







Ambient Air and Water Quality Investigation in Quetta

February 2007

Pak-EPA

PEP

Pakistan Environment Programme

INTERPRETATION OF RESULTS

7-1 Particulate Matter

Characteristics of the distribution of the TSP, PM_{10} and $PM_{2.5}$ concentrations are presented in Table 4-5, 4-6 and 4-7. Distribution of TSP, PM_{10} and $PM_{10-2.5}$ are given in Table 7-1.

Table 7-1 DISTRIBUTION OF TSP, PM_{10}, $PM_{2.5}$ AND $PM_{10-2.5}$

Study Area	Concentration (µg/m^3)			
	TSP	PM_{10}	$PM_{2.5}$	$PM_{10-2.5}$
Meezan Chowk	1005.00	308.20	139.00	169.20
Imdad Chowk	1778.00	709.45	124.00	585.45
Sirki Road	1057.00	315.13	104.00	211.13
Govt. Offices Colony, Airport Road	385.30	126.70	222.00	-95.30

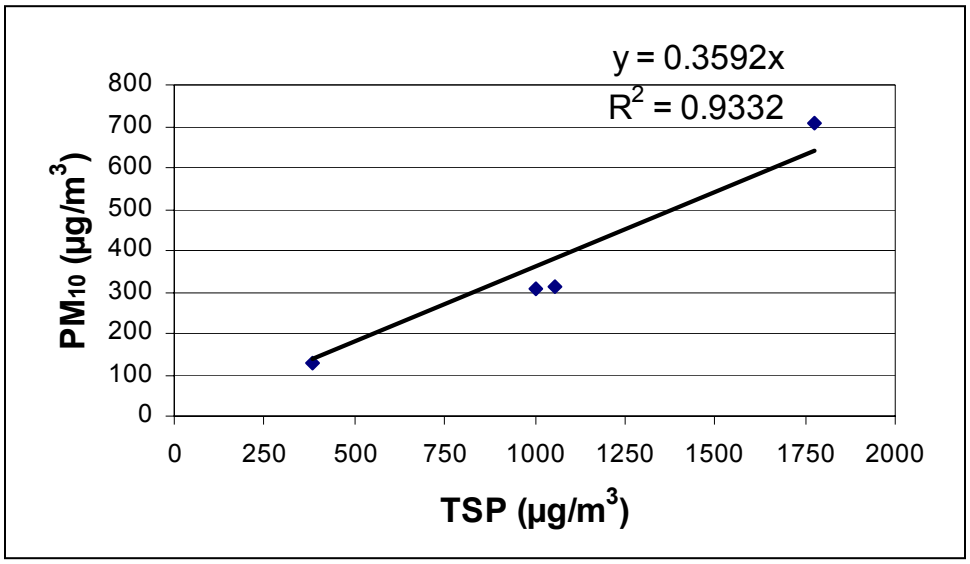
The largest variation within study areas for $PM_{10-2.5}$ is a derived measure, which measurement error is relatively high since it is affected by uncertainties in both direct PM_{10} and $PM_{2.5}$ measurement. Apart from an increase in measurement error, the higher variability of $PM_{10-2.5}$ concentrations can be explained by the nature of Particulate Matter in the different size fractions. US Environmental Protection Agency[1] in 1998 have shown that sources for $PM_{2.5}$ tend to be regional in nature and that fine particles are capable of traveling long distances. This results in relatively uniform distributions of $PM_{2.5}$ concentrations over large areas. This is not a case in the study area in Quetta. $PM_{2.5}$ concentration varies very much due to number of reasons, which are explained in previous chapters. $PM_{10-2.5}$ concentrations tend to be more dependent on particulate matter emitted by local sources with a short lifespan in the atmosphere, causing greater variability on a local scale.

In all TSP concentrations data, $PM_{2.5}$ showed minimal charges in concentration, while the PM_{10} concentration increased, when the TSP concentration increased. $PM_{2.5}$ concentration stayed between 104 and 222 µg/m^3, PM_{10} stayed between 126.70 and 709.45µg/m^3 and the TSP concentration ranged from 385.30 and 1778.00µg/m^3. The data suggests that $PM_{2.5}$ is not produced locally but could be brought in by regional factors and may not significantly affected by increases in local TSP concentration.

