongly shown to be associated with the high concentrations of these particulate matters. Thus it is imperative that stringent and prompt action is taken to control pollution in all its forms.

**Keywords:** particulate matter, environmental monitoring, mental disorders.

## Introduction

Pollution is a worldwide problem but is much worse health wise particularly in the developing countries like Pakistan. Pollution consists of several chemicals both solids and in the liquid or gaseous forms such as formaldehyde vapours, sulphur dioxide, carbon monoxide and carbon dioxide gases. In addition to these, some particulate matters, of minute sizes, are also present which are the focus of this study and which were measured in various places at Lahore. The particulate matters of interest in this study are the PM 2.5 (0.0025 mm in diameter) and the PM 10 (0.01 mm in diameter) particulates which are called 'fine' and 'coarse' particulates according to their respective sizes. These are usually described in terms of mass per volume of air micrograms per cubic meter (µg/m3). The particulate matters come from various sources such as burning natural coal, organic materials such as wood and some artificially manufactured materials such as rubber and plastics. These can also be produced by emissions from cars and power plants. However, wild fires such as extended bush fires in Mexico, the US and Australia.

According to the Global Burden of Disease Study conducted in 2015, exposure to fine particulate matter (PM) 2·5 was the fifth largest risk factor for deaths throughout the world. Thus, the deaths worldwide due to particulate matter were in the region of 4.2 million and resulted in 103.1 million disabilities in 2015.[1] Cohen and colleagues estimated that pollution resulting from the ambient PM2·5 was the fifth-ranking mortality risk factor in 2015. The 2015 Global Burden of Disease survey estimated that fine particulate matter was responsible for 7.6% of all deaths worldwide.[2] The WHO has issued guidelines regarding the allowable atmospheric levels of PM2.5 and PM10. **(Table-1).**

**Table-1:** W.H.O. guidelines, regarding allowable levels of particulate matter (PM) concentrations in the atmosphere. Https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-uality-and-health.

| | PM 2.5 µg/m3 | PM 10 µg/m3 |
|---|---|---|
| Annual mean measurements | 10 | 20 |
| 24 hour man measurements | 24 | 50 |

## Methods

A new specific pollution monitor with multi- item measuring capability was used to measure the

particulate matters (PM2.5, PM1,PM10) in the air. The machine was calibrated before every use. Lahore is a huge city and it is not possible to take readings from every locality or area. A route was decided which was logistically convenient and fairly representative of Lahore including affluent and non-affluent areas and busy and not so busy areas. For accurate readings the monitor is kept in the open environment for at least 3 minutes so that the surrounding air has a good chance to penetrate the monitor sensor window. The readings were finally tabulated for analysis and discussion.

## Results

The Highest concentration of the particulates called the 'fine' particulates were in the areas where it is most expected such as The Data Darbar (90 µg/m3) due to the large number of people that visit the shrine with accompanying 'Chingxie" rickshaws bellowing out smoke and un-burnt fuel from inefficient and un-tuned engines. The following observation although not statistically substantiated is most important as it conveys the sheer impact on the future health of people of different ages compacted in this busy part of Lahore. In addition to male and female adults the elderly and the children were in large numbers as well. Visitors might inhale their share of the high concentration of pollutants here but there were people who were stationed in the vicinity of the Shrine who were duty bound to stay at that spot for hours. These were the traffic policemen, who were exposed to hours of unfiltered particulate matters. In addition to these the common vendors, rickshaw drivers, children on their way to or back from school and also the small shops on the roadside were noted to be exposed to the heavy particulate laden air. It is conceivable, why and how such people can be affected mentally in an adverse manner by inhaling the particulate matters. Children would be exposed to this pollution for the near future for certain. All this, might possibly result in health problems for adults and children alike, of a physical or a mental form. The lowest concentration was in the Government Officers Residence 1 which is a strictly gated area and is not a thorough fare and thus is free from heavy traffic, especially the motorcycle rickshaws. This only confirms the huge contribution to the pollution by the cars on the busy Lahore road. On average, the concentration of the PM2.5 was 79.43 µg/m3, which is way beyond what the WHO or the Environment Protection Agency has recommended. Similarly, PM1 and PM10 were 187 µg/m3 and 244 µg/m3 on average, respectively, again not in the recommended limit zones.

The average concentration of the PM2.5 in the present study falls into the fourth category (40.0106.9 µg/m3 which is the worst environmental state categorized by the environmental agency of Australia. The WHO recommends 25µg/m3 as the safe environmental levels of PM2.5 worldwide.

