6. Observations and Recommendations

In an attempt to assess the deterioration in air and water quality in the major cities of Pakistan, JICA and Pakistan EPA undertook a project to measure air and water quality in three cities, Lahore, Rawalpindi, and Islamabad. This study forms the initial part of the agencies' plan to stem the deterioration.

The air and water quality monitoring that was conducted in the three cities provided a basic understanding of issues associated with standard field sampling, measurement, and laboratory test methods and procedures.

Based on the analysis carried out in this report, HBP identified some observations and recommendations, which are presented below.

6.1 Ambient Air Quality Monitoring

Urban air quality results of the three cities present an alarming situation as two of the criteria air pollutants (CO, SO_2, NO_X, PM_{10} and Pb), including PM_{10} and NO_X, exist in higher levels than the WHO limits. This situation calls for a well-structured, countrywide air quality monitoring program.

Some observations made during the study are briefly discussed below:

- Air quality monitoring is the first step in determining the magnitude and characteristics of air pollution problems. The monitoring capacity, in terms of equipment (field and laboratory) and trained staff, is limited, and therefore representative data and information on air quality across the country is non-existent.
- Correct interpretation of air quality data is essential for formulating policy recommendations to improve air quality. The current staff capacity to correctly synthesize and analyze air quality data is minimal, with the result that whatever little information and data *is* available on air quality is not used properly to develop an appreciation of air quality issues.
- There is a lack of uniformity in the test methods and procedures of environmental laboratories in the public and private sectors. This leads to controversies in quality control and assurance issues. The laboratory test methods for sampling and measuring air pollutants are not chosen carefully and do not take into account the purpose of measurement or available resources. In addition, the following points are generally ignored:
  - The method should be widely accepted
  - The method should be precise and accurate
  - The method should be economical and time conserving
  - The method should give results that can be used for inter-laboratory comparison.
- Emission inventories and air quality monitoring are the scientific foundations upon which air quality plans are built. The monitoring data help in identifying the emission sources and intensity of problems, while emission inventories show the relative contribution of different sources. Emission inventories are used to:

  - Predict air quality impacts of emission reductions;
  - Determine which type of control measures are needed to lower the ambient air pollution levels in a specific area; and
  - Show emission trends over time and provide inputs to health risk assessments.
- No air quality management program can be successful without identification of emission sources, and development of emission inventories based on local emission factors, such as pollutant emitted per ton of fuel burned or distance traveled by motor vehicle.
- Local ambient air quality standards are necessary for protection against potential adverse effects of air pollution. Currently, national ambient air quality standards do not exist. These need to be developed and introduced to assess the level of pollution in urban areas, in terms of air quality indices (AQI). This activity calls for online air quality monitoring

in most air-polluted cities; the information obtained will provide sufficient grounds for legislation and identification of legal strategies, such as enactment of a 'Pakistan Clean Air Act.'

6.2 Water Quality Monitoring

Natural streams, canals, rivers, and the sea are the main receptors of untreated domestic and industrial wastewaters in Pakistan. The water quality monitoring results of Lahore, Rawalpindi, and Islamabad cities present a scary situation, as, out of 40 wastewater samples tested, only one was declared fit for human consumption. The river water quality in Lahore, Rawalpindi, and Islamabad necessitates a well-designed, countrywide water quality monitoring program. Some observations made in the course of this study are briefly discussed below:

- The information and data generated from previous studies should provide guidelines for future studies on similar subjects. Several studies on water quality have been conducted by a number of research institutes and individuals in major cities of Pakistan. However, environmental information and data generated through these studies were not placed at a central location, and access to them was denied to researchers and the general public. Research in this area could therefore not build up. The need for a central databank for all such information is strongly felt. Currently, such a system does not exist in the country.
- Like air monitoring, water quality monitoring also identifies the magnitude and characteristics of water pollution problems. In Pakistan, water quality monitoring capacity, in terms of field and laboratory equipment and trained staff, is also limited, so only very scanty representative data and information on water quality across the country is available.
- Spot sampling and testing play a significant role in providing representative data on water quality. Currently, little attention is paid to standard sampling and spot testing procedures during the collection of water samples from natural streams, canals, lakes, and rivers. Concerned agencies and their relevant staff require essential hands-on training on spot sampling and testing procedures.
- Current pollution levels in canals, lakes, and rivers provide enough reasons for enacting a Pakistan Clean Water Act. Periodic water quality monitoring of canals, lakes, and rivers can generate essential data that can be used to develop water quality indices (WQI) for all receptors. This information should be made public so it is aware of the current water quality of canals, lakes, and rivers.

7 Comments on 3 Cities Environmental Investigation Results

7.1 Comments on Air Quality Analysis Written by Y. SHIGETA (JICA Environmental Expert, Pak-EPA)

7.1.1 The Outline of this Investigation

This part of study covers the ambient air quality monitoring of three cities of Pakistan i.e. Islamabad, Rawalpindi and Lahore. The air quality parameters i.e. SO_2, NO_x, O_3, CO etc. have been investigated using air mobile station inspite of short term investigation. The data collection points (sampling points) are given in Table 7.1.

Table 7.1: Sampling Points in Lahore, Rawalpindi and Islamabad

No.	Ambient Air Quality Station	Location	Monitoring Date
1.	Chowk Yateem Khana, Multan Road	Lahore	April 5, 2000
2.	Azadi Chowk	Lahore	April 6, 2000
3.	Chowk Lohari Gate	Lahore	April 7, 2000
4.	Bank Square, Shahrahe Quaid-i-Azam	Lahore	April 8, 2000
5.	Qurtaba Chowk	Lahore	April 10, 2000
6.	Raja Bazar	Rawalpindi	May 6, 2000
7.	Murree Road, near Committee Chowk	Rawalpindi	May 8, 2000
8.	Pir Wadhai Chowk	Rawalpindi	May 9, 2000
9.	Aabpara Chowk towards Melody Market	Islamabad	May 10, 2000
10.	Industrial Area, I-9 near Police Station	Islamabad	May 11, 2000

The data reported in this investigation is averaged data for a period of 15 minutes and one hour. One hour air quality obtained data has been compared with air quality standards of Japan and WHO guidelines to assess the levels and see the implications on human health if any.

However, 15 minutes average data has been taken for data analysis and interpretation of possible chemical reactions occurring in the atmosphere under prevailing conditions of temperature, humidity, pressure and concentration of pollutants i.e. O_3 formation by photochemical reaction presence in different air pollutants.

7.1.2 Characteristics of Air Quality in Selected 3 Cities

The reported data shows the levels of different pollutants during the day in the month of March and April, 2000. Variation in the levels of pollutant could be related with the traffic density and other human activities. However, high concentration of particulate matter (SPM, PM-10) has been recorded at each sampling point that further increases with traffic density and other activities at different time period. The details of each parameter and comparison with ambient air quality standards of other countries are given below,

- **High SPM Concentration**

Comparing with Japanese Standard at 200 µg/m^3 (1 hr.) or WHO guideline at 120 µg/m^3 (24 hrs.) for SPM, the average SPM data in 3 cities shows that SPM concentration exceeded 3.8 times from the Japanese Standard, and 6.4 times from WHO guideline (this guideline number is only for 24 hrs. evaluation). The concentration of SPM at the sampling points were found 2.6 to 4.4 times higher than Japanese Standards and 4.4 to 7.5 times higher than WHO guidelines.

Data from 10 sampling points in Lahore (5 points), Rawalpindi (3 points), and Islamabad (2 points) shows that Lahore city has the highest concentration of SPM while Rawalpindi is less contaminated with SPM. The Islamabad has least concentration of SPM compared to Lahore and Rawalpindi showing better environmental conditions.

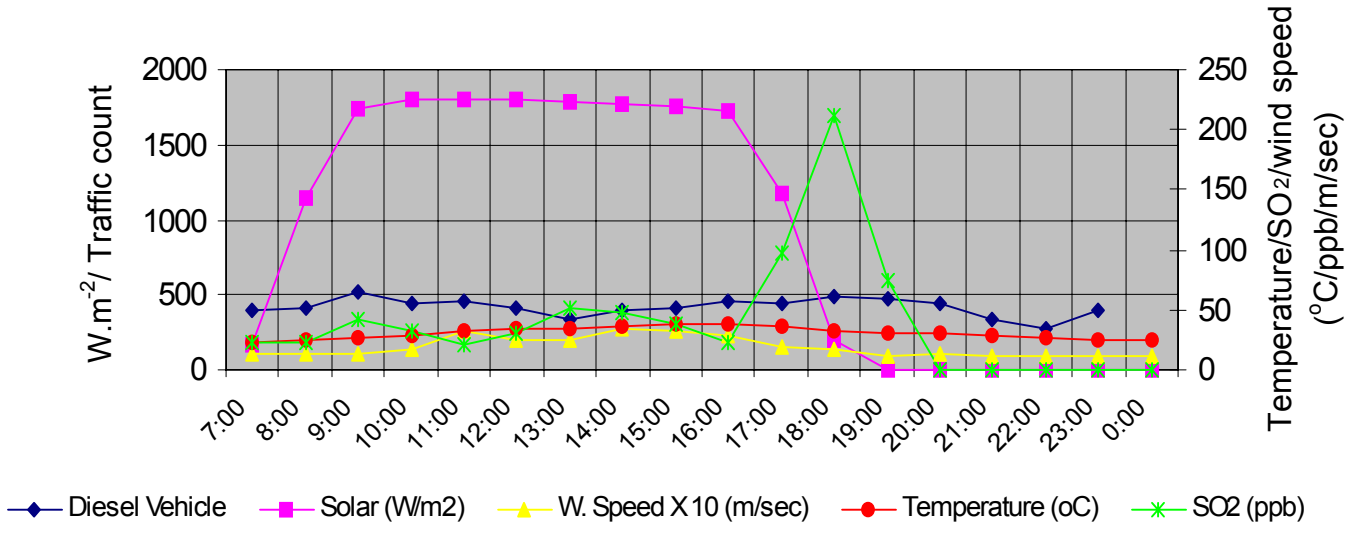
♦ It is one of the important air pollutants. Historical background and literature showed that all the air pollution episodes occurred so far are due to high concentration of SO_2 and SO_3 mist in the environment of the affected cities. The higher concentration of this pollutant in these cities was because that the people were using coal and heavy oil that contaminated higher levels of sulphur compounds by house heating and industrial usage for a long time.

Fortunately, the 3 cities studied presently are not using large quantity of fuel for these purposes. The only SO_2 emission source is diesel-powered engine in cars, except in case of industrial areas of Lahore where some emissions source could be from the industries.

While comparing the results of this investigation, the concentration of SO_2 was found lower than that of Japanese EAQS and WHO guidelines at nine points out of ten. Only one sampling point i.e. Lohari gate in Lahore city was found to have higher concentration of SO_2 than Japanese standards and WHO guidelines.

To know the reasons for high concentration of SO_2, which was recorded at 18:00 hourly average, the numbers of hourly diesel vehicles there were 492, that was second big number in that day. The other reason could be that solar power suddenly went down because of sunset and the wind speed was also lower. The air movement energy was gradually loosing, and ultimately stable conditions reached as shown in Fig 7.1.

Figure 7.1: Formation of SO_2 effecting by other factors at Lohari gate, Lahore.



➢ Low CO Concentration

It is one of the emission gases from gasoline motor vehicles, therefore, it was expected higher concentration of CO on the roadside of sampling sites. On the contrary, the results of CO investigation were very low, that means the number of vehicles passing nearby the sampling points were in small numbers compared with other foreign cities. The number of motor vehicles in each city is shown in Table 7.2.

Table 7.2: Number of Motor Vehicles in 5 Cities

Motor Vehicles	Cities				
	Lahore	**Rawalpindi**	**Santiago**	**Mexico**	**Tokyo**
Gasoline car	157,669	30,390	408,569	2,357,800	2,788,000
Diesel car	35,593	47,291	85,094	354,200	800,000
Other type of car	3,706	378	5,744	-	102,900
Motor cycle	277,381	132,683	-	-	-
Total No. of cars	474,489	271,254	499,407	2,712,000	4,616,851
% of installation with catalytic converter (estimation)	-	-	Gasoline car installed about 12% in 1993	Gasoline car installed about 48% in 1996	Gasoline car registered since 1978 is now 100%
Car inspection	-	-	Every one year	Every one year	New car 3 years, 1-2 years
Population	7,026,000	2,470,000	5,293,000	17,480,000	11,630,000

Note: Issued year of population, Lahore/Rawalpindi in 1997, Santiago in 1990, Mexico in 1994, Tokyo in 1994.