---

[1] ***"USEPA, 1998, National Air Quality and Emission Trend Report.***

Figure 7-1 RELATIONSHIP BETWEEN PM_{10} AND TSP CONCENTRATIONS IN QUETTA



However PM_{10} concentrations and TSP concentrations increased at the same times since PM_{10} has a strong correlation with TSP concentrations, the data suggests that PM_{10} is locally produced and was of more concern to Quetta area.

Figure 7-1 shows relationship between PM_{10} and TSP concentration in Quetta. The correlation coefficient of 0.93 was obtained, which reflects a good correlation between PM_{10} and TSP data.

At three locations except Govt. Officers Colony Airport Road, $PM_{2.5}$ concentrations were nearly similar and help conclude that $PM_{2.5}$ is not driven by local events. Thus $PM_{2.5}$ will not play a role in finding relationships with TSP in Quetta as $PM_{2.5}$ would likely not differ significantly across the site locations.

Figure 7-2, 7-3 and 7-4 show the comparison of TSP, PM_{10} and $PM_{2.5}$ concentrations at various locations in Quetta with other countries Standards respectively. There is no Standard for TSP in USA. TSP concentration at Imdad chowk is 9 times higher than Indian Standard. Even the government residential area, which is supposed to be a clean area, the TSP concentration at this location is 2 times higher than Indian Standard. PM_{10} concentration at Imdad chowk is about 5 times higher than WHO Guidelines and USA Standard of 150 $\mu g/m^3$ for 24 hours average. Only at one location, Government Officer's colony, the PM_{10} concentration is lower than WHO Guidelines and USA Standard. On the other hand, the $PM_{2.5}$ at the same location is higher than the other locations in Quetta. The matter has to be re-investigated and thorough monitoring of $PM_{2.5}$ is required to establish the hypothesis and source apportionment. $PM_{2.5}$ concentration at Officer's colony is more than 3 times higher than USA Standard of 65$\mu g/m^3$. $PM_{2.5}$ concentration at all locations in Quetta were much higher than USA Standard.

Figure 7-2 COMPARISON OF TSP CONCENTRATION AT DIFFERENT SAMPLING LOCATIONS IN QUETTA AND THE STANDARDS SET IN OTHER COUNTRIES

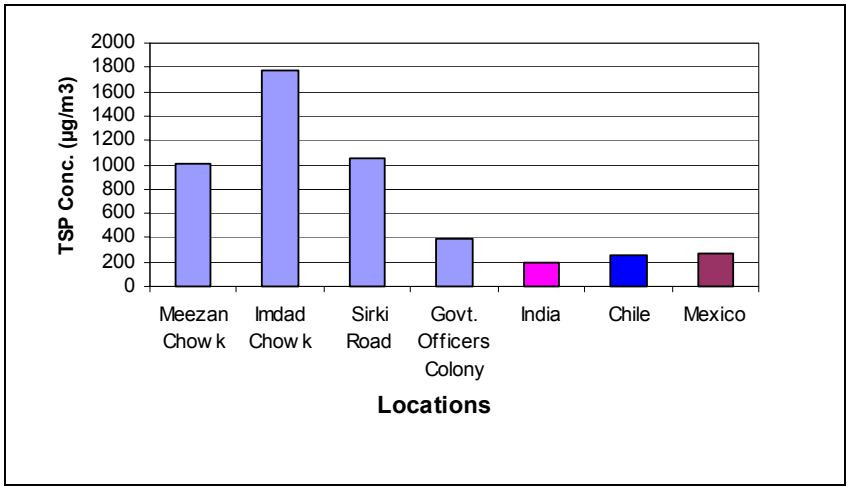


Figure 7-3 COMPARISON OF PM_{10} CONCENTRATION AT DIFFERENT SAMPLING LOCATIONS IN QUETTA AND THE STANDARDS SET IN OTHER COUNTRIES

