

Ambient Air Particulate Matter Concentration at different Locations in Gujranwala City, Pakistan

1- General Profile of the City:

Gujranwala is a city in Punjab, Pakistan with a population of 3.5 million. It is located at 32.16° North, 74.18° East and is 700 feet above sea-level. The District of Gujranwala, with a population of about 11 million has an area of 3198 sq. miles. Gujranwala is the 5th largest city of Pakistan. Gujranwala city is 67 kms from Lahore and is situated on the Grand Trunk (GT) Road. The climate is mainly influenced by its inland position. Extreme dryness with an intensely hot summer and cold winter are the characteristics of the climate.

Annual mean of maximum temperature are 30.9°C and 18.8°C respectively. Annual average rainfall is around 325 mm. In Gujranwala, there are more than 200 major industrial units, which comprise mainly of Foundaries, Aluminium Textile Dying and Brick kilns etc. These foundries and Brick kilns are the main source of air pollution. Total number of registered vehicles in Gujranwala are 115,000.

2- Particulate Matter (PM)

Particulate Matter (PM) suspended in air includes total Suspended Particles (TSP), PM₁₀, PM_{2.5}, fine and ultra fine particles, diesel exhaust, coal fly-ash, mineral dust, metal dust and fumes etc. suspended Particulate Matter provokes respiratory diseases and can cause cancers, corrosion, destruction to plant life etc. they can also constitute a nuisance interfere with sunlight to form smog and haze and also act as catalytic surfaces for reaction of adsorbed chemicals.

In Pakistan the number one problem related to air pollution is PM. Therefore, more emphasis has been given to monitor the concentration of PM (both TSP and PM₁₀) using β -ray detection method and gravimetrically to know the extent of concentration at different locations of the City.

3- Monitoring Sites

In Gujranwala, 5 sites were selected for ambient air monitoring. The detail about sites and types of emission are listed in Table-1

Table-1: Air Monitoring sites in Gujranwala

S. No.	Monitoring Sites	Sources of Emission
1	Rawalpindi Bypass, G.T. Road	Vehicular emission
2	Gondalanwala Chowk, on G. T. Road	Vehicular and Commercial
3	Baghbanpura Chowk, Jinnah Road, Hafizabad Crossing	Industrial Commercial and Residential Area
4	Sheikhupura Road, Rehman Colony behind Euroasia Fan Building	Industrial emission (Aluminum , Copper etc)
5	Gulshan-e-Iqbal, Sialkot Road. 12 Km from city center	Background (Unpolluted)

4- Analyzers/Instruments

The dust (PM₁₀) monitoring analyzer was calibrated once every 24 hours during its operation. The analyzer is programmed for automatic calibration by the analyzer manufacture.

The measurements of PM₁₀ were taken by the MPSI-100 analyzer of the Punjab-EPD Mobile Air Monitoring Station.

MPSI-100 analyzer uses a sampling procedure, which allows rejection of dust particles greater than 10 microns, and thus, measurement of the concentration of PM₁₀ only.



**Punjab EPD air Monitoring
Mobile Lab in field.**

Two Hi-Vol air samplers, HV-500F, AC 100v 50/60Hz, SIBATA, Japan were used for Total Suspended Particulate (TSP) and PM_{7.07}. These samplers have maximum capacity of sucking air at the rate of 800 liters/min, which can be adjusted according to the requirement of investigation. Size separator of PM_{7.07}µm was used for sampling of PM_{7.07}. To run these samplers, electric supply was provided from the Air Monitoring Mobile generator to ensure continuous SPM sampling.

Mini - Vol. Portable Air samplers, SN2723, Air Metrics, USA was used for PM₁₀ sampling. Flow rate of 6 liters/min was maintained throughout the sampling time. This sampler run on rechargeable sealed lead acid battery.



Hi- vol. Air sampler



Mini vol. Air sampler

5- Results and Discussions

Air Monitoring Mobile and air samplers were used to monitor the following parameters:

- Total Suspended Particulates (TSP)
- Particulate Matter (PM₁₀)

5-1 Suspended Particulate Matter (SPM)

SPM in air generally consisted to all airborne solid and low vapor pressure liquid particles, involving a complex, multi-phase system consisting of a spectrum of aerodynamics particle sizes ranging from below 0.01 μm to 100 μm and larger. Larger particles are likely to be deposited close to their source; they are unlikely to be inhaled. Smaller particles can be carried long distances and inhaled particles having a diameter of 20 μm and are relatively large, while the particles with least diameter exist in aerosol. The life period of particulates vary from a few seconds to several months, which depend on their setting rate, size, density of particles and turbulence of air.