**Table-2:** Measured levels of Particulate Matters (PM) at various sites in Lahore.

| | PM 2.5 | Pm1 | PM 10 |
|---|---|---|---|
| Jail Road | 73 | 199 | 265 |
| Ferozepur Road | 81 | 190 | 164 |
| Lyttton Road | 80 | 164 | 196 |
| M.A.O College | 77 | 170 | 223 |
| Kachehri | 77 | 160 | 200 |
| G.C.U | 77 | 198 | 253 |
| Data Darbar | 90 | 259 | 330 |
| Bhati Gate | 80 | 200 | 268 |
| Negative predictive value | 84 | 203 | 247 |
| Bansanwala Bazar | 80 | 185 | 256 |
| Gawalmandi | 85.5 | 175 | 232 |
| Lakshmi Chowk | 80.3 | 263 | 340 |
| Montgomery Road | 79 | 200 | 256 |
| Shimla Pahari | 82 | 189 | 245 |
| Davis Road | 84 | 182 | 223 |
| G.O.R-1 | 61 | 155 | 207 |

## Discussion

It is evident from the measurements at Lahore that in every area measured, the W.H.O. allowable levels were not met and the 'Air Quality Index' obtained is in the 'severe unhealthy range'. Thus, the recommendation in this case is strict and directs especially children to avoid prolong out door exertion. People with preexisting respiratory conditions are especially advised to avoid the outdoors. Unfortunately, during data collection for this study, it was noted that policemen were posted in this polluted spot for hours. School children had to tread along the heavily polluted road side and vendors were no less exposed to the onslaught of these injurious particulate matters. How mental illness is affected by air pollution is described by two hypotheses, called the

Neuro-inflammatory hypothesis and the Gene-environment interaction hypothesis. In the neuro-inflammatory hypothesis, the neurovascular unit is damaged by production of autoantibodies against neural and tight-junction proteins.[3-6] The second hypothesis takes into consideration the effects of the environment on the genes. It is an established fact that the environment can affects how the animals' genes are expressed. These environmental factors can be chemicals in the atmosphere, temperature, oxygen levels, humidity and mutagens. This in turn determines some characteristics of the organism (phenotype).[7]

A multi European study with US contributions concluded that heavy metals such as lead and cadmium, environmental particulate matter and some oxides of sulphur and nitrate can cause psychotic disorders such as schizophrenia. They suggest a mediation role of pollution in the association of urban birth/upbringing and the elevated risk.[8] Thus inflammation is thought to be an important contributor to psychiatric symptoms such as depression and Schizophrenia.[9,10] A Korean study recruited 537 elderly citizens who visited a community centre were examined for depressive symptoms. They concluded that exposure to particulate matters such as PM10 and ozone may increase depressive symptoms amongst the elderly. The symptoms evaluated which were strongly associated with particulate matter and most affected were the emotional symptoms.[11] This study from mainly from Spain also suggests the association between environmental particulate matter and depression.[12] The Canadian study suggests that emergency room admissions and visits were more after ambient air pollution especially in the warm season.[13] This 2015 study, looked at 71, 271 women aged between 57 and 85 years and their anxiety levels associated with ambient pollutant levels of PM2.5 and Pm10 found out that the women had higher

Another urban study recruiting 243 611 people also concluded that pollution is associated with cases of dementia.[15] An unacceptable environmental level of particulate matter is also suspected to be associated with autism spectrum disorders. The quantum of this association depends on the size of the particulate matter the child is exposed to. The most strongly influencing factor is the PM2.5 and the diesel PM.[16] The association between particulate matter especially the PM 2.5 and autism was also suggested by another study where exposure to the pregnant mother was associated with greater odds of a child developing autism.[17] A systemic review and meta-analysis of 23 studies done in China in 2017 strongly suggests that the exposure to the particulate matter of the pregnant mother increases the risk of preterm birth and term low birth weight.[18] Another study in 2017 but from the US suggest that even low exposures to ambient air pollutants (PM2.5) resulted in reduced birth weight but not with risk of preterm birth.[19] A study in Beijing has shown that there is a strong association between psychosis and particulate matter concentrations in the atmosphere.[20] Similarly, it is shown that long-term exposure to fine particulate matter (PM2.5) and nitrogen dioxide was positively associated with dementia.[21] Lancet published a study in 2017,in which the authors used a large population-based cohort which resided near a heavy traffic area, and concluded that the incidence of dementia was greater as the residents were exposed to pollution particulate matters on a long term basis.[22] Thus, both Swiss and German studies have shown that there is ample evidence to safely conclude that environmental factors are associated with mental illness.[24] It was observed that particulate material (PM) was seen in olfactory bulb neurons, and 'fine' PM were observed in the blood from the lung, frontal, and trigeminal ganglia capillaries. These changes result in damage starting in early childhood if the child is exposed to the pollutants.[25] Worryingly, several multi centre international studies have shown a positive association between suicide attempts and exposure to particulate matter.[26-30] When pollutants enter the body they elicit an innate immune response resulting in the release of cytokines such as interleukin 1β and 6. There is also release of the tumour necrosis factor alpha. The consequence of release of these chemicals results are the characteristics of inflammation like swelling and recruitment of more such mediators resulting in a wide spread inflammation resulting in nerve and brain damage. Brockmeyer and colleagues identified such damaged areas in the cortex and the midbrain which caters to cognitive function, especially, a precarious situation if a child is the victim. These researchers also identified reduced blood flow to the brain with resulting demyelination of neurons.[31] A brief and extensive survey of the effects of particulate matter on mental health is found in the Journal of urban design.[32]

## Conclusion

Pollution is a worldwide problem but is more so in the

developing world due to a poor infrastructure heightened by cultural carelessness. The present study confirmed the presence of high concentrations of particulate matter throughout the areas measured in Lahore. The association between these injurious levels and various mental illnesses is well studied world over. We, as a nation should take prompt and adequate measures to safe guard our future generations.

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