Table 7.3 shows that air quality at the roadside is not only depending on the car numbers but other important factors that influence air quality i.e. meteorological conditions and dispersion pattern of air pollutants. So far this reason, air quality data at roadside at studied points shows clean conditions.

The air quality in Mexico and Santiago cities after 1998 are improving a lot, because of percentage on the installation with catalytic converter in the cars has reached over 50%.

♦ Major sources of the NO gas emission are from mobiles at the roadside. NO is usually changed to NO_2 after short time period by exposing of sunlight and existence of oxygen in the atmosphere.

It is a harmful gas among the air pollutants, therefore, the AQS value is 110 ppb for 1 hour and 40 ~ 60 ppb for 24 hours by WHO and Japanese standard. This investigation shows that 80% of the obtained data exceed Japanese standard and 30% of the data exceeded the WHO guideline.

Japanese standard for 24 hours average value is smaller than that of WHO level, therefore, exceeded data rate is increased in 3 cities. Among the 6 air pollutants, extremely high value is shown for SPM and the secondary high value is for NO_x data. Rest of the parameters such as SO_2, CO and O_3 generally do not exceed the AQS values. Among the 3 cities investigated, Islamabad shows lower concentration. The reason considered is the same as in case of high concentration of CO at Aabpara Chowk, because of the parking of the mobile station in the middle of slope on the road.

In addition, Aabpara cross have traffic signals at each corner there and the vehicles after changing the signal to the green color, emit higher concentration of NO_x while passing to the ascending slopes. The high concentration of NO_x data also depends on the proportional increased rate by the number of vehicles.

- **Ozone (O_3)**

The present study shows very low concentrations of O_3 compare with international standards and also measured values in other foreign cities. The existence in high concentration of SPM hinders the O_3 formation even though there is rich sunlight and high NO_2 and HC concentration in the atmosphere.

The other important reason could be that the sampling points have not been taken in suburb areas, so this investigation plan has not aim to get high concentration of O_3 measurement.

7.1.3 Discussion on Air Quality Parameters

- **Suspended Particulate Matter (PM –10)**

During investigation, fortunately there were continuously stable fine days. Therefore, data can be easily compared with the dust scattering equally in 3 cities, having same dry conditions for all sampling points. The actual measurement concentrations of SPM showed extremely high level as shown in Table 7.3.

Table 7.3: SPM Data in 3 Cities (μg/m^3)

Sampling Point / Term of data evaluation	Lahore					Rawalpindi			Islamabad	
	Yateem khana Chowk	Azadi Chowk	Qurtaba Chowk	Lohari Gate	Shahrahe Quaid-i-Azam	Raja Bazar	Murree Road	Pir Wadhai	Aabpara Chowk	I-9
Hourly average data in a day	1048	745	932	888	860	787	827	514	501	539
Hourly maximum data	1362	1349	1535	1324	1400	1167	1214	1403	938	854
Hourly average data in city	895					709			520	

Table 7.4 shows the comparison of the actual measurement in 3 different cities with Japanese standard and WHO guideline.

Table 7.4: Comparison of SPM Data to International EAQS (times higher)

Sampling Point / EAQS	Data	Lahore					Rawalpindi			Islamabad	
		Yateem khana Chowk	Azadi Chowk	Qurtaba Chowk	Lohari Gate	Shahrahe Quaid-i-Azam	Raja Bazar	Murree Road	Pir Wadhai	Aabpara Chowk	I-9
Japanese Standard 200 (1 hr.)	**Ave.**	5.2	3.7	4.7	4.4	4.2	3.9	4.1	2.6	2.5	2.7
	Max.	6.8	6.7	7.7	6.6	7.0	5.8	6.1	7.0	4.7	4.3
WHO Guidelines 120 (24 hrs.)	**Ave.**	8.7	6.2	7.8	7.4	7.2	6.6	6.9	4.3	4.2	4.5
	Max.	11.4	11.2	12.8	11.0	11.7	9.7	10.1	11.7	7.6	3.0
Japanese Standard	**All City Ave.**	3.80	Each City Ave.		4.44		3.53			2.60	
WHO Guideline		6.38			7.46		5.93			4.35	

It is very clear from the measured data that SPM concentrations compared with other air quality parameters were very high and level are over the Japanese AQS and WHO guidelines. The changing pattern of SPM concentration in day time did not show typical 2 peaks at rush hour in the morning and in the evening. The SPM peaks usually appeared in late night as shown in Fig 7.2. It shows that there is some relationship between SPM, wind speed and traffic count.

In the case of Lahore especially, the wind speed in the night decreased and staying calm condition recorded as shown in Fig 7.3, except the data at Qurtaba chowk shows that the SPM value is also effected by the traffic count.

Figure7.2 Comparison of SPM Among Different Sampling Points in Lahore City (5-10 April, 2000)

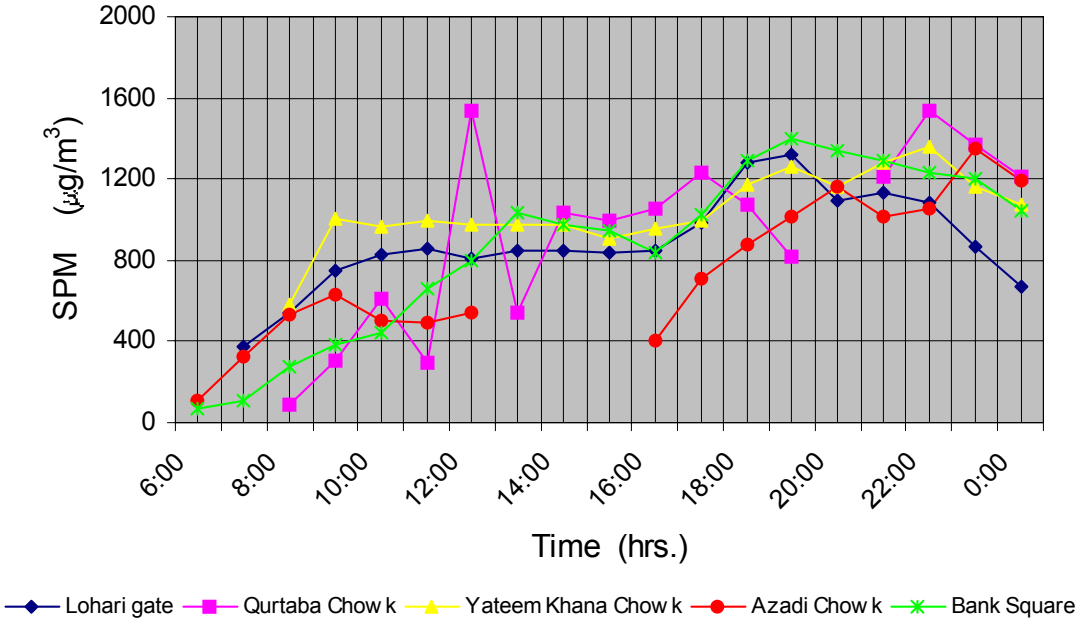
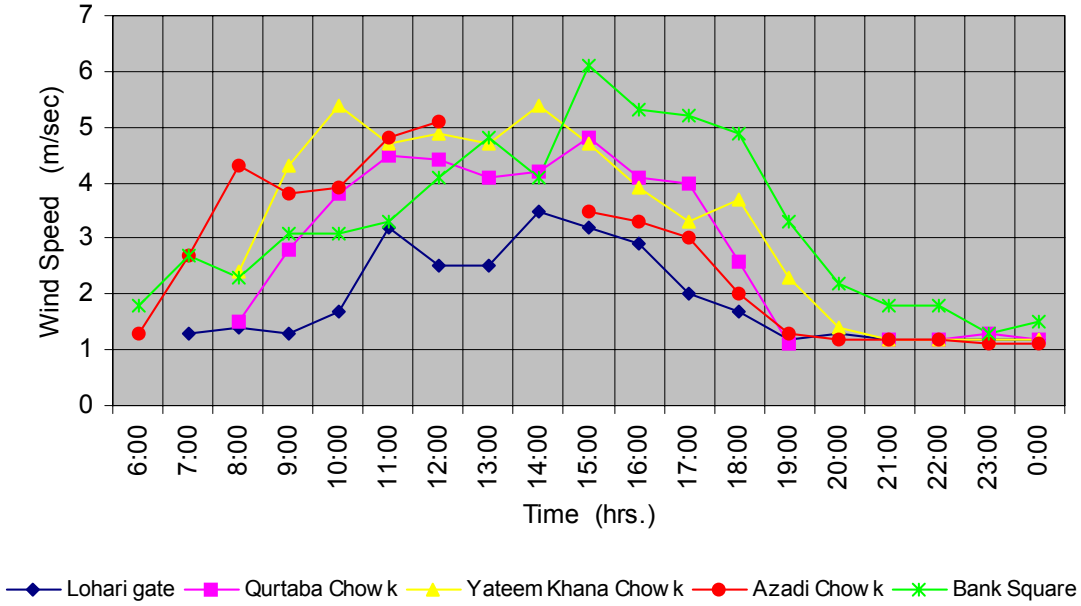


Figure7.3 Comparison of Wind Speed Among Different Sampling Points in Lahore City (5-10 April, 2000)



7.1.4 Comparison with other Big Cities in Several Countries

Table 7.5 shows the comparison of SPM level in 3 different big cities of Santiago, Mexico and Tokyo

Table 7.5: Comparison of the SPM Data to other Foreign Cities Level (μg/m^3)

Term of data evaluation	Cities									
	Santiago (City area)			Mexico (5 City area)				Tokyo (City area)		
	Daily Ave. in the month			Max. Data in 24 hrs.				Year's average		
	1990		1991	Area	1990	1992	1994	1989	1991	1993
Range of daily average in month	Oct.	Nov.	Mar.	NW	1089	2829	358			
	18-250	67~205	11~160	NE	2624	2041	806			
				Cent	1441	1316	392			
				SW	295	544	352			
Monthly average	115	143	68	SE	1745	1220	518			
Year's average	83		74		1434	1590	587	57	59	46

The Mexico city was the most contaminated city in Latin America in early 1990s, and Santiago in the Chile was the second contaminated city at that time. Tokyo was also polluted city until middle of 1970s, but now it is recovering to get the blue sky again.

Table 7.5 shows that Mexico city had a high level of SPM, reached > 2500 μg/m^3 in NW and NE area (industrial area). In Pakistan, SPM level also reached 1535 μg/m^3 at Qurtaba chowk, 1400 μg/m^3 at Shahrahe Quaid-i-Azam and 1349 μg/m^3 at Yateem khana in Lahore. However, these investigation were made only for one day (24 hrs.) at each sampling place, if each sampling site has to be continuously investigated throughout the year, then may be the maximum 1 hour average data having higher level of SPM, something like the maximum data in Mexico city.

- **Origin of SPM Emission**

The origin of the SPM sources may be the natural phenomenon, such as unpavement roads and the place where are not covered by the green grasses or trees. Fine particles size of soil may be raised in the form of dust cloud by driven motor vehicles and by strong wind blow. Other origins may be considered coming from artificial emission of SPM, such as emission gases including the particulate matter from the motor vehicle and industrial activity. Other natural sources effecting the SPM level are higher,

- Kind of surface soil
- Quantity of rainfall
- Relative moisture content in the atmosphere
- The cleaning condition on pavement roads and under construction road is included the cause of scattering factor for the SPM

➢ Analytical Procedures for Determination of the Origin of SPM

It is considered that there are several approaches to reach the origin of SPM. The analysis of the data which is coming from meteorological and air monitoring pollution parameters showing the high concentration of air pollutants together with SPM may be coming from the mobile emission. Concentration of CO, NO_x, HC might be high in gasoline engines and also SO_2 level would be high usually in diesel vehicles (in the case of diesel oil contains more than 1% of sulphur in it).

Chemical analysis methods that are often used for determination of heavy metals in ambient air are UV visible spectrometers, Atomic absorption, ICP and Polarography.