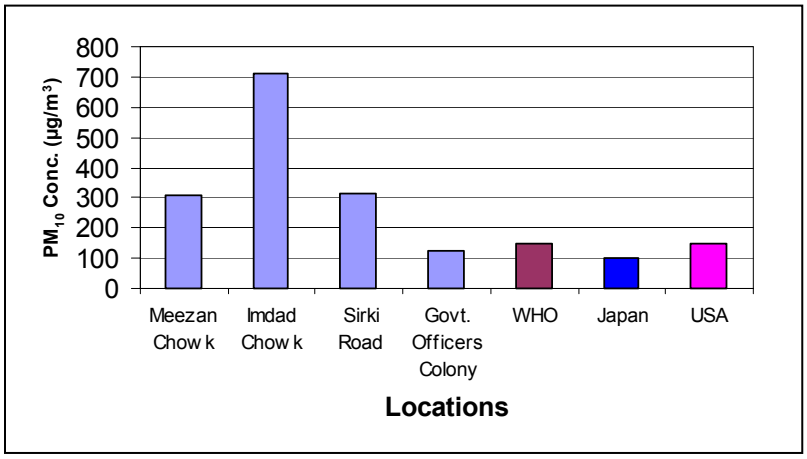
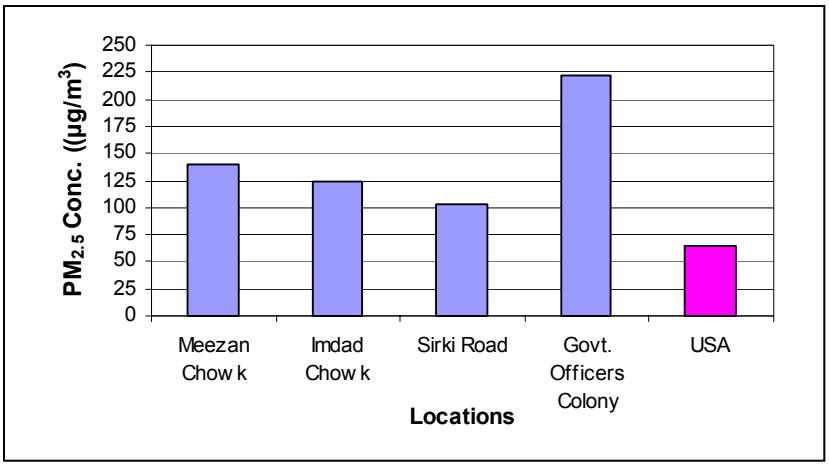


Figure 7-4 COMPARISON OF $PM_{2.5}$ CONCENTRATION AT DIFFERENT SAMPLING LOCATIONS IN QUETTA AND THE STANDARDS SET IN OTHER COUNTRIES



The Maximum concentration of Particulate Matter with respect TSP, PM_{10} and $PM_{2.5}$ at Quetta are 1778.0 µg/m^3, 709.45µg/m^3 and 222.0 µg/m^3 respectively. PM_{10} concentration at Meezan chowk was found 308.20 µg/m^3, where as SUPARCO Study the PM_{10} concentration of 4th cycle monitoring was 270 µg/m^3. There is not much difference between this study at this location and the SUPARCO value.

Due to different topography and meteorology of Quetta haze problem is very much persistent in Quetta. In the recent years the matter has aggravated. 85 flights[1] were cancelled between June 2004 to February 2005 due to haze or dust storm. Haze occurs when dust and smoke particles accumulate in relatively dry air. When weather conditions block the dispersal of smoke and other pollutants they concentrate and impairs visibility. Dense haze caused by industrial pollution is also known as smog. But in Quetta there is not a smog problem because there are no big industries located in the vicinity. During the haze period, fine Particulate sampling may be carried out along with ambient concentration of elemental and organic carbons. Chemical analysis of these fine particles for sulphate, nitrate along with elemental analysis will enable this agency to establish the cause of impair visibility.

