#### **Situation and Objective**

A construction boom in central Texas in recent years has resulted in a high and increasing demand for crushed stone and related materials, limestone, granite, traprock, and sandstone. Texas leads in the production of limestone in the US (see figure below).





The map below depicts the locations for crushed stone resources in Texas.

Source: http://www.beg.utexas.edu/minerals/aggregate-industrial

Given its abundance it is no wonder that crushed stone related industry has experienced substantial growth in recent years.



Growth and Value of Crushed Stone in Texas

While growth is expected and can bring economic benefits, limestone quarrying, crushing, and cement and asphalt manufacture are well documented sources of airborne pollution called particulate matter (PM) that pose significant health risks.

Particulate matter is produced by fossil fuel combustion of fossil fuels (gasoline, diesel, coal, etc), and mineral mining processes such as limestone quarrying operations and related processing considered pollution by the World Health Organization (WHO) and the US Environmental Protection Agency (EPA) because exposure is associated with a range of negative health effects.

The objective of this article is to summarize the health risks of exposure to PM.

## What is Particulate Matter (PM)?

Generally, PM comprises two kinds of microscopic particles, mineral (silica and other minerals from rock processing), and hydrocarbon and soot from diesel exhaust of industrial equipment and trucks (ozone, polyaromatic hydrocarbons) that are heavily utilized in the quarrying industry. PM is classified into size ranges. The PM of interest in terms of health risks are those that are very small, invisible to the naked eye, and are referred to as PM<sub>2.5</sub> and PM<sub>10</sub>. PM<sub>2.5</sub> comprises particles ~2.5 micrometers in size, PM<sub>10</sub> comprises particles ~10 micrometers in size. PM<sub>2.5</sub> and PM<sub>10</sub> are easily carried in wind currents, can remain airborne for long periods of time, and can be carried up to 30 miles (PM<sub>10</sub>) or hundreds of miles (PM<sub>2.5</sub>) from the source.

Source: USGS Minerals Yearbook 2014

# Source: What is Particulate Matter



## Source: EPA Particulate Matter Basics

### What are the health risks associated with exposure to PM?

PM<sub>10</sub> and PM<sub>2.5</sub> are particles that are small enough to penetrate the delicate lining of the respiratory system following inhalation. The health effects of inhalable PM are well documented. Health risks are due to exposure over both the short term (hours, days) and long term (months, years). Short-term exposure can result in coughing, shortness of breath, tightness in the chest and irritation of the eyes. Long-term exposure can result in reduced lung function, and respiratory diseases such as asthma, chronic obstructive pulmonary disease (COPD), lung cancer, emphysema, and aggravation of existing lung disease. Long term exposure is also associated with increased risk of allergies, cardiovascular disease and autoimmune disease. PM exposure affects health adversely such that there is increased absence from school and work, increased visits to emergency room and doctors' offices, and hospitalization. The figure below shows a more comprehensive listing of health risks from PM<sub>2.5</sub> exposure. Epidemiological studies also have documented a significant association between PM exposure and mortality.

Sources: WHO Health Effects of Particulate Matter

### **EPA Overview of Particle Air Pollution**

EPA Particle Pollution and Your Health; Environmental Health Perspective Particulate Matter Air Pollution Exposure

60-Million-Strong Study Shows Clear Link Between Exposure To Air Pollution & Premature Death

A Review of Airborne Particulate Matter Effects on Young Children's Respiratory Symptoms and Diseases

Association of Short-Term Exposure to Air Pollution with Mortality in Older Adults

Brief exposure to tiny air pollution particles triggers childhood lung infections

Health effects for the population living near a cement plant: An epidemiological assessment

Health Outcomes of Exposure to Biological and Chemical Components of Inhalable and Respirable Particulate Matter

Respiratory health effects of diesel particulate matter

Expert position paper on air pollution and cardiovascular disease

WHO Health effects of particulate matter

- EPA Particulate Matter (PM) Pollution
- EPA Particle Pollution and Your Health

Kings College Particulate Matter and Health

# Health effects of PM<sub>2.5</sub> exposure



### Figure Source: Kings College Particulate Matter and Health

### Who is at risk from exposure to PM?

Susceptible groups with pre-existing lung or heart disease, as well as children and the elderly, are particularly vulnerable.

Source: EPA Particle Pollution and Your Health

### How much exposure to PM is considered potentially harmful?

There is no evidence of a safe level of exposure or a threshold below which no adverse health effects occur. Exposure is influenced by proximity to the source, i.e., close proximity will incur higher exposure and higher risk, and by the time of exposure. Other factors include winds and weather conditions. Source: <u>EPA Particle Pollution and Your Health</u>

#### Where is PM produced in Texas?

A study conducted by the University of Texas in 2002 reported the PM production estimates shown in the four figures below. The first two figures show Mineral Product  $PM_{10}$ , and the second figures show Mineral Product  $PM_{2.5}$ . The amount of limestone quarrying has grown significantly since then, and it is clear that there are already "hotspots" for PM production (see Texas county map figures below).