The sensory observation method are also available as the rough judgement of the origin by the color (dark brown to black color means surely coming from contaminated emission sources), size, out looking, feeling of pushing and touching it by fingers.

On the other hand, chemical and physical measurements are also an important approach, especially by the specific quality test. SPM can be divided into organic substances (high percentage of organic dust like soot, black smoke of brick kiln etc.) and inorganic substances like metals, clay or silicates. Organic content can be roughly determined by using the electronic heating furnace (350ºC, 30 minutes) to measure the reducing weight ratio (organic substance is burnt at the furnace), and an inorganic dust (like fine particles of sand and clay). Microscopic observation can be always brought more precise result on structural image, and also more helpful information to judge the originated source.

➢ SPM Effect on the Human Health

Particulate matter in air is classified broadly into "falling dust" and suspended dust. The suspended dust is further classified into suspended particulate matter of which the grain diameter is 10 μm or less for the environment standard, and others.

➢ Size

Grain diameter is very important factor, because of > 10 μm of particulate are mostly (> 90%) caught by the membranes of a nasal and throat organs. The most dangerous diameter for human health is between 2-5 μm, those ranges of size can reach the end cells of the lung tissue, and they are absorbed on the surface and accumulated there permanently.

Less than 2 μm diameter of SPM, the behavior is almost as same as air movement, so for that reason that sedimentation rate is lower for these particles i.e. between 25 ~ 30 %.

➢ Secondary Generated Particles

Apart from SPM originated by artificial or natural sources, particulate also grows from gaseous matter, such as SO_2, NO_2 and other organic chemicals receiving physical and chemical changes in the atmosphere.

Because of their complicated generation mechanism and aerosol type of secondary generated particulate, effective and conclusive effect on the human health and measures to control them have not yet been investigated.

However, exhaust emission from diesel powered vehicles, is considered that it is containing harmful mixed type of particulate by Japanese Central Council for Environmental Pollution Control in 1989.

Restrictions against black smoke emitted from diesel powered vehicles have been tightened and effected since 1993 and 1994 in Japan.

7.1.5 Sulphur Dioxide (SO_2)

- **Comparison of SO2 Data and their Moving Pattern in a Day**

Generally speaking, SO_2 in 3 cities were not so high (Table 7.6) as compared with the International Air Quality Standard and WHO guideline (Table 7.7). Only one sampling point (Lohari gate in Lahore) among all hourly average data in 3 cities exceeded from both the EAQS and WHO guideline.

Table 7.6: SO_2 Data in 3 Cities (ppb)

Sampling Point / Term of data evaluation	Lahore					Rawalpindi			Islamabad	
	Yateem khana Chowk	Azadi Chowk	Qurtaba Chowk	Lohari Gate	Shahrahe Quaid-i-Azam	Raja Bazar	Murree Road	Pir Wadhai	Aabpara Chowk	I-9
Hourly average data in a day	48	36	41	40	58	32	25	35	36	21
Hourly maximum data	88	72	95	211	95	35	47	61	60	47
Hourly average data in each city	44.6					30.7			285	

Table 7.7 shows that only data in Lohari gate in Lahore was over 2.1 times from the Japanese Standard and 1.8 times from WHO guideline. The rest of about 160 measured data value were less than the standard and guideline values.

Table 7.7: Comparison of SO_2 Data to International EAQS (times higher)

Sampling Point / EAQS	Data	Lahore					Rawalpindi			Islamabad	
		Yateem khana Chowk	Azadi Chowk	Qurtaba Chowk	Lohari Gate	Shahrahe Quaid-i-Azam	Raja Bazar	Murree Road	Pir Wadhai	Aabpara Chowk	I-9
Japanese Standard 100 ppb (1 hr.)	**Max.**	<	<	<	2.1	<	<	<	<	<	<
WHO Guideline 120 ppb (1 hr.)	**Max.**	<	<	<	1.8	<	<	<	<	<	<

Note: < means less than the standard value.

Concerning hourly SO_2 changing pattern data at sampling sites for 3 cities show rather flat line in a day. But, it shows a general tendency in increasing at SO_2 concentration in the evening and in the night time.

➢ Comparison of SO_2 Data to Other Cities

Hourly total average data in Lahore city recorded SO_2 44.6 ppb, Rawalpindi city 30.7 ppb and Islamabad 28.5 ppb, values are rather low to compare with data shown in Table 7.8.

Table 7.8: Comparison of the SO_2 Data to other Cities Level (ppb)

Term of data evaluation	Cities									
	Santiago (City area)		Mexico (5 City area)				Tokyo (City area)			
	Daily average in the month		Max. data in 24 hrs.				Year's average			
	1990		Area	1988	1991	1994	1960	1973	1985	1996
Range of daily average in month	City area	Suburb	NW	653	446	267				
	5~126	5~103	NE	542	431	412				
			Cent	326	406	194				
			SW	308	323	216				
Monthly average	41.7	31.5	SE	531	187	128				
Max. average in 24 hours				411	359	243				
Year's average				117	85	41	59	30	10	7

Note: **NW** – North West area
NE – North East area
Cent. – Central area
SW – South West area
SE – South East area

Table 7.8 shows the monthly average data for Santiago city. Comparing with air quality standards which is 240 ppb for 1 hour, 24 hours standard will be half (140 ppb) in the case of Japanese SO_2 standard. For that reason, 1-month standard value in Santiago must be lower than 140 ppb. Accordingly, it can be said that total Lahore hourly data is lower than that of Santiago monthly data.

➢ Relationship Between the Number of Vehicles and SO_2 Concentration

Any relationship between the number of vehicles and SO_2 concentration was not recognized in this study. Diesel oil in Pakistan contains about 1% of sulphur compounds in it, therefore there should be some relationship between SO_2 concentration and diesel vehicles numbers at sampling point.

Emission gas volume of diesel cars in Lahore and Rawalpindi are mostly smaller size to compare with other foreign cities, so that reason, it cannot be estimated the polluted factor by the numbers of checking the diesel cars there, as compared to large transport bus. The other reason could be that diesel engine combustion condition looks like incomplete in small diesel engine cars. Consequently the conversion rate from the sulphur compound in it, to form the SO_2 gas is lower.

On the other hand, SO_2 data in Mexico city shows all data of daily average exceeded the Japanese daily standard of 140 ppb. On the contrary, in case of Tokyo data are stable in lower level in the atmosphere since 1986.

➢ Air Pollution Episode in the World Caused by SO_2

SO_2 episode occurs from the combustion of coal (London smog in 1952, 1962, industrial cities in china now) and petroleum that contains such as heavy oil and diesel oil for the diesel engines.
Besides being known as the substance that is the cause of respiratory disease such as Yokkaichi Asthma, Yokohama Asthma, even in Tokyo area. If there is more than high concentration of 280 ppb existed in the atmosphere, there is the possibility of respiratory disease having such as Bronchitis, Bronchial Asthma, etc. In atmosphere, SO_2 is changed to SO_3 mist by chemical reaction such as photochemical oxidation in the atmosphere, SO_3 mist has many toxic stimuli to our membranes of eyes, nose, throat and lung tissues to compare with SO_2 effect. SO_3 mist is 4 ~ 20 times stronger to stimulate to the membranes than that of SO_2.

➢ Analysis of SO_2 Data by Test Tube Method

Gastec test tube method is based on to detect the air pollutant concentration in the atmosphere by changing the color of chemicals, which is packed into the testing glass tube sucking the outside air by 100-ml syringe. In the case of target measurement air pollutant existed there, specific chemicals will be changed the color by chemical reaction in the tube. And then the inspector knows the target gas concentration by the changing color length on the concentration mark of the testing tube.

Sampling time for test tube method was usually around 2 – 10 minutes and sampling height was about 1.2 m from the ground level. On the other hand, in the case of air monitoring by mobile station, the height was about 4.5 m from mobile sampling point. The testing tube sampling point was closer to the mobile emission source.

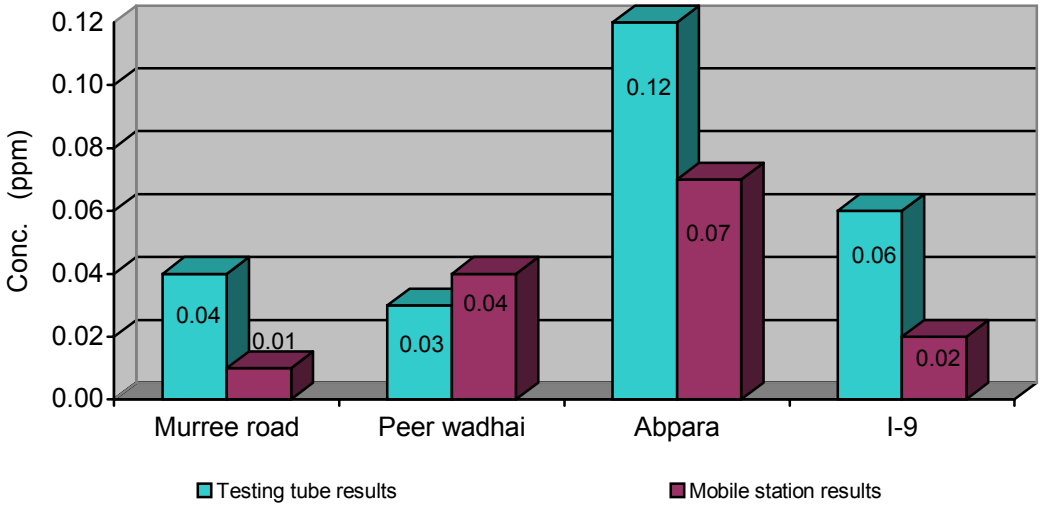
According to the reasons mentioned above, the value of measurement data by test tube method would have higher value than the measurement data by monitoring station as shown in Table 7.9.

Table 7.9: SO_2 Data Analyzed by Test Tube Method

Sampling Point / Measurement Method	Lahore					Rawalpindi			Islamabad	
	Yateem khana Chowk	Azadi Chowk	Qurtaba Chowk	Lohari Gate	Shahrahe Quaid-i-Azam	Raja Bazar	Murree Road	Pir Wadhai	Aabpara Chowk	I-9
Testing Tube Method	0.16	2.0	0.1	0.07	0.1	-	0.04	0.03	0.12	0.06
Mobile Station Data	-	-	-	-	-	-	0.01	0.04	0.07	0.02
Ratio between testing tube & mobile lab. data	-	-	-	-	-	-	4.0	0.8	1.7	3.0

Fig 7.4 shows the measurement of SO_2 data by testing tube method and its comparison with the data recorded by mobile station.

Figure-3 Measurement of SO_2 data by testing tube and mobile station.



7.1.6 Carbon Monoxide (CO)

Carbon monoxide in the air occurs due to incomplete combustion of fuel. The major source is from motor emission.

- **Consideration on CO Data by Mobile Station**

The CO data measured by mobile station of EPD in this investigation showed low concentration as compared by visual information on roadside sampling points were fully occupied by the blue color of emission gas in Lahore and Rawalpindi cities.

Table 7.10 shows that hourly maximum values reached to 9.4 ppm at two monitoring sites in Lahore city and Rawalpindi, Islamabad has lower CO than the Lahore. There may be several reasons of it, one may be the different quantity of vehicle count in each city. Lahore sampling points were rather crowded having more traffic load among the three cities except Murree road in Rawalpindi.

Table 7.10: CO Data in 3 Cities (ppm)

Sampling Point / Term of data evaluation	Lahore					Rawalpindi			Islamabad	
	Yateem khana Chowk	Azadi Chowk	Qurtaba Chowk	Lohari Gate	Shahrahe Quaid-i-Azam	Raja Bazar	Murree Road	Pir Wadhai	Aabpara Chowk	I-9
Hourly average data in a day	2.3	2.7	2.9	2.3	3.9	1.4	2.4	1.7	1.2	1.9
Hourly maximum data	7.0	9.4	9.4	4.2	6.8	2.8	6.7	3.6	3.0	3.6
Hourly average data in each city	2.82					1.83			1.55	
Hourly maximum data in each city	7.36					4.04			3.30	
All hourly average data	2.27									

Table 7.11 shows that comparison of CO data to International Air Quality Standards, all measured data in this investigation were lower than Japanese standard and WHO guidelines.