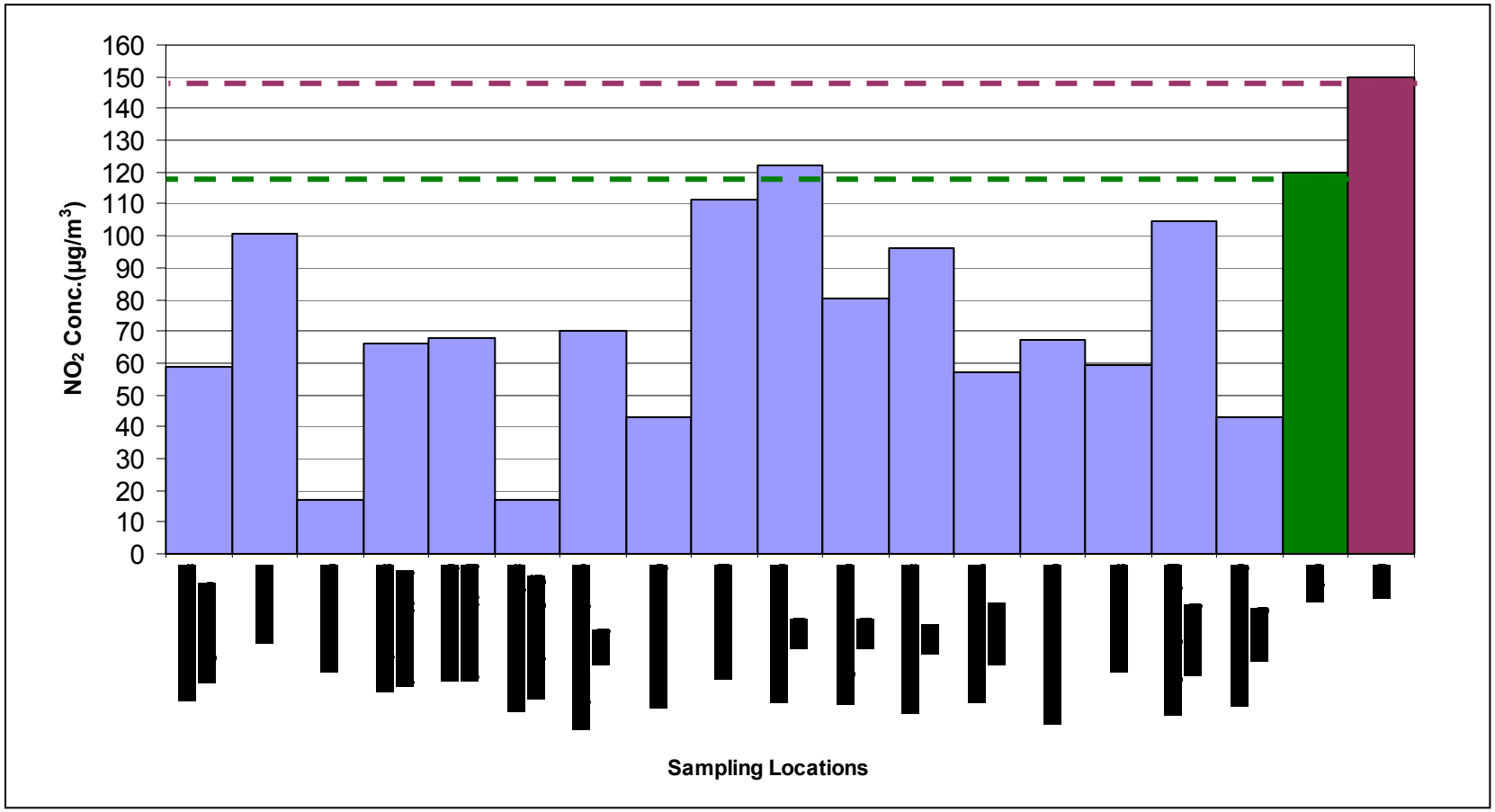
7-2 Comparison of NO_2 with International Standard

Figure 7-5 shows the comparison of NO_2 concentration in ambient air at different locations in Quetta with International Standards. The concentration of NO_2 at all locations are less than the Standard set by the World Health Organization (WHO), which is 150µg/m^3. Only at one location, Manan Chowk Jinnah Road, the concentration of NO_2 is marginally higher than the Japanese Standard of 120µg/m^3. rest of all locations, the NO_2 concentration in ambient air lower than the Japanese Standard.