Source: Texas PM Emissions Atlas



Source: Texas PM Emissions Atlas



Source: Texas PM Emissions Atlas



Source: Texas PM Emissions Atlas

More recently, a new satellite-based method, aerosol optical density, has been used to estimate airborne  $PM_{2.5}$  levels between 2008 and 2013 (see figure below). The intense red regions on the map correspond to areas that have on average had  $PM_{2.5}$  exposure levels at 11.5  $\mu$ g/m<sup>3</sup> or higher over this time frame, the highly populated areas of Houston, Dallas, San Antonio, Austin, and Brownsville.





Source: Zhang, X, Chu, Y, Wang, Y, Zhang K. Science of the Total Environment 631–632 (2018) 904–911 (UT Houston Health Science Center)

Recently, there has been a significant publication by researchers from the Harvard University TH Chan School of Public Health that revises the WHO health risk exposure threshold to  $10 \,\mu\text{g/m}^3$  for PM<sub>2.5</sub>. This meta-analysis research, based upon results from 53 separate studies, reports significant risk for increased mortality for PM<sub>2.5</sub> exposures as low as  $10 \,\mu\text{g}/\text{m}^3$  (see Table below).

Table 2, from this publication, summarizes the percent all cause mortality risk increase for  $PM_{2.5}$  exposure at levels of 10 µg/m<sup>3</sup> (far right hand column). For all causes of mortality, exposure to  $PM_{2.5}$  levels of 10 µg/m<sup>3</sup> or higher increases risk by 1.29%. This may seem like an insignificant increase, but considering the number of individuals exposed, a 1.29% increase amounts to 12,900 more deaths per million of population.

Estimates from meta-regression for the association between long term PM<sub>2.5</sub> exposure on Overall and Specific Mortality risk.

Mortality	Coefficient	SE	p-value	Percent increase at PM <sub>2.5=</sub> 10, (%)
Inverse transform of average PM <sub>2.5</sub>	0.071	0.038	0.060	-
= <u>1</u> PM2.5 Intercept (All-cause mortality) <sup>a</sup> CAUSE specific MORTALITY	0.006	0.003	0.033	1.29(1.09–1.50)
Cardiovascular mortality	0.002	0.001	< 0.001	1.46 (1.25–1.67)
Lung cancer mortality	0.002	0.001	0.008	1.22 (0.87–1.39)
Respiratory mortality	- 0.002	0.001	0.139	1.13 (0.85–1.41)
Cardiopulmonary mortality	0.006	0.001	< 0.001	1.92 (1.59–2.25)
Elderly studies only (yes/no)	0.003	0.001	< 0.001	1.61 (1.35–1.85)
Female studies only (yes/no)	0.0002	0.001	0.892	1.31 (1.01–1.62)

<sup>a</sup> All-cause, all-ages mortality represents the reference group to indicators for cause specific mortality.

Source: E Vodonos A, Awad YA, Schwartz J. Environ Res. 2018 Oct;166:677-689.

## Summary

Particulate matter emissions from aggregate industry sources in heavily populated areas of Texas have been sufficient to sustain average  $PM_{2.5}$  levels at or above ~11. 5 µg /m<sup>3</sup> during the 2008 - 2013 timeframe.

The most current health risk assessment science provides evidence of increased risk for all cause mortality from this increased exposure to PM<sub>2.5</sub>.

## Conclusion

There is good evidence that residents of highly populated areas of Texas have increased health risks from exposure to PM<sub>2.5</sub>.

This evidence is sufficient to warrant appropriate  $PM_{2.5}$  monitoring and adoption of PM best practice methods for aggregate and rock crushing operations.

#### References

- **EPA Particulate Matter Basics**
- What is Particulate Matter
- **EPA Overview of Particle Air Pollution**
- Environmental Health Perspective Particulate Matter Air Pollution Exposure
- Health Aspects of Air Pollution with Particulate Matter, Ozone and Nitrogen Dioxide
- Texas PM Emissions Atlas
- Government Census
- 60-Million-Strong Study Shows Clear Link Between Exposure To Air Pollution & Premature Death
- A Review of Airborne Particulate Matter Effects on Young Children's Respiratory Symptoms and Diseases
- Association of Short-Term Exposure to Air Pollution with Mortality in Older Adults
- Brief exposure to tiny air pollution particles triggers childhood lung infections
- Health effects for the population living near a cement plant: An epidemiological assessment
- <u>Health Outcomes of Exposure to Biological and Chemical Components of Inhalable and Respirable Particulate</u> <u>Matter</u>
- Respiratory health effects of diesel particulate matter
- Expert position paper on air pollution and cardiovascular disease
- WHO Health effects of particulate matter
- EPA Particulate Matter (PM) Pollution
- EPA Particle Pollution and Your Health
- Kings College Particulate Matter and Health
- Prepared by R Keith Randolph PhD, June 17, 2018
- Dr. Randolph's career in biomedicine began at the Armed Forces Academy of Medical Sciences in San Antonio, Texas, U.S., where he graduated as a clinical laboratory technologist. He then graduated magna cum laude in chemistry and biology from Wayland College and earned a doctorate in experimental pathology from the School of Medicine at Wake Forest University. He has 40 years of experience in academia and industry as a basic researcher, consultant, author and speaker on topics related to human health and disease, and the factors that influence disease and health.