Table 7.11: Comparison of CO Data to International EAQS (times higher)

Sampling Point / EAQS	Data	Lahore					Rawalpindi			Islamabad	
		Yateem khana Chowk	Azadi Chowk	Qurtaba Chowk	Lohari Gate	Shahrahe Quaid-i-Azam	Raja Bazar	Murree Road	Pir Wadhai	Aabpara Chowk	I-9
Japanese Standard 20 ppm (8 hrs.)	**Ave.**	<	<	<	<	<	<	<	<	<	<
	Max.	<	<	<	<	<	<	<	<	<	<
WHO Guidelines 35 ppm (1 hr.)	**Ave.**	<	<	<	<	<	<	<	<	<	<
	Max.	<	<	<	<	<	<	<	<	<	<

Note: < means less than the standard value.

➢ Comments on the CO Data by Test Tube Method

Table 7.10 shows CO data that was measured at 9 sampling points in 3 cities. Three sampling points (Yateem khana chowk, Azadi chowk and Qurtaba chowk in Lahore) have > 30 ppm concentration of CO. The reason for such high concentration could not be pointed out but the following factors might be considered for high concentration of CO at these sampling points in Lahore.

➢ Sampling Point

CO measurement data by Gastec test tube method was taken so close to the mobile emission source where the distance between sampling site and car stream was roughly 2 ~ 3 m.

Therefore, sometimes the possibility of sucking by syringe high concentration of CO gas directly from the emission source.

- **The other Reason Might be the Number of Cars Passing During the Test Tube Sampling Period**

In case of CO, also measurement by Gastec testing tube method indicates the limitation of temperature within 40ºC, however, actual temperature on that day in the morning was 36ºC, mid day was 41ºC and in the late afternoon was 39ºC. Observation at high temperature shows that the color in the test tube was quickly finished before sucking < 50 ml of air.

- **Comparison of the CO Data to other Foreign Cities**

Table 7.12 shows the comparison of CO data with other foreign cities.

Table 7.12: Comparison of the CO Data to other Cities Level (ppm)

Term of data evaluation	Cities									
	Santiago (City area)		Mexico (5 City area)				Tokyo (City area)			
	Daily average in the month		Maximum data in 24 hours				Year's average			
	Aug. 1990		Area	1987	1991	1994	1960	1971	1982	1994
Range of daily average in month	City area	Suburb	NW	50	37	34				
	1.5~29.9	0.9~3.9	NE	30	30	25				
			Cent	47	50	23				
1 hour maximum	24	4.0	SW	44	24	25				
8 hours maximum	11.2	3.2	SE	43	42	30				
Monthly average	10.4	2.0		28.7	27.7	21.6				
Year's average	3.1	0.9		8.1	10.8	7.3	6.5	3.1	1.0	0.8

Note: **NW** – North West area
NE – North East area
Cent. – Central area
SW – South West area
SE – South East area

Comparing the two data between 3 cities and foreign cities, hourly maximum data for Qurtaba chowk and Azadi chowk were recorded to be 9.4 ppm in Lahore city. However, to compare with the data of Mexico city, 8 hours data is reaching to 40 ~ 50 ppm and for Santiago city is 24 ppm for 8 hours average. The CO value in 3 cities is not higher as compared to Mexico and Santiago city.

- **CO Effect on Human Health**

CO is very toxic gas for the reason that it has the capacity to easily react with hemoglobin (Hb) in the blood replacing oxygen. The combining power with Hb is about 210 times stronger than O_2. So for that reason it prevents oxygen-carrying function. Therefore, if there is 30 ppm of CO concentration of > 4 ~ 6 hours, this CO-Hb ratio in the blood reached to about 5%, that percentage of CO-Hb usually have effects on the obstruction to exchange the function from CO_2 to O_2 by Hb.

7.1.7 NO and NO_x

NO and NO_2 occur mainly due to the combustion of fossil fuels. The sources of these gases in the atmosphere are the mobile emission and stationary sources, such as the boilers and furnaces of industrial activities.

Table 7.13: NO Data in 3 Cities (ppb)

Sampling Point / Term of data evaluation	Lahore					Rawalpindi			Islamabad	
	Yateem khana Chowk	Azadi Chowk	Qurtaba Chowk	Lohari Gate	Shahrahe Quaid-i-Azam	Raja Bazar	Murree Road	Pir Wadhai	Aabpara Chowk	I-9
Hourly average data in a day	82	57	163	18	122	18	101	88	120	70
Hourly maximum data	194	332	499	25	242	57	207	263	355	192
Hourly average data in each city	88.4					69.0			95.0	
Number's of traffic count	89,889	101,243	192,484	81,835	111,743	-	110,639	19,646	44,755	8,736

There is no international EAQ standard, therefore, the data of 3 cities cannot be compared with those standards.

Table 7.14 shows NO_x data in 3 cities. The values are very high next to SPM in this investigation.

Table 7.14: NO_x Data in 3 Cities (ppb)

Sampling Point / Term of data evaluation	Lahore					Rawalpindi			Islamabad	
	Yateem khana Chowk	Azadi Chowk	Qurtaba Chowk	Lohari Gate	Shahrahe Quaid-i-Azam	Raja Bazar	Murree Road	Pir Wadhai	Aabpara Chowk	I-9
Hourly average data in a day	195	155	233	70	130	47	121	56	173	124
Hourly maximum data	345	401	556	96	423	110	237	95	350	239
Hourly average data in each city	156.6					74.7			148.5	
Number's of traffic count	89,889	101,243	192,484	81,835	111,743	-	110,639	19,646	44,755	8,736
% of traffic (Total 760,970)	11.8	13.3	25.3	10.6	14.7	-	14.5	2.6	5.9	1.2

Table 7.15 shows the comparison of NO_x concentration to international EAQ Standard. Japanese standard is set up for 24 hours evaluation period and WHO guidelines for evaluation period of 1 hour.

Table 7.15: Comparison of NO_x Data to International EAQS (times higher)

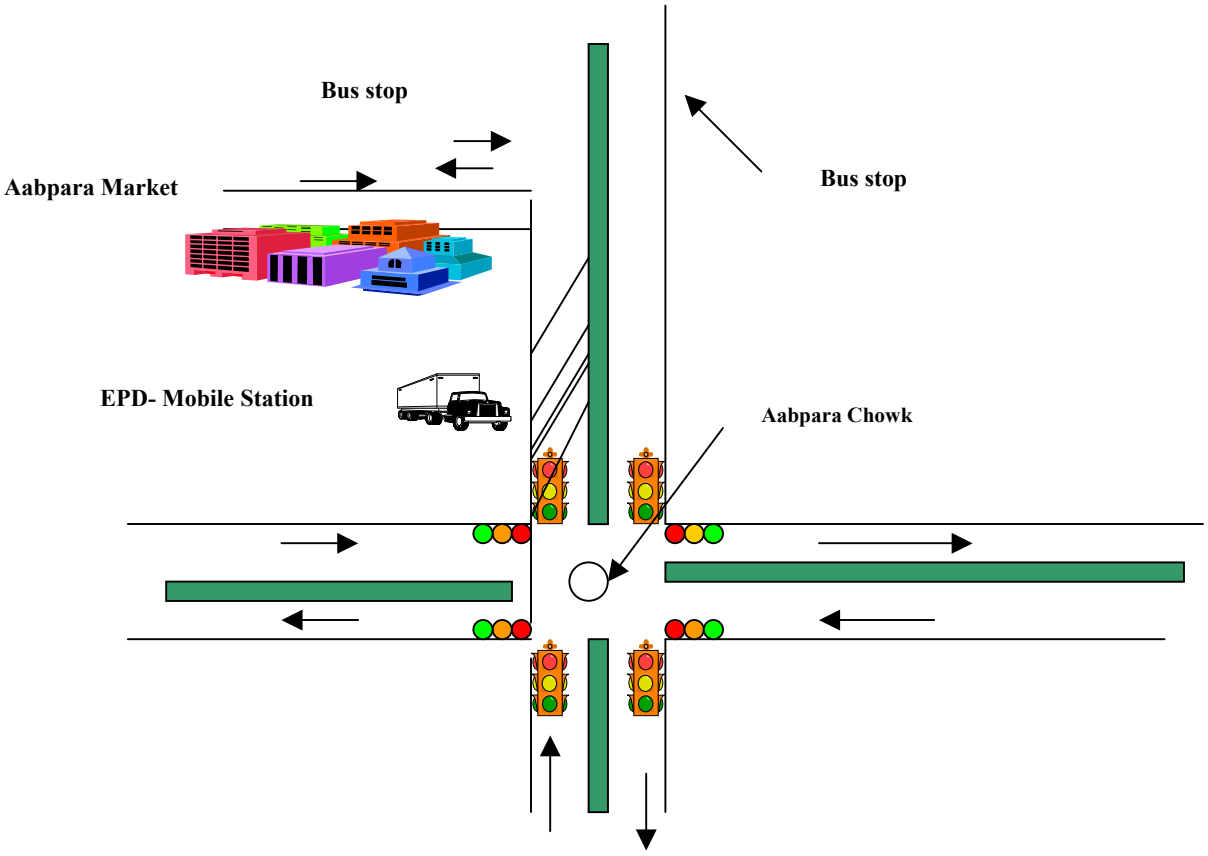
Sampling Point / EAQS	Data	Lahore					Rawalpindi			Islamabad	
		Yateem khana Chowk	Azadi Chowk	Qurtaba Chowk	Lohari Gate	Shahrahe Quaid-i-Azam	Raja Bazar	Murree Road	Pir Wadhai	Aabpara chowk	I-9
Japanese Standard 40~60 ppb (24 hrs.)	**Ave.**	1.4	<	2.7	<	2.0	<	1.7	1.5	2.0	1.2
	Max.	3.2	5.6	8.3	<	4.0	<	3.5	4.4	5.9	3.2
WHO Guidelines 110 ppb (1 hr.)	**Ave.**	<	<	1.5	<	1.1	<	<	<	1.1	<
	Max.	1.8	3.0	4.5	<	3.8	<	1.9	2.4	3.2	1.8

Note: < means less than the standard value.

The results in Table 7.15 show that NO_x concentration at Qurtaba chowk and Shahrahe Quaid-i-Azam in Lahore and at Aabpara chowk in Islamabad exceeded the WHO guideline. The percentage of traffic count at Qurtaba chowk (25.3%) and Shahrahe Quaid-i-Azam (14.7%) in Lahore seemed to be effected also by the mobile emission.

Aabpara sampling point in Islamabad have not so big number of traffic count (5.9%) that might be explained by the reason that parking of the mobile station was located in the middle of slope on the road, beside traffic signal at Aabpara cross as shown in Fig 7.5.

Figure7.5: Location of Mobile Lab. at Aabpara Sampling point in Islamabad.



Therefore, most cars, which pass through on the side of mobile station, had to accelerate their engine power strongly. This driving acceleration made car's emission bigger volume and worth its quality.

Table 7.16: Comparison of the NO_x Data to other Foreign Cities Level (µg/m^3)

Sampling Point / Measurement Data	Cities									
	Santiago (City area)		Mexico (5 City area)				Tokyo (City area)			
	Daily Ave. in the month		Max. Data in 1 hr. (ppb)				Year's average			
	Aug. 1990 (µg/m3)		Area	1989	1991	1994	1965	1978	1985	1994
Range of daily average in month	City area	Suburb	NW	320	273	391				
	135~346	67~313	NE	189	370	176				
			Cent	300	324	351				
			SW	252	270	202				
Monthly average	310	189	SE	232	238	188				
Year's average	1990. 45	1990. 28		112	86	85	18	39	30	32

Note: **NW** – North West area
NE – North East area
Cent. – Central area
SW – South West area
SE – South East area

The hourly maximum data in Mexico city is shown between 176 – 390 ppb in Table 7.16, while on the other hand, 3 cities data shows level in between 96 – 556 ppb. The data for 3 cities is not so much different as compared to the data for Mexico city, means that both are the worst air contaminated cities.

➢ Analysis of NO and NO_x Data by Test Tube Method

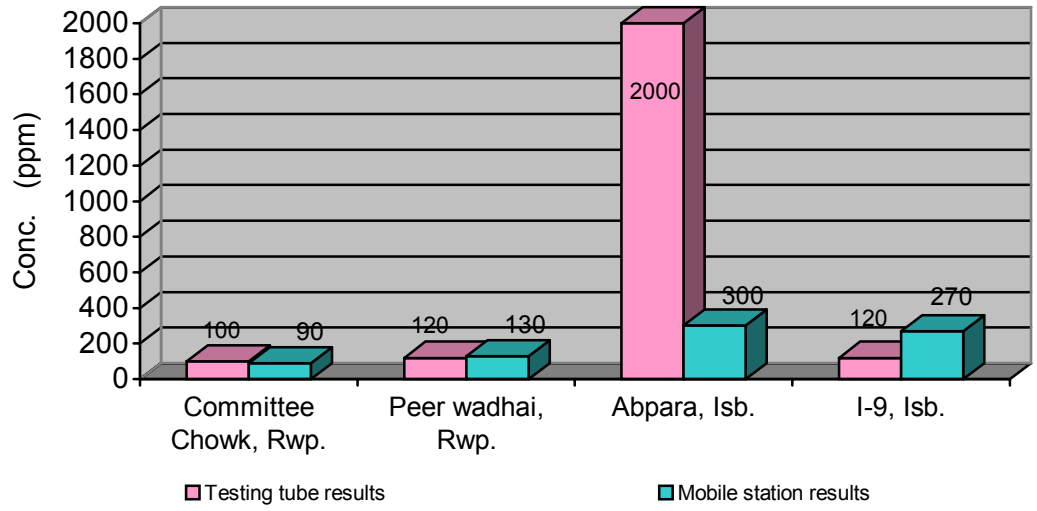
Test tube method for NO and NO_x in case of Lahore have not been measured. In case of measured data in Rawalpindi and Islamabad, the data at 4 sampling points by both mobile station and test tube at almost the same sampling point have been checked (Table 7.17). Aabpara sampling point of NO and NO_x detected very high concentration measured by Testing tube. It was not estimated the reason of high concentration but, Aabpara and I-9 in Islamabad there were big passenger cars (which emit bigger emission gas volume) running there to compare with Rawalpindi.

Table 7.17: NO and NO_x Data Analyzed by Test Tube Method (ppb)

Sampling Point / Measurement Method	Rawalpindi		Islamabad	
	Pir Wadhai Chowk	Committee Chowk	Aabpara	I-9
Testing tube method	120	100	2000	120
Mobile station data	130	90	300	270
Ratio between testing tube and mobile lab. data	0.92	1.11	6.66	0.44

Fig 7.6 shows not much difference between the values measured by Gastec test tube and mobile station, except Aabpara chowk, Islamabad.

Figure-5 Measurement of NO and NO_x data by testing tube and mobile station.



7.1.8 Ozone (O_3)

- **Measurement of O_3 Concentration in 3 Cities and Health Effects**

Hourly average concentration of O_3 in this investigation is within the WHO guidelines. However, looking at the 15 minutes average data at 3 sampling points among 10 sampling points shows high concentration of ozone such as 161 ppb at Aabpara, Islamabad, 160 ppb at Murree road, Rawalpindi, 150 ppb at Qurtaba chowk, Lahore. 15 minutes average data cannot be compared directly with one hours average data of O_3 concentration with WHO guideline. So it is necessary to pay attention to the effect on the human being health. Table 7.18 shows hourly average ozone data in 3 cities.

Table 7.18: O_3 Data in 3 Cities (ppb)

Sampling Point / Term of data evaluation	Lahore					Rawalpindi			Islamabad	
	Yateem khana Chowk	Azadi Chowk	Qurtaba Chowk	Lohari Gate	Shahrahe Quaid-i-Azam	Raja Bazar	Murree Road	Pir Wadhai	Aabpara Chowk	I-9
Hourly average data in a day	2.3	11	8.9	8.3	12	24	11	16	8.3	12
Hourly maximum data	13	41	49	44	52	59	53	55	48	53
Hourly average data in each city	8.5					17.0			10.2	

Usually higher value of ozone is recorded for those sampling points where the concentration of primary air pollutants such as SO_2, NO, NO_x, and SPM was low by comparing hourly average data for 3 cities.
All the recorded ozone data in 3 cities were found to be within the Japanese standard and WHO guidelines, as shown in Table 7.19.

Table 7.19: Comparison of O_3 Data to International EAQS (times higher)

Sampling Point / EAQS	Data	Lahore					Rawalpindi			Islamabad	
		Yateem khana Chowk	Azadi Chowk	Qurtaba Chowk	Lohari Gate	Shahrahe Quaid-i-Azam	Raja Bazar	Murree Road	Pir Wadhai	Aabpara Chowk	I-9
Japanese Standard 60 ppb (1 hr.)	**Ave.**	<	<	<	<	<	<	<	<	<	<
	Max.	<	<	<	<	<	<	<	<	<	<
WHO Guidelines 90 ppb (1 hr.)	**Ave.**	<	<	<	<	<	<	<	<	<	<
	Max.	<	<	<	<	<	<	<	<	<	<

Note: < means less than the standard value.

➢ Factors Effecting the Ozone (O_3) Formation in 3 Cities

Photochemical oxidants are substances that have a strong oxidizing power, such as ozone (O_3) secondarily formed by the photochemical reaction. It is formed when the primary polluting substances such as the nitrogen oxides (NO_x) and non Methane Hydrocarbons (n-MeHC), which are emitted from motor vehicles and factories, when they are hit by ultraviolet rays of the sun in the atmosphere.

On the other hand, progression of the photochemical reaction is usually promoted in the existence of high concentration of NO_x (Nitrogen oxide), which is the most dominant factor, and also it is usually obstructed by the high concentration of existence of suspended particulate matter (SPM) and sulphur dioxide (SO_2) in the atmosphere. Therefore, relatively high concentration of ozone appeared in the suburb area in the big cities, as in the cases of Mexico, Santiago and Tokyo.

Concerning O_3 formation, the existence of solar rays, high temperature, low wind speed (< 2m/sec), and high concentration of NOx and n-MeHC, accelerate the photochemical reaction.

The formation of ozone at 15:15 shows high peak because the wind speed went down from 3-4m/sec, the solar ray became weaker and the air movement was slowly descending towards the ground level on the road.
At the same time, SPM (dust) and SO_2 concentration were decreasing. This phenomenon happened at three different stations exactly at the same time showing sharp peaks of ozone from 15:15 to 15:30 in different cities (Fig 7.7-7.8).

Figure7.7: Factors effecting concerning O_3 formation at Murree Road, Rawalpindi.

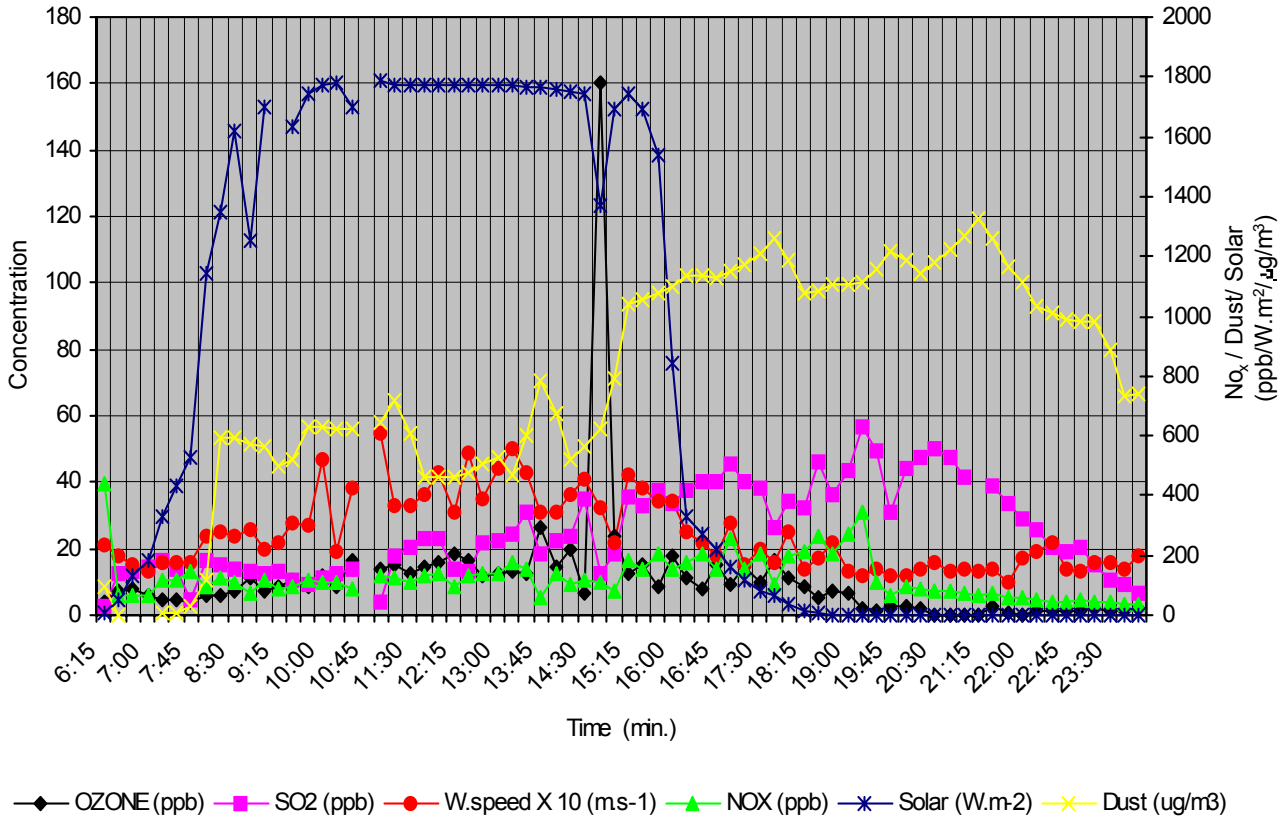


Table 7.20 shows the data recorded in other foreign cities. Hourly average data in Mexico city and the suburb of Santiago city recorded > 250ppb and also year's average data in Mexico and Tokyo cities exceeded 183 –240 ppb in 1993 and 1994. The high peak of O_3 was recognized at 16:45, it was looked like same electrical error of the O_3 meter.

Table 7.20: Comparison of the O_3 Data to other Foreign Cities Level (ppb)

Sampling Point / Measurement Data	Cities									
	Santiago (City area)		Mexico (5 City area)				Tokyo (City area)			
	Daily Ave. in the month		Max. Data in 1 hr. (ppb)				City area		Suburb	
	Aug. 1991 (ppb)		Area	1987	1990	1994	1989	1993	1989	1993
Range of daily average in month	City area	Suburb	NW	407	341	301				
	29~194	23~703	NE	139	198	202				
			Cent	302	496	285				
			SW	405	403	312				
			SE	223	268	262				
Monthly average	109	257	Ave.	295	341	272				
Year's average	-	-		103	124	183	150	210	190	240

Note: **NW** – North West area
NE – North East area
Cent. – Central area
SW – South West area
SE – South East area

➢ O_3 Effecting Human Health

High ozone concentration effecting on the respiratory organs and mucous membrane are known in Japan. The episode of ozone effected to the human health has been observed in case of Tokyo and Osaka, Japan, when high concentration of ozone effect the students being under exercise at playground of senior high school in suburb area of the Tokyo, July in 1970. Same student fell down on the ground with difficulty of breathe and complained of a pain at eyes and the throat. O_3 attacking time might be < 20 minutes after checking the symptoms of these and taking the rest of several hours in the hospital. They recovered from these symptoms in one or two days.

7.1.9 Hydrocarbons (H.Cs)

➢ Hydrocarbons Concerning Air Pollution

Hydrocarbons are important air pollutant to be known by the source of mobile emission and also stationary sources such as repair shops for car, printing and painting companies etc.

Hydrocarbons consist of lot of toxic gases such as Benzene, Toluene, Xylene, Methyl Ethyl Ketone (MEK), Methyl iso-Butyl Ketone (MiBK), Trichloroethylene, Tetrachloroethylene and Styrene etc. These gases have toxicity to the human health and also BTX (Benzene, Toluene and Xylene) are usually known to be one component for promoting the photochemical reaction.