5-2 Total Suspended Particulate (TSP)

Historically, Particulate Matter (PM) measurement has concentrated on Total Suspended Particulate (TSP), with no preference to size selection. The method used for the determination of TSP was a high volume sampler to collect particles with aerodynamic diameters of approximately 100 μm or less. The TSP high volume can be used to determine the average ambient TSP concentrations over the sampling period. The mass of particulate matter subsequently was determined gravimetrically and average ambient concentration over the sampling period was calculated.

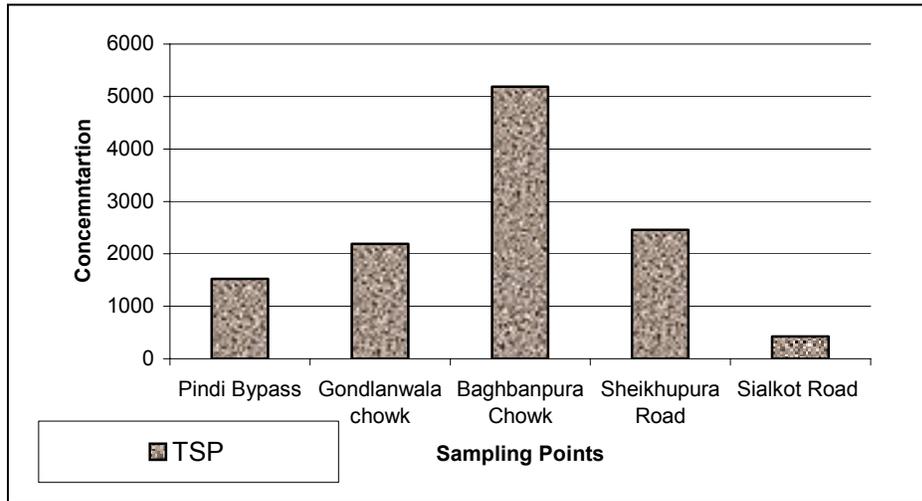
Table-2 and Figure-1 show the average TSP concentration at different sampling points in Gujranwala.

The highest concentration of TSP in Gujranwala was found in Baghbanpura Chowk, which is 5190 $\mu\text{g}/\text{m}^3$. The second highest concentration was found in Sheikhupura road, which is 2456 $\mu\text{g}/\text{m}^3$. TSP concentrations in other two polluted sampling locations are 1520 $\mu\text{g}/\text{m}^3$ and 2192 $\mu\text{g}/\text{m}^3$ in Pindi Bypass and Gondalanwala Chowk respectively. Even at the unpolluted site on Sialkot road, the TSP concentration was found to be 424 $\mu\text{g}/\text{m}^3$. The above data shows the gravity of pollution level with regard to SPM in Pakistan.

Table-2: Data of TSP at different sampling points in Gujranwala

Sampling Location	Weight of SPM (mg)	Total Sucked Volume (m ³)	Concentration of TSP $\mu\text{g}/\text{m}^3$
1. Pindi Bypass	591.4	389.0	1520
2. Gondalanwala Chowk	1036.8	472.8	2192
3. Baghbanpura Chowk	2313.8	445.8	5190
4. Sheikhupura Road	1261.8	513.6	2456
5. Sialkot Road	176.9	416.8	424

Figure-1 : TSP Concentrations at different Sampling Points in Gujranwala
Unit: $\mu\text{g}/\text{m}^3$



5-3 Inhaled Particulates (PM_{10})

The inhaled particulates were measured using PM_{10} sampler. Inhaled dust is a new term used to describe dust that is hazardous when deposited anywhere in the respiratory track including the nose, mouth and lungs. Researchers generally recognize that these particulates ($<10\mu\text{m}$) may cause significant adverse effects. Recent studies involving particle transport and transformation strongly suggest that atmospheric particles commonly occur in two distinct modes; the fine ($<2.5\mu\text{m}$) mode and coarse ($2.5\text{-}10.0\mu\text{m}$) mode.