[1] ***Civil Aviation Authority (CAA), Quetta.***

Figure 7-5 COMPARISON of NO_2 CONCENTRATIONS in AMBIENT AIR at DIFFERENT LOCATIONS in QUETTA with INTERNATIONAL STANDARDS

24 Hours Average



7-3 Drinking Water

Major problem in drinking water supply to the citizens of Quetta is bacteriological. 20.8% of sampled waters are contaminated with bacteria (Coliform and Ecoli). It means that out of 5 samples, one sample is contaminated with bacteria. The possible sources of contamination are listed in Table 7-2. No contamination was detected from the source water (tube well). 2 samples from the overhead tanks and 3 samples of tap water were found positive for bacteriological check. It clearly indicates that the sources of bacteriological contaminations are human activities.

Hardness of water is not a matter of concern for drinking purposes. Anyhow only 2 water samples out of 24 are placed in the range of medium hardness. Hardness is expressed in the units of $CaCO_3$. Alkalinity is also expressed with reference to $CaCO_3$.

By comparing hardness with alkalinity, the amount of permanent and temporary hardness is generally by the presence of Carbonate and bicarbonate of calcium and magnesium and non-carbonate or permanent hardness associated with sulphate and chloride of calcium and magnesium.

When hardness is greater than alkalinity, then the alkalinity result correspond to the amount of carbonate hardness present. The result of water samples collected in Quetta (see table 5-3) shows that hardness values are very low to the alkalinity values. It indicates that the hardness is present as carbonate hardness, means temporary hardness in all water samples collected in Quetta.

12.5% water samples collected in Quetta were contaminated with fluoride. The level of fluoride in these samples are not exceeding the acceptable value of WHO or other International Standards. Fluoride contamination is often associated with underground sources. Only one source sample (tube well) out of 24 in Quetta is contaminated with fluoride, where as 2 samples (one from overhead tank and second from tap water) are contaminated with fluoride. The possible sources of fluoride contamination in distribution system may be searched out for remedial measures.

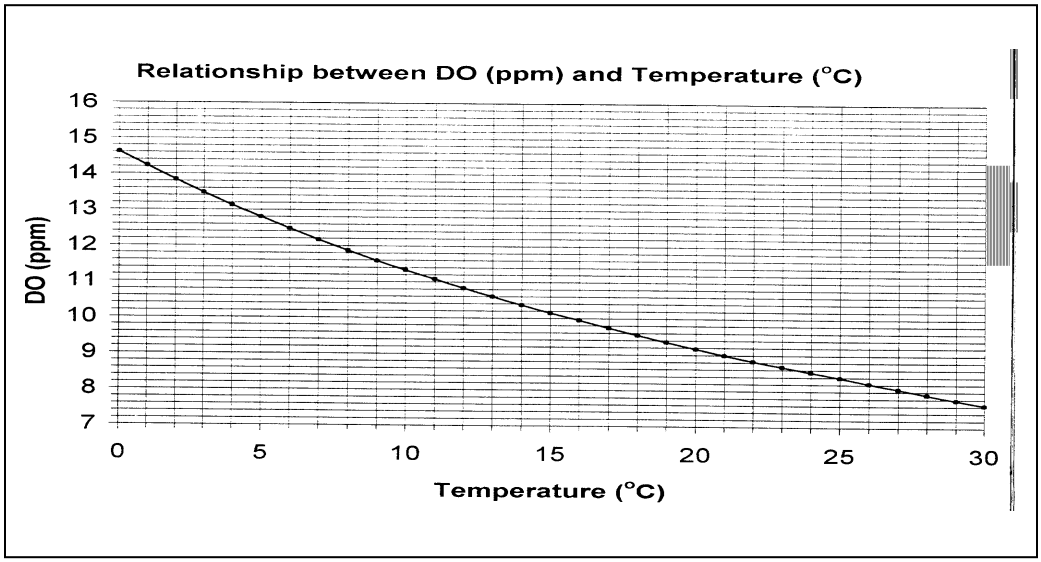
Table 7-2 DETERMINATION EXCEEDING PERMISSIBLE LIMITS

Parameters	Total No. of samples	No. of sample fails	%age of sample	Major sources in Drinking water
Transparency	24	3	12.5	Both dissolved and suspended materials
Hardness	24	2	8.3	Calcium and magnesium in minerals like limestone etc. and some industrial products.
Bacteriological	24	5	20.8	Leakage of pipes (problem in distribution system), pollution from sewage pipes, contamination due to human activities.