➢ Hydrocarbons Measurement Data

Mobile air monitoring station has installed two types of HC meter, one is the total hydrocarbon and other is non-methane hydrocarbon (n-MeHC) that means from

T-HC - methane = n-MeHC

Table 7.21 shows data of methane HC at 3 sampling points in Rawalpindi

Table 7.21: Methane HC Data in 3 Cities (ppm)

Sampling Point / Measurement Item	Lahore					Rawalpindi			Islamabad	
	Yateem khana Chowk	Azadi Chowk	Qurtaba Chowk	Lohari Gate	Shahrahe Quaid-i-Azam	Raja Bazar	Murree Road	Pir Wadhai	Aabpara Chowk	I-9
Hourly average data in a day	-	-	-	-	-	0.6	0.8	0.1	-	-
Hourly maximum data	-	-	-	-	-	1.6	2.2	0.7	-	-
Hourly average data in each city	-									
Number of traffic count	-	-	-	-	-	-	110,639	19,646	-	-

Table 7.22 shows the data of non-methane hydrocarbon concentration and Table 7.23 shows the data of total hydrocarbon concentration.

Table 7.22: non-Methane Hydrocarbon Data in 3 Cities (ppm)

Sampling Point / Term of data evaluation	Lahore					Rawalpindi			Islamabad	
	Yateem khana Chowk	Azadi Chowk	Qurtaba Chowk	Lohari Gate	Shahrahe Quaid-i-Azam	Raja Bazar	Murree Road	Pir Wadhai	Aabpara Chowk	I-9
Hourly average data in a day	-	-	-	-	-	4.8	5.4	0.5	-	-
Hourly maximum data	-	-	-	-	-	10.3	10.5	4.7	-	-
% of non-methane average hourly data in a day	Data not available					88.8%	87.0%	83.3%	-	-
% of non-methane hourly maximum data	Data not available					86.5%	82.6%	83.3%	-	-

Table 7.23: Total Hydrocarbon Data in 3 Cities (ppm). (Methane + non-Methane)

Sampling Point / Term of data evaluation	Lahore					Rawalpindi			Islamabad	
	Yateem khana Chowk	Azadi Chowk	Qurtaba Chowk	Lohari Gate	Shahrahe Quaid-i-Azam	Raja Bazar	Murree Road	Pir Wadhai	Aabpara Chowk	I-9
Hourly average data in a day	-	-	-	-	-	5.4	6.2	0.6	-	-
Hourly maximum data	-	-	-	-	-	11.9	12.7	5.4	-	-

Ratio of non-methane hydrocarbon in total hydrocarbon for Rawalpindi is about 80%.

Table 7.24: Comparison of Total Hydrocarbon Data Between Santiago and Rawalpindi (ppm)

	Santiago				Rawalpindi		
	June 1990		September 1990		City area		
	City area	Suburb	City area	Suburb	Raja Bazar	Murree Road	Pir Wadhai
Hourly maximum total Hydrocarbon in a day	6.6	2.0	3.3	1.6	11.9	12.7	5.4
Hourly average of the sampling					10.0		

To compare with total hydrocarbon between the data of Rawalpindi and Santiago (Chile). It is recognized that data of Rawalpindi was much higher than that of data in Santiago. It might be considered that the quality of emission gas in Rawalpindi has more high concentration of THC and non-methane hydrocarbon.

- **Hydrocarbons by Solvent Checker and Gastec Test Tube Method**

Table 7.25 shows hydrocarbon concentration of roadside for the same sampling points as for test tubes.

Table 7.25: Hydrocarbon Data by Solvent Checker (ppm)

Sampling Point	Lahore					Rawalpindi			Islamabad	
	Yateem khana Chowk	Azadi Chowk	Qurtaba Chowk	Lohari Gate	Shahrahe Quaid-i-Azam	Raja Bazar	Murree Road	Pir Wadhai	Aabpara Chowk	I-9
	85	46	32	74	8	-	-	-	-	-
	112	64	72	90	120					
	102	36	50	36	140					
	80	60	56	64	-					
Average	95	52	53	66	89	-	-	-	-	-

As the sampling points were relatively closer to the car running stream at a distance of about 2 ~ 3m, therefore, measurement data by solvent checker and Gastec test tubes showed higher levels than by the mobile station data.

7.2 Comments on Water Quality Analysis Written by Y. SHIGETA (JICA-Environmental Expert, Pak-EPA)

7.2.1 The Outline of this Investigation

This part of the study covers the river water quality sampling and analysis in 3 cities in Pakistan i.e. Lahore, Rawalpindi and Islamabad. The water quality parameters analyzed were BOD, COD, Total Nitrogen, TSS, Oil and Grease, E.Coli[1], and also hazardous chemicals such as Arsenic, Copper, Chromium, Cadmium, Lead and Zinc. Other parameters such as flow rate, temperature, pH, DO, conductivity, odor, turbidity, color were measured at the site of sampling. The data collection points (sampling points) are given in Tables 7.26 and 7.27.

Table 7.26: Sampling Points in Lahore

No.	Sampling Point	Monitoring Date
1.	River Ravi BRB Siphon (Composite)	April 4, 2000
2.	New Shadbagh Sewage Drain, Bund Road	April 7, 2000
3.	River Ravi Bara Dari Near Boat Station	April 4, 2000
4.	Babu Sabu Drain, Bund Road	April 7, 2000
5.	Babu Sabu Outfall, (Before joining river Ravi)	April 5, 2000
6.	Main Outfall Drain, Bund Road	April 7, 2000
7.	Deg Nullah, Sheikhupura Road	April 9, 2000
8.	Choti Deg Nullah, Sheikhupura Road	April 9, 2000
9.	Bhed Nullah Sheikhupura Road	April 11, 2000
10.	Hudiara Drain, From India	April 8, 2000
11.	Hudiara Drain, Ferozepur Road	April 8, 2000
12.	Satokatala Drain, Defence Road	April 12, 2000
13.	Hudiara Drain, Multan Road	April 7, 2000
14.	River Ravi at Junction of Hudiara Drain	April 5, 2000
15.	River 1 KMD/S of Hudiara Drain	April 5, 2000
16.	Baloki Headworks (Composite)	April 13, 2000
17.	Chichukimallian Drain, Sheikhupura Road	April 9, 2000
18.	Barian Drain 1 km off Sheikhupura Road	April 11, 2000
19.	Deg Nullah II, Before River Ravi After Baloki HW	April 10, 2000
20.	Mundawana, Samundari Drain before Ravi	April 10, 2000

BOD : Biochemical Oxygen Demand
COD : Chemical Oxygen Demand
DO : Dissolved Oxygen
O & G : Oil and Grease
E-Coli[1] : Escherichia Coli
TSS : Total Suspended Solid

Table 7.27: Sampling Points in Rawalpindi and Islamabad

No.	Sampling Point	Monitoring Date
1.	E-8 Near Navy House Karakuram Road	April 4, 2000
2.	E-7 Hill Side Road opp. St. 16	April 13, 2000
3.	F-8/2 Before Fatima Jinnah Park	April 4, 2000
4.	F-6/2 Near Alkhizar Mosque Margalla Road	April 5, 2000
5.	F-5/2 Near Azad Jammu Kashmir Secretariat	April 5, 2000
6.	Near American Embassy	April 6, 2000
7.	Peshawar Road	April 6, 2000
8.	I-10 Pirwadhai Crossing, Nullah 1	April 7, 2000
9.	I-10 Pirwadhai Crossing, Nullah 2	April 7, 2000
10.	I-10 Pirwadhai Crossing, 200 m After Joining	April 7, 2000
11.	Nullah Leh Near Gawalmandi Bridge	April 10, 2000
12.	Jahanda Chichi, Airport Road	April 10, 2000
13.	Nullah Leh at Gulistan Colony Line-1	April 13, 2000
14.	Nullah Leh Before Joining River Soan	April 11, 2000
15.	Chattar Park	April 7, 2000
16.	Rawal Dam	April 13, 2000
17.	Stream Water Korang Nullah Lehtrar Road	April 12, 2000
18.	Nullah Kura, Shahrah-e-Islamabad	April 12, 2000
19.	River Soan Before Soan Bridge	April 11, 2000
20.	Mix of Soan and Nullah Leh	April 11, 2000

Sampling was carried out batch-wise system and samples were immediately carried in cooling boxes by car to transport them in different laboratories. The data reported in this investigation consists of samples taken in duplicate at each sampling point in one day. The obtained data was then compared with water quality standards of Japan to assess the levels and see any implications on the health of human beings.

However, the sampling method of twice a day at one place can be used to know the polluted condition at that time on the day only, because the water quality can be affected and changed by the conditions of water polluting sources, quality of rainfall and usage of the river water as irrigation before upper stream of the sampling point.

7.2.2 Characteristics of Water Quality in Selected 3 Cities

The reported data shows the levels of different pollutants at the time of sampling for the month of March and April, 2000. A variation in the levels of pollutants could be related with the rainfall and different operational conditions of the polluting sources mentioned above.

High concentrations of BOD, COD and TSS have been recorded at each sampling point at River Ravi in Lahore, Nullah Leh in Rawalpindi and a small stream in both cities Rahagum Kass. The details of each parameter and its comparison with water quality standard of Japan are given below.

7.2.3 High BOD Concentration

Comparing with Japanese Environmental Water Quality Standard of BOD in river water shown in Table 7.28, that showed 70% of samples taken from the rivers in Lahore detected more than 100 ppm of BOD, while 30% of samples in rivers of Rawalpindi exceeded 100 ppm of BOD.

Table 7.28: Japanese Environmental River Water Quality Standards for Living Environment Items

Purpose of Water		Standard Values				
		pH	BOD	SS	DO	No. of Coliform Groups
AA	Water supply, class 1 conservation of natural environment, and uses listed in A-E	6.5-8.5	1 ppm or less	25 ppm or less	7.5 ppm or more	50 MPN/100 ml or less
A	Water supply, class 2 fishery, class 1 bathing and uses listed in B-E	6.5-8.5	2 ppm or less	25 ppm or less	7.5 ppm or more	1000 MPN/100 ml or less
B	Water supply, class 3 fishery, class 2 and uses listed in C-E	6.5-8.5	3 ppm or less	25 ppm or less	5 ppm or more	5000 MPN/100 ml or less
C	Fishery, class 3 industrial water, class and uses listed in D-E	6.5-8.5	5 ppm or less	50 ppm or less	5 ppm or more	-
D	Industrial water, class agricultural water and uses listed in E	6.0-8.5	8 ppm or less	100 ppm or less	2 ppm or more	-
E	Industrial water, class conservation of the environment	6.0-8.5	10 ppm or less	Floating matter such as garbage should not be observed	2 ppm or more	-

BOD : Biochemical Oxygen Demand
SS : Suspended Solids
DO : Dissolved Oxygen

According to Table 7.28, the BOD concentration in the river water being used for the conservation of natural environment (i.e. category AA) should be 1 ppm or less. While river water required for industrial purpose could have a concentration of 10 ppm or less. Comparing with these Japanese Standard values, the BOD concentrations detected in the samples in Lahore, Rawalpindi were extremely high.

Table 7.29a shows the BOD values of river water in Lahore, and Table 7.29b shows the BOD values in Rawalpindi and Islamabad. Highest BOD value recorded is at sampling point No. 10 along the Bhed Nullah. This high BOD could be attributed and effected by industrial wastes and fertilizers, as this sampling point is located in industrial area. Generally speaking, sewage water in domestic waste has usually 160-200 ppm of BOD. So, a BOD of more than 400 ppm means very polluted organic substances which easily decayed by the bacterial enzyme can consume such a high DO demand i.e. BOD value.

Comparing with the more than 100 ppm of BOD samples in the river water quality, 70% of samples in Lahore and 30% in Rawalpindi areas are over 100 ppm, on the other hand 10 Islamabad area samples are all less than 100 ppm. Originated water starts from mountainside in the northern part of Islamabad and goes to Rawalpindi rivers where it is much more loaded with domestic Wastewater. This then goes to Lahore area as river Ravi. Usually downstream of river is much more polluted.

However, the river water has self purification function i.e. TSS including organic components descend to the bottom of water stream as a sludge when river flow speed is low (sedimentation) and also the bacteria in the water are decomposing by their enzyme from high molecular weight substances to lower molecular weight substances. During the streaming if there is some aeration, purification function could be accelerated. As a result of self-purification, BOD and COD concentrations in the river water are usually decreasing.