PM_{10} measurement is based on particulate selection, separation followed by filtration and gravimetric determination of PM_{10} mass on the filter substrate.

Table-3 and Figure-2 show the PM_{10} concentration at different sampling points in Gujranwala using Mini-vol Air sampler.

Figure-2: PM_{10} Concentrations at different Sampling Points in Gujranwala using Mini-vol Sampler

Unit: $\mu\text{g}/\text{m}^3$

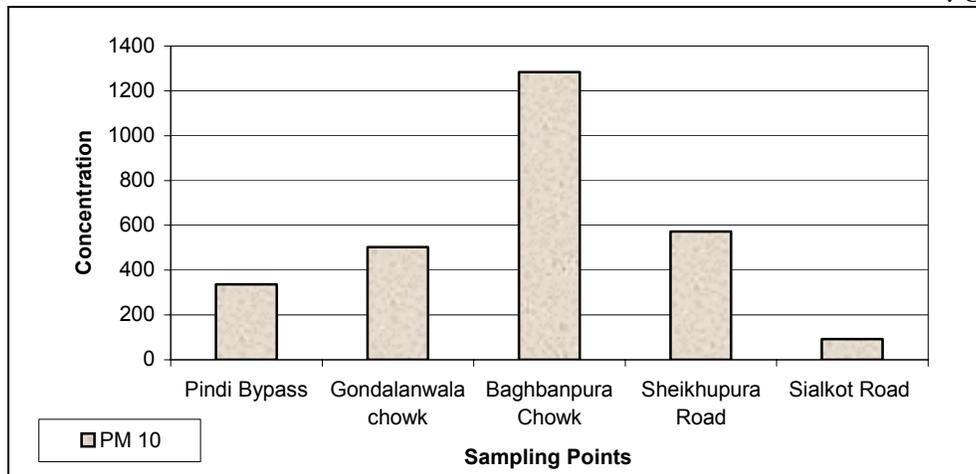


Table-3: Data of PM₁₀ Concentrations in Gujranwala using Mini-vol Air Sampler

Sampling Location	Wt. of SPM (mg)	Total Sucked Vol. (m ³)	PM ₁₀ Conc. (µg/m ³)	
			Mini-vol. sampler	MPSI-100 analyzer
Pindi Bypass	1.7	5.04	337	397.3
Gondalanwala Chowk	2.9	5.76	503	728.07
Baghbanpura Chowk	7.4	5.76	1284	1122.3
Sheikhupura Road	3.3	5.76	572	650.4
Sialkot Road	0.3	3.24	92	235.8

Results of MPSI-100 analyzer, which was fixed in Air Monitoring Mobile for the measurement of PM₁₀ are higher as compared to Mini-vol. Air sampler of all sites except Baghbanpura Chowk. The higher values of these results might be due to gas sampling aperture is located approximately 4m height, where as mini-vol air sampler was placed on 1.5 m sampling stand. Wind velocity at height is higher compared to low level.

As compared to TSP at Gujranwala, PM₁₀ concentration values are higher at Baghbanpura Chowk, which is 1284 µg/m³. The second highest concentration was found at Sheikhupura road, which is 572 µg/m³. PM₁₀ data varies in the same pattern as compare to TSP.

Figure-3 shows the variation in PM₁₀ concentration at different sampling points with respect to time. The highest concentration of PM₁₀ was observed at Baghbanpura Chowk at 1800 hours, which is 2208.5µg/m³. At the same sampling point, the higher values of PM₁₀ concentrations were also detected at 1300 and 2100 hours, which are 1665.8 µg/m³ and 1863 µg/m³ respectively.

At Sheikhupura road, at 0300 hours in the morning more than 1000 µg/m³, PM₁₀ concentration was monitored, which was due to the emission from the foundries, mostly operation at nighttime.

Figure-4 shows comparison between TSP and PM₁₀ concentrations at different sampling points in Gujranwala.