7-4 Wastewater

The most common source of wastewater in Quetta is domestic. Domestic wastewater comes primarily from residence, non-industrial business and institutional sources. Some examples of domestic wastewater are restroom, laundry and kitchen waste. Wastewater contains two primary types of waste: Organic and inorganic. The source of wastewater influences the amount of organic and inorganic in a particular waste stream. Wastewater sampling was performed in extreme winter in Quetta, therefore wastewater temperature varied between 10.0 to 12.2 ºC. At low temperature the microbial activities are always less but still the Dissolved Oxygen level are quite low, ranged between 0.63 to 2.94mg/l. These DO values show that the microbial activities are quite high even at low temperature. DO is very much dependent on temperature. Figure 7-6 show relationship between DO and Temperature.

Figure 7-6 Relationship between DO and Temperature.



As temperature increases, dissolved oxygen content decreases and vice versa. Low DO concentrations (less than 1.0 mg/l) can indicate inadequate aeration or an excessive amount of organic material entering the system.

The pH of potable water in Quetta should had typically ranged between 7.40 to 8.30 keeping in view the results of drinking water quality as reported in chapter-5 of this report.

The pH concentration of almost all wastewater samples were within the potable water pH range. It reflects that the main source of wastewater in Quetta is domestic discharge except at few locations, where some indication of non-domestic discharges were observed.

Figure 7-7 shows the comparison of BOD concentration with National Environmental Quality Standards (NEQS) for liquid and industrial effluents.

Almost at all locations the BOD values are higher than NEQS Permissible limit except at one location (WW8) Durrani Nallah near CIA Center. These high values of BOD in Quetta wastewater samples indicate high levels of organic matter in wastewater. The typical range of BOD in domestic wastewater ranges from 100 to 300 mg/l of BOD. BOD values obtained from the Quetta wastewater samples fall in this range. It is another step of confirmation that the Quetta wastewater is mainly composed of domestic wastewater sources.

Figure 7-7 The comparison of BOD Concentration with NEQS

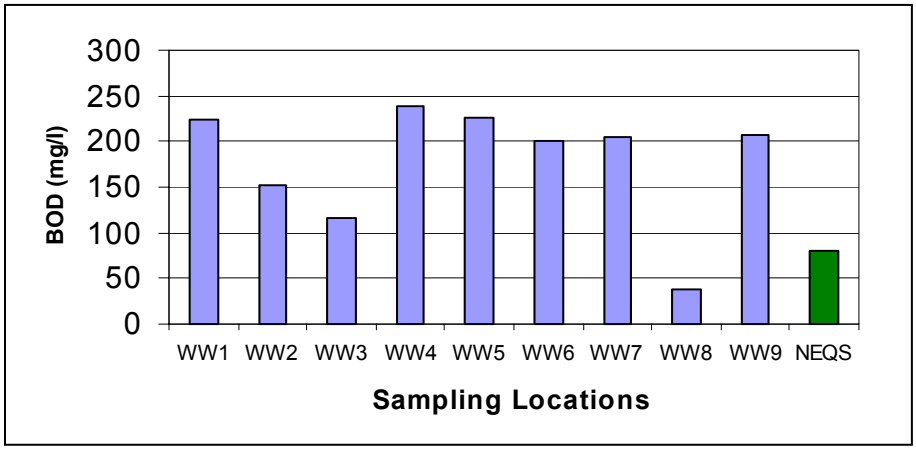


Figure 7-8 shows the comparison of COD values with NEQS permissible limit. COD concentration in all wastewater samples collected in Quetta are much higher than NEQS permissible limit of 150mg/l. COD results are not directly related to BOD. However, COD can be used as a mean of rapidly estimating the BOD of a sample, if BOD to COD ratios are developed for a particular system. The ratio between the two varied from drain to drain. The average ratio between BOD to COD in Quetta wastewater stream is 0.27:1, which reflects that domestic wastewater in Quetta is well stabilized secondary effluent.