This ratio should be determined depending on the following conditions such as supplying the oxygen from air into river water (aeration), which occur in rapid water flow rate, in case of a high inclination and a rocky river. Another important factor is a high water temperature and a long time river stream is accelerated the purifying function also, if it is necessary oxygen demand supplied constantly to the river water.

Table 7.29a: Comparing BOD Concentration in Lahore with the Japanese Standard of 10 ppm

No.	Sampling Point	BOD Concentration (ppm)	Times higher than 10 ppm
1.	River Ravi BRB Siphon (Composite)	9.2	-
2.	New Shadbagh Sewage Drain, Bund Road	110.0	11.0
3.	River Ravi Bara Dari Near Boat Station	12.1	1.2
4.	Babu Sabu Drain, Bund Road	110.0	11.0
5.	Babu Sabu Outfall (Before Joining River Ravi)	102.0	10.2
6.	Main Outfall Drain, Bund Road	109.0	10.9
7.	Deg Nullah, Sheikhupura Road	159.0	15.9
8.	Choti Deg Nullah, Sheikhupura Road	109.0	10.9
9.	Bhed Nullah, Sheikhupura Road	140.0	14.0
10.	Hudiara Drain, From India	449.0	44.9
11.	Hudiara Drain, Ferozepur Road	163.0	16.3
12.	Satokatala Drain, Defence Road	103.0	10.3
13.	Hudiara Drain, Multan Road	117.0	11.7
14.	River Ravi at Junction of Hudiara Drain	63.0	6.3
15.	River 1 KMD/S of Hudiara Drain	7.1	-
16.	Baloki Headworks (Composite)	7.1	-
17.	Chichukimallian Drain, Sheikhupura Road	73.0	7.3
18.	Barian Drain 1 km off Sheikhupura Road	142.0	14.2
19.	Deg Nullah II, Before River Ravi After Baloki Hw	105.0	10.5
20	Mundawana, Samundari Drain Before Ravi	161.0	16.1

Table 7.29b: Comparing BOD Concentration in Rawalpindi and Islamabad to Japanese Standard of 10 ppm

No.	Sampling Point	BOD Concentration (ppm)	Divided into the Standard by 10 ppm
1.	E-8 Near Navy House Karakuram Road	6.8	-
2.	E-7 Hill Side Road opp. St. 16	58.0	5.8
3.	F-8/2 Before Fatima Jinnah Park	60.1	6.0
4.	F-6/2 Near Alkhizar Mosque Margalla Road	17.0	1.7
5.	F-5/2 Near Azad Jammu Kashmir Secretariat	12.2	1.2
6.	Near American Embassy	16.3	1.6
7.	Peshawar Road	31.3	3.1
8.	I-10 Pirwadhai Crossing, Nullah 1	57.6	5.7
9.	I-10 Pirwadhai Crossing, Nullah 2	59.5	5.9
10.	I-10 Pirwadhai Crossing, 200 m After Joining	34.2	3.4
11.	Nullah Leh Near Gawalmandi Bridge	139.1	13.9
12.	Jahanda Chichi, Airport Road	139.3	13.9
13.	Nullah Leh at Gulistan Colony Line-1	118.8	11.8
14.	Nullah Leh Before Joining River Soan	81.7	8.1
15.	Chattar Park	14.2	1.4
16.	Rawal Dam	BDL	-
17.	Stream Water Korang Nullah Lehtrar Road	10.9	1.0
18.	Nullah Kura, Shahrah-e-Islamabad	16.0	1.6
19.	River Soan Before Soan Bridge	26.9	2.6
20.	Mix of Soan and Nullah Leh	42.6	4.2

The water quality of River Ravi and Nullah Leh is so polluted that its usage is prohibited for household use (use as dish washing, laundry etc.). During this investigation, the children were swimming as well as buffaloes standing in these waters were observed. This river water is also used for irrigation purposes. The local government person told us that polluted river water is some beneficial for crop growing.

Polluted water contains a lot of nitrate and phosphate compounds which are beneficial for the growth of agricultural products, but there are also possibility to contaminate lots of dangerous intestinal bacteria such as S. Shigella, E-Coli and other hazardous chemicals such as CN, As, Cr. These harmful organisms and metals not only affect the farmers, but the plants also. High levels of BOD, COD. Suspended solid matter and low levels of DO have an adverse effect on the growth of plants. Figure 7.9, 7.10 and 7.11 showed the outside appearances of the river water samples with data of important pollution parameters.

7.2.4 High COD Concentration

The result of this water quality investigation showed very high COD values. That means that the water proved not only polluted by organic substances but also by chemically reactive substances.

We noticed the fact that branched streams passing through the industrial areas were polluted by COD demanded sources. That means wastewater from industrial has sometimes higher COD sources compared with that of BOD. According to Tables F-1 (page 249) in the report of Investigation on Air and Water Quality (Lahore, Rawalpindi and Islamabad) in 2000, sampling point No. 18 shows a BOD of 142 ppm and a COD of 2,383. Similarly, sampling point No. 19 shows a BOD of 105 ppm and a COD of 1,046 ppm. This shows COD concentration being 10 times higher than BOD concentration.

There are two reasons that should be considered; firstly, there is polluted river water by industrial chemical waste which might sometimes show such extremely high values and secondly, it might be happened something difficulties of calculation or measuremental technologies.

Table 7.30: COD Concentrations in Lahore

No.	Sampling Point	COD Concentration (ppm)
1.	River Ravi BRB Siphon (Composite)	9.2
2.	New Shadbagh Sewage Drain, Bund Road	110.0
3.	River Ravi Bara Dari Near Boat Station	12.1
4.	Babu Sabu Drain, Bund Road	110.0
5.	Babu Sabu Outfall, (Before joining River Ravi)	102.0
6.	Main Outfall Drain, Bund Road	109.0
7.	Deg Nullah, Sheikhupura Road	159.0
8.	Choti Deg Nullah, Sheikhupura Road	109.0
9.	Bhed Nullah Sheikhupura Road	140.0
10.	Hudiara Drain, From India	449.0
11.	Hudiara Drain, Ferozepur Road	163.0
12.	Satokatala Drain, Defence Road	103.0
13.	Hudiara Drain, Multan Road	117.0
14.	River Ravi at Junction of Hudiara Drain	63.0
15.	River 1 KMD/S of Hudiara Drain	7.1
16.	Baloki Headworks (Composite)	7.1
17.	Chichukimallian Drain, Sheikhupura Road	73.0
18.	Barian Drain 1 km off Sheikhupura Road	142.0
19.	Deg Nullah II, Before River Ravi After Baloki HW	105.0
20.	Mundawana, Samundari Drain before Ravi	161.0

Table 7.31: COD Concentrations in Rawalpindi and Islamabad

No.	Sampling Point	COD Concentration (ppm)
1.	E-8 Near Navy House Karakuram Road	25.6
2.	E-7 Hill Side Road opp. St. 16	89.3
3.	F-8/2 Before Fatima Jinnah Park	101.3
4.	F-6/2 Near Alkhizar Mosque Margalla Road	18.4
5.	F-5/2 Near Azad Jammu Kashmir Secretariat	20.9
6.	Near American Embassy	19.3
7.	Peshawar Road	58.2
8.	I-10 Pirwadhai Crossing, Nullah 1	83.7
9.	I-10 Pirwadhai Crossing, Nullah 2	114.3
10.	I-10 Pirwadhai Crossing, 200 m After Joining	81.0
11.	Nullah Leh Near Gawalmandi Bridge	357.5
12.	Jahanda Chichi, Airport Road	215.4
13.	Nullah Leh at Gulistan Colony Line-1	209.6
14.	Nullah Leh Before Joining River Soan	147.1
15.	Chattar Park	34.8
16.	Rawal Dam	7.0
17.	Stream Water Korang Nullah Lehtrar Road	15.8
18.	Nullah Kura, Shahrah-e-Islamabad	18.4
19.	River Soan Before Soan Bridge	45.6
20.	Mix of Soan and Nullah Leh	68.7

Sampling point numbers 18 and 19 in Lahore are not located in the city area and are far away from borderline of India; point No. 18 is 290 km and point 19 is 363 km from the border. These areas shouldn't be thought as industrial area because of the long distance from the Lahore city. However, sampling point No. 18 is located rather near the textile and paper industries area and thus there is a possibility of water sampling point 18 being affected by the industrial waste. Point 19 is an almost similar situation; it is also polluted by the two above mentioned kinds of industrial wastes.

The Japanese method of measuring COD involves the use of $KMnO_4$ (Potassium permanganate) method at 20°C and incubation for 4 hours. While in Pakistan $K_2Cr_2O_7$ (Potassium dichromate) method is used instead of that. Thus usually, the COD value by Japanese method is a little bit lower than $K_2Cr_2O_7$ method, which is being used here. Relationship among the data of BOD, COD and TSS concerning the domestic Wastewater pollution in Japanese rivers, if BOD value is 100 ppm, COD value usually is 30-50 ppm and TSS value might be 100-150 ppm.

7.2.5 High TSS Concentration

Investigated levels of TSS in the three cities showed high TSS concentration especially Lahore, show very high as compared to the other two parameters of COD and BOD. TSS values at point 11 and 17 showed close to 6,000 and more than 1,500 ppm inspite of BOD values being 163 and 73 respectively. There must be a reason for BOD levels as high as 36 times as in the case of point No. 11. While in case of point No. 17, it is about 20 times higher. Comparatively, such different values do not occur in Japan.

Originated natural TSS is sometimes born in the rapid flow stream from the mountainside for example, the water color of Indus river. There is a need to investigate whether this occurs by natural phenomenon only in this country or also occurs in other South Asian countries.

Table 7.32: TSS Concentrations in Lahore

No.	Sampling Point	TSS (mg/l)
1.	River Ravi BRB Siphon (Composite)	124.0
2.	New Shadbagh Sewage Drain, Bund Road	855.0
3.	River Ravi Bara Dari Near Boat Station	162.0
4.	Babu Sabu Drain, Bund Road	249.0
5.	Babu Sabu Outfall, (Before joining River Ravi)	110.0
6.	Main Outfall Drain, Bund Road	342.0
7.	Deg Nullah, Sheikhupura Road	348.0
8.	Choti Deg Nullah, Sheikhupura Road	278.0
9.	Bhed Nullah Sheikhupura Road	4.5.0
10.	Hudiara Drain, From India	537.0
11.	Hudiara Drain, Ferozepur Road	5,982.0
12.	Satokatala Drain, Defence Road	170.0
13.	Hudiara Drain, Multan Road	126.0
14.	River Ravi at Junction of Hudiara Drain	133.0
15.	River 1 KMD/S of Hudiara Drain	134.0
16.	Baloki Headworks (Composite)	80.0
17.	Chichokimalian Drain, Sheikhupura Road	1,562.0
18.	Barian Drain 1 km off Sheikhupura Road	736.0
19.	Deg Nullah II, Before River Ravi After Baloki HW	495.0
20.	Mundawana, Samundari Drain before Ravi	152.0

Table 7.33: TSS Concentrations in Rawalpindi and Islamabad

No.	Sampling Point	TSS Concentration (ppm)
1.	E-8 Near Navy House Karakuram Road	4,041.0
2.	E-7 Hill Side Road opp. St. 16	50.0
3.	F-8/2 Before Fatima Jinnah Park	16,154.0
4.	F-6/2 Near Alkhizar Mosque Margalla Road	107.0
5.	F-5/2 Near Azad Jammu Kashmir Secretariat	42.0
6.	Near American Embassy	47.0
7.	Peshawar Road	146.0
8.	I-10 Pirwadhai Crossing, Nullah 1	358.0
9.	I-10 Pirwadhai Crossing, Nullah 2	89.0
10.	I-10 Pirwadhai Crossing, 200 m After Joining	210.0
11.	Nullah Leh Near Gawalmandi Bridge	284.0
12.	Jahanda Chichi, Airport Road	272.0
13.	Nullah Leh at Gulistan Colony Line-1	127.0
14.	Nullah Leh Before Joining River Soan	255.0
15.	Chattar Park	43.0
16.	Rawal Dam	106.0
17.	Stream Water Korang Nullah Lehtrar Road	77.0
18.	Nullah Kura, Shahrah-e-Islamabad	36.0
19.	River Soan Before Soan Bridge	94.0
20.	Mix of Soan and Nullah Leh	22.0