Figure-3: PM₁₀ Concentrations at different sites in Gujranwala

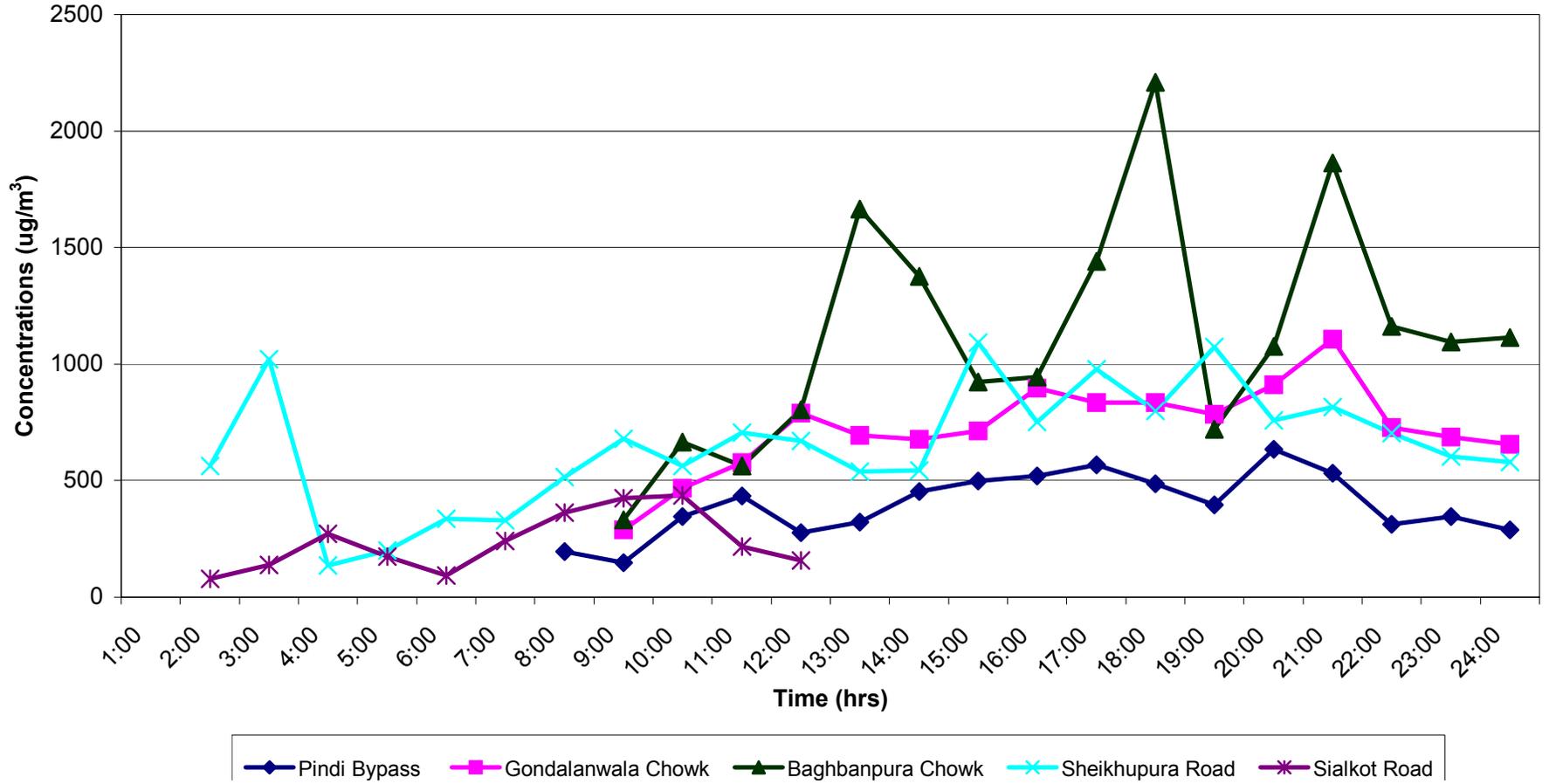
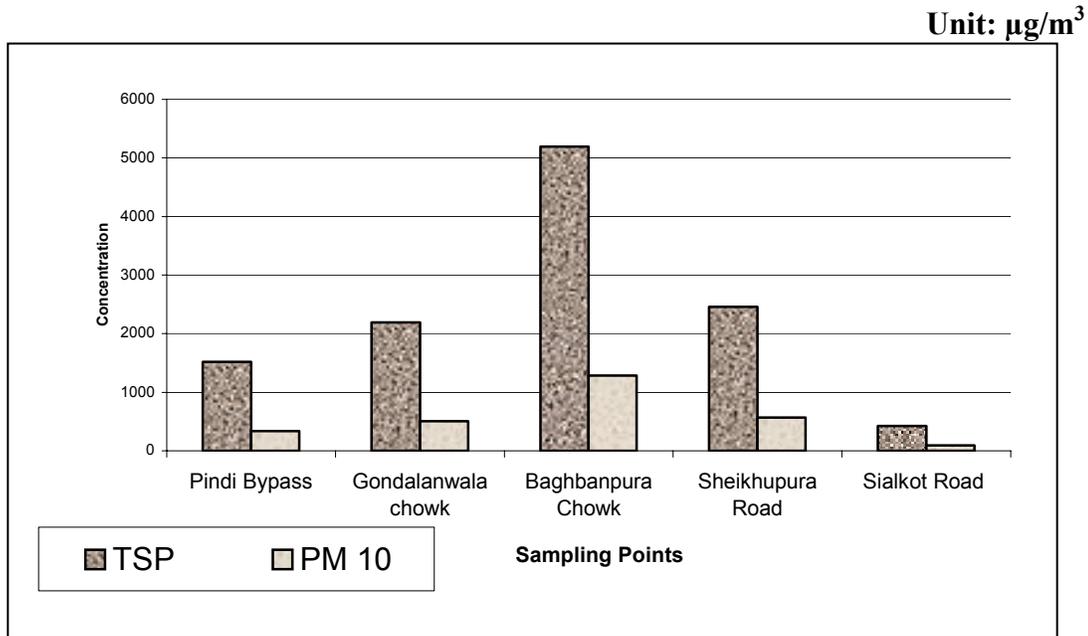