Figure 7-8 Comparison of COD concentration with NEQS

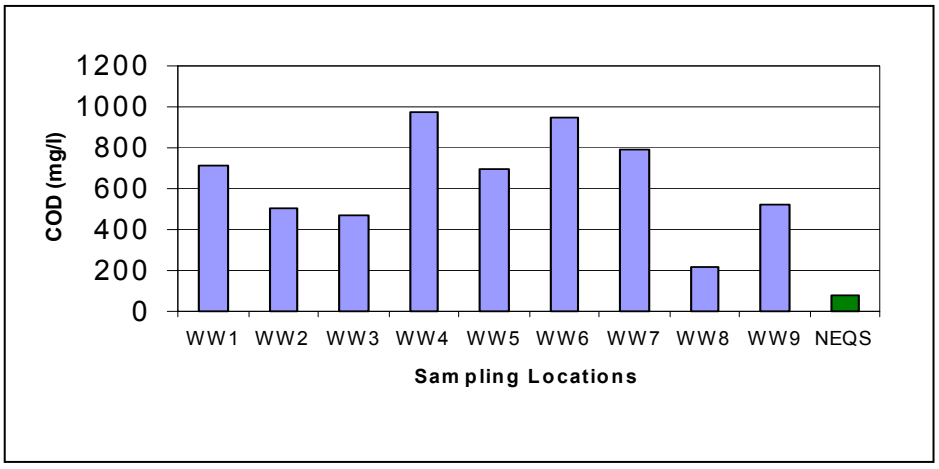


Table 7-3 shows the BOD and COD loadings at different sampling locations in Quetta. The highest BOD loading was found 18.57 tons/day at WW4 sampling location. At the same location, the maximum COD loading 75.89 tons/day was measured. In Quetta the wastewater as mentioned earlier is being used for irrigation purposes, therefore the loading rates of constituents are important operating parameters at a wastewater land application site. COD is a common measure of organic matter in land applied wastewater. Excessive COD loadings can create soil clogging[1].

Metals concentration in wastewater varied at different sampling locations in Quetta, see Table 6-9. wastewater samples collected in Quetta have low concentrations of metals, which also reflect that main composition of this wastewater is from domestic source. Because Industrial wastewater may be very high in metal concentration. By comparing the metals concentration in the wastewater samples collected in Quetta with NEQS values, almost all analyzed metals concentration are within the permissible limits of NEQS.

Table 7-3 BOD and COD loadings at different sampling locations in Quetta

Parameters	Sampling Locations								
	WW 1	WW 2	WW 3	WW 4	WW 5	WW 6	WW 7	WW 8	WW9
Flow (m^3/sec)	0.26	0.15	0.29	0.90	0.04	0.07	0.34	0.04	Negligible
DO (mg/l)	0.63	0.98	1.03	1.30	2.14	2.07	2.13	2.31	2.94
BOD (mg/l)	223.2	152.0	116.0	238.8	227.0	200.8	205.6	37.2	208.0
COD (mg/l)	716.0	502.0	470.0	976.0	694.0	948.0	794.0	216.0	526.0
BOD Loading (tons/day)	5.01	1.97	2.91	18.57	0.78	1.21	6.04	0.13	-
COD Loadings (tons/day)	16.08	6.50	11.78	75.89	2.40	5.73	23.32	0.75	-
BOD:COD ratio	0.31:1	0.30:1	0.24:1	0.24:1	0.32:1	0.21:1	0.25:1	0.17:1	0.39:1

1. Wastewater Land Application Operators/study and Reference Manual, Idaho Department of Environmental Quality, Sept., 2005.