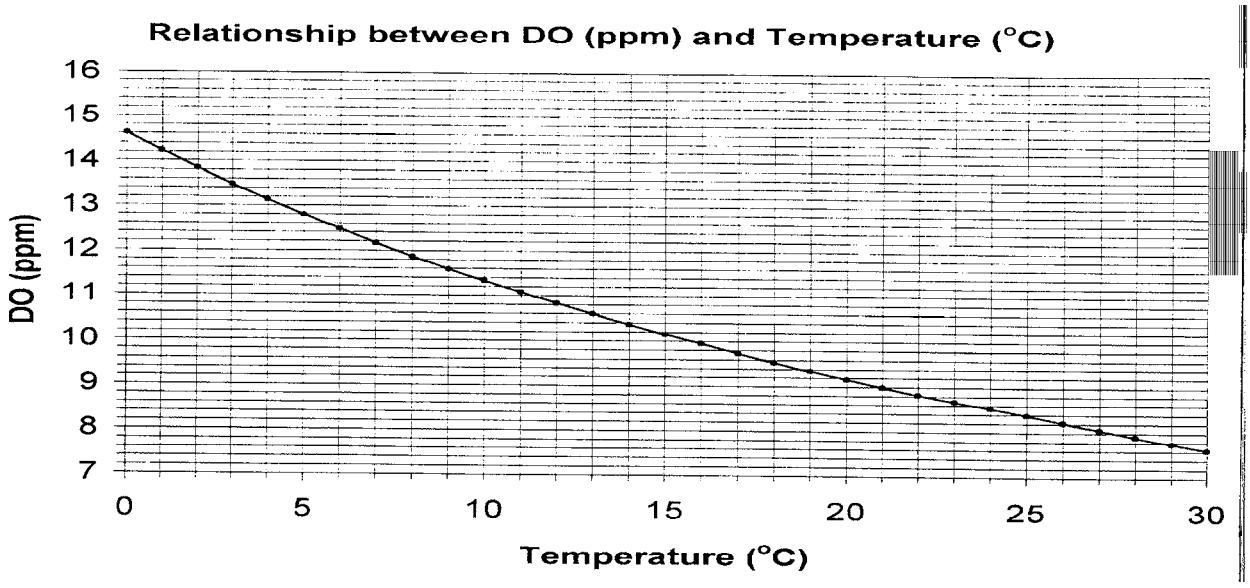
7.2.6 Relationship Between BOD and DO Values

The river water polluted by organic substances for instance domestic Wastewater, should have an appropriate relationship between DO and BOD. This is because BOD measurement means measuring DO before incubation for 5 days and then after incubation. Therefore, high BOD water needs a lot of DO consumption in the decomposition of the organic substances by bacterial enzymes digestion to make lower molecular weight substances during incubation. If a high BOD value is detected in river water, the high DO value should not be detected of the same sample. If a high DO value still occurs, the BOD value should be once again checked for measurement accuracy.

DO measurement is usually carried out by DO meter. DO meter should be calibrated punctually at least once a week. BOD values should be checked because there are many wrong operated processes such as an adequate diluted ratio is required by the judgement of operator which remains a little of DO value (3~5 ppm) after incubation or miscalculation in the measurement procedure could result in anomalies in the final results. Therefore, the person who responsible for the analysis should repeat it to confirm the value of BOD.

From the results of this investigation, the relationship between DO and BOD values in some samples were not appropriate proportion. The DO value of sampling point No. 10 (Lahore) was 0.16 ppm, while BOD was 499 ppm, which is too high and also, concerning the DO value should be 0 ppm generally. Similarly, the DO value at sampling point No. 14 (Lahore) was 1.2 ppm whereas BOD observed was only 7.1 ppm. The same trend was seen in some samples in Rawalpindi and Islamabad. The DO value at sampling point No. 10 (Islamabad) was 0.1 ppm while BOD was 34.2 ppm. Also, sampling point No. 20 (Rawalpindi) had a DO value at 5.4 ppm and a BOD at 42.6 ppm. These also do not reflect a proper relationship between BOD and DO.

Figure 7.9: Relationship Between Temperature and DO in Pure Water at Saturated Condition



7.3 Accuracy of Analytical Measurement

➢ Necessity of Cross Checking (Duplication)

Two samples each were collected from the river water and sent to three different organizations for analysis. Some anomalies were noted in some samples. These were sample numbers 16 and 18 in Lahore. It is shown in Table 7.34

Table 7.34: Duplicated Values of Samples in Lahore

No.	Analyst	BOD	COD	TSS	Oil & Grease	T-N	Heavy Metals					
							As	Cu	Cr	Cd	Pb	Zn
16	**Hagler Bailly**	7.1	36.4	80.0	ND	ND	-	-	-	-	-	-
	PCSIR	6.2	15.1	20.0	0.6	0.1	-	-	-	-	-	-
	NUST											
18	**Hagler Bailly**	142.0	2383.0	736.0	53.3	3.9	14.0	0.2	< 0.5	< 0.1	< 0.2	< 0.3
	PCSIR	965.0	2826.0	1092.0	2.7	0.3	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.1
	NUST											

PCSIR : Pakistan Council of Scientific and Industrial Research
NUST : National University of Science and Technology

➢ Escherichia Coli (E- Coli)

Sample No. 7,8,9,11,13,15,17 and 18 of Lahore showed E-Coli numbers of more than 180.0 MPN/100ml. Hagler Bailly asked one more bacteriological test for duplicate E-Coli analysis of the samples to the institute but couldn't succeed in getting any data. To consider the source of water pollution comes from the domestic wastes and high contaminated condition of BOD, COD and TSS.

The E- Coli numbers should be more high, for instance, it is reported that the "Implementation of the National Conservation Strategy Pollution and Monitoring Survey of the River Ravi" by the Asian Development Bank in 1998 where were taken the samples at almost same places of this investigation showed the E-Coli (MPN/100ml) numbers were between $10^4 \sim 10^{10}$ that means there are 10,000 to 10 billion numbers of E-Coli existed in 100 ml of samples in case of BOD values were more than 100 ppm.

So that reason, almost all data of E-Coli in Lahore were more than 180 and all data of E-Coli in Rawalpindi more than 18 have no meaning of the E-Coli investigation. In Japan, the results of E-Coli like this is difficult to be accepted those data by client.

7.4 Most Important Indicators for the Polluted Condition on Investigated Rivers in 3 Cities

➢ BOD Loading

According to this investigation, we tried to find out the amount of the pollution factor, which is expressed as the BOD loading at each sampling point especially in big rivers in Rawalpindi and Lahore. Fig 7.13 & 7.14 shows the BOD loading in Lahore and Rawalpindi / Islamabad respectively. In both figures, numbers written in red in the bracket denote BOD loading (tons/day) and percentage of the total BOD loading respectively.

➢ BOD Loading in Lahore

Several rivers were investigated in Lahore areas such as the major River Ravi and other streams which are located in Lahore downtown area and industrial area. Samples where taken from 12 different streams going to River Ravi.

River Ravi and Hudiara Drain come from India. Analytical data of both 2 rivers coming form India were estimated based on the samples collected on April 4, 2000 and April 10, 2000. These points were measured as BOD values of 9.2 ppm and 449 ppm respectively. These BOD data then calculated by the river water quantity makes BOD loading in a day. As a result, the BOD loading of River Ravi was found to be 266 tons/day and that of Hudiara Drain (this river water is coming from the India) to be 138 tons/day. Adding both these values makes 404 tons/day, which could be considered to be coming from the Indian side.

This investigation has not measured all sources of BOD loading from each stream which enter River Ravi, therefore, we cannot estimate what percentage of the total BOD loading came from India. However, a BOD loading of 404 tons/day is not a small amount of pollution factor.

➢ BOD Loading in Rawalpindi

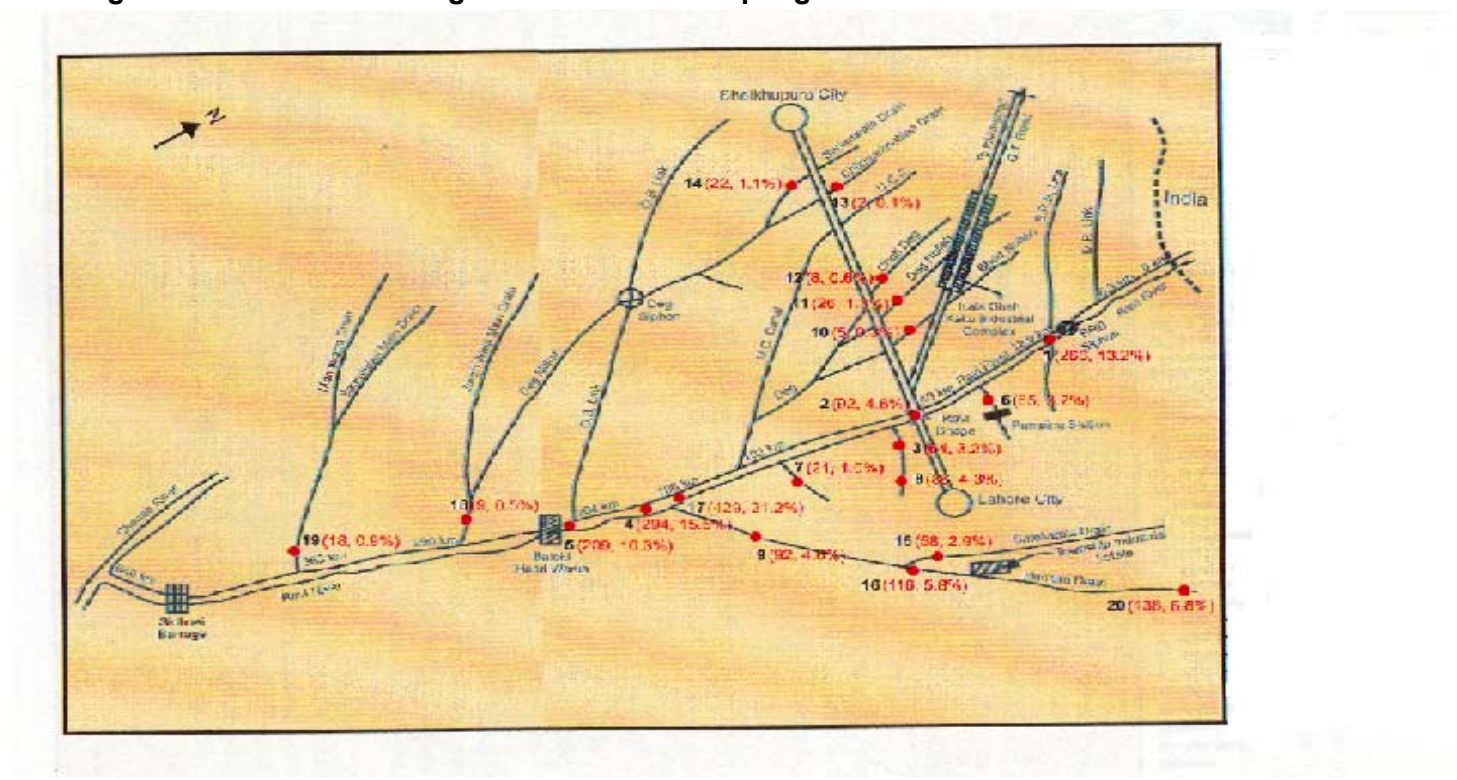
The quantity of BOD loading depends on the population size whose domestic Wastewater is not treated and goes to the river directly. Similarly, the results of this investigation showed that BOD loading was proportional to the population and probably the number of buffaloes and other animals in that location.

An important fact to be given attention to, with respect to Lahore and Rawalpindi water quality is that, Lahore which has a large water quantity of River Ravi makes low BOD concentration by high dilution ratio compared with that of Rawalpindi. This is because Nullah Leh has a low flow rate. The population in Rawalpindi is $1/3^{rd}$ of that in Lahore but the BOD and COD levels are not much different. Another important factor contributing to this high BOD loading in Rawalpindi is a part of the BOD source coming from the dumping of domestic solid wastes on the sides and banks of the rivers.

➢ BOD Loading in Islamabad