Figure-4: Comparison between TSP and PM₁₀ at different Sampling Points in Gujranwala



6- Comparison of TSP and PM₁₀ with International Standards

Figure-5 shows the comparison of TSP concentration (24 hours average) with other countries Standards in Gujranwala. In Gujranwala the maximum concentration of TSP was recorded at Baghbanpura Chowk, which was $5190 \mu\text{g}/\text{m}^3$. This concentration is more than 20 times higher if compared with other countries Standards, such as India, Mexico, Chile. According to WHO Guidelines, the short-term exposure (24 hour average) for TSP is $150\text{-}230 \mu\text{g}/\text{m}^3$.

All sampling points in Gujranwala showed very high concentration of TSP, if compared with WHO Guidelines and other countries Standards. Even in the unpolluted site (Sialkot road in Gujranwala), the TSP concentration was almost double than the WHO Guidelines.

The short term Concentrations of in Gujranwala was $2839 \mu\text{g}/\text{m}^3$. If we compare this city TSP concentration with other developing countries cities in Asia, then the situation is very serious. When the TSP concentration in Bangkok reached at level $2180 \mu\text{g}/\text{m}^3$, the World Bank called for “immediate action” to tackle the problem.

Figure-5: Comparison of TSP Concentrations (24 hrs Average) at Gujranwala Sampling Points and Standards set in other Countries