SUMMARY AND CONCLUSION

Suspended Particulate Matters (TSP, PM_{10} and $PM_{2.5}$) in ambient air along with water quality (both drinking water and wastewater) were investigated to ascertain the present state of environment in Quetta. In ambient air, more emphasis was given to the SPM because Quetta is facing haze and dust storm problem most of the times of the year. Four locations were selected for the monitoring of SPM. Two locations among them were at Kerbside, are at industrial area and one residential area. TSP, PM10 and PM2.5 were monitored on all these locations simultaneously by using High Volume Air samplers and Mini volume Air samplers. TSP, PM_{10} and $PM_{2.5}$ concentrations at different sampling locations in Quetta varied between 385.30 to 1778.00µg/m^3, 126.70 to 709.45µg/m^3 and 104.00 to 222.00µg/m^3 respectively. The highest concentration of TSP was found at Imdad Chowk, where the number of vehicles passed per hour was the highest with respect to other locations. At the same location, PM_{10} has shown the highest concentration, which reflects that the generation sources are the source as for TSP. TSP and PM_{10} have shown a good correlation coefficient of 0.93. $PM_{2.5}$ tends to be regional in nature. Surprisingly the highest concentration of $PM_{2.5}$ was determined at the residential area (Govt. Officers Colony, Airport Road), which is supposed to be a cleaner locality in Quetta. It is suggested that a thorough investigation along with source apportionment may be carried out to pin point the sources of $PM_{2.5}$. The proposed study will verify either the sources of $PM_{2.5}$ are regional or local.

On average across Quetta, PM_{10} accounts for approximately 33% of TSP, while PM2.5 accounts for approximately 10% of TSP without including the $PM_{2.5}$ concentration of residential area. Consequently the average ratio of $PM_{2.5}/PM_{10}$ is about 36%. There is considerable variation among sites in these ratios.

Drinking water samples collected in Quetta at different locations covering the major residential areas of the City. These samples were collected from the source supply (tube wells), over head tank and tap. The analytical data compiled and processed which revealed that the major problem with drinking water in Quetta is bacteriological. The compiled data showed that 20.8% of samples were unfit for human consumption. Only two deficiencies were detected in case of chemical analysis. One was transparency and the other hardness. Transparency of water is related with aesthetic quality, where as hardness has little contribution towards drinking water quality.

The organic contamination in wastewater in Quetta area is very high compare to inorganic contamination. BOD and COD at all sampling locations in Quetta were much higher than the NEQS permissible limits. The average ratio determined between BOD to COD in Quetta wastewater drain is 0.27:1, which reflects that major composition of wastewater in Quetta is generated from domestic sources. The highest BOD and COD loading were found 18.57 tons/day and 75.89tons/day respectively. Wastewater samples collected in Quetta have shown very low concentration of metals. It also reflects that main composition of this water is from domestic sources.

RECOMMENDATIONS AND FUTURE SUGGESTIONS

1- Highest concentration of $PM_{2.5}$ was determined at Residential area of Quetta, which is supposed to be one of the cleanest areas of the city. It is recommended that detail survey with regard to $PM_{2.5}$ may be conducted in and around the city area to ascertain either $PM_{2.5}$ is generated locally or it is a regional phenomena.

2- Source apportionment may be carried out of ambient air SPM samples especially $PM_{2.5}$ to pinpoint the generation sources.

3- During $PM_{2.5}$ sampling in Quetta for source apportionment, ambient air NOx and SO_2 may also be monitored, which are precursor gases of $PM_{2.5}$ and also a contributor to the haze formation in Quetta Valley.

4- Overhead water tanks, which are the main source of water supply to the public are not cleared periodically. These should be cleared and disinfected regularly.

5- Water leakage in the distribution system may be properly monitored by the concerned authorities and remedial action may be taken timely.

6- Prevention of cross-contamination may be controlled by not passing pipelines along or across the sewage lines.

7- It must be mandatory on the agencies responsible to regularly monitor quality of water being supplied to the consumers.

8- Almost all wastewater, which is generated in Quetta is being utilized for irrigation purposes in and around Quetta valley. The high organic contamination level of this water is being entered into food chain and than to human body. It is recommended that a treatment plant on the combined drains must be installed for safe supply of water for irrigation purposes.