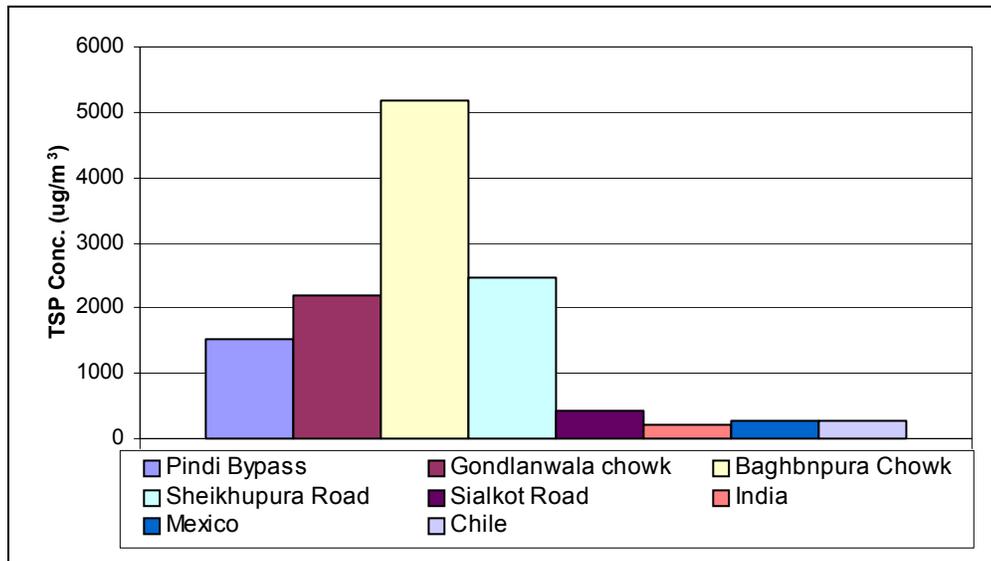
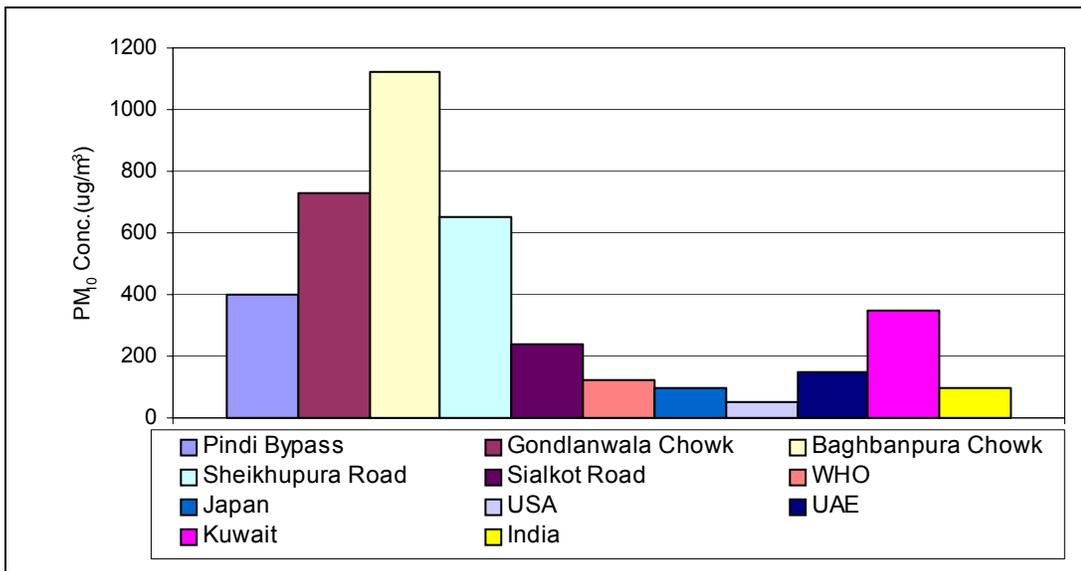


Figure-6 shows the comparison of concentrations of PM₁₀ with WHO Guidelines and other countries Standards in Gujranwala. 24 hours average and 1-hour average of PM₁₀ in the city is given with short term Standards set by other countries. At all sampling points in the city PM₁₀ concentrations remained very high compare to the WHO Guidelines, which is 120 µg/m³ for 24 hours and 50 µg/m³ for 1-hour. The maximum polluted site in Gujranwala, where the PM₁₀ concentration reached to 1122 µg/m³ was Baghbanpura Chowk. Here the PM₁₀ concentration was more than 9 times higher for 24-hours average and 44 times higher for 1-hour average according to the WHO Guidelines. In Gujranwala city, the PM₁₀ concentrations for 24-hours and 1-hour average were 724 µg/m³ and 1260 µg/m³ respectively. A detailed study of the fine particle level in Jakarta by the Indonesian Environment Impact Management Agency has shown that the maximum daily average measured can reach a value of 140 µg/m³. This reveals that fine particle concentrations in our city (Gujranwala) is 5 times higher than Jakarta, which is supposed to be one of the polluted cities of Asia.

The only possibility of high concentration of TSP in Gujranwala is due to the maximum concentration of TSP at Baghbanpura Chowk, where traffic congestion was observed from time to time, throughout the day. On this busy road all types of traffic were playing such as heavy duty vehicles, two stroke auto rickshaws, wagons and animals driven carts, etc.

Figure-6: Comparison of Dust (PM₁₀) concentrations in Gujranwala with WHO Guidelines and Standards set in other Countries.

a) 24 hours Average



b) 1 hour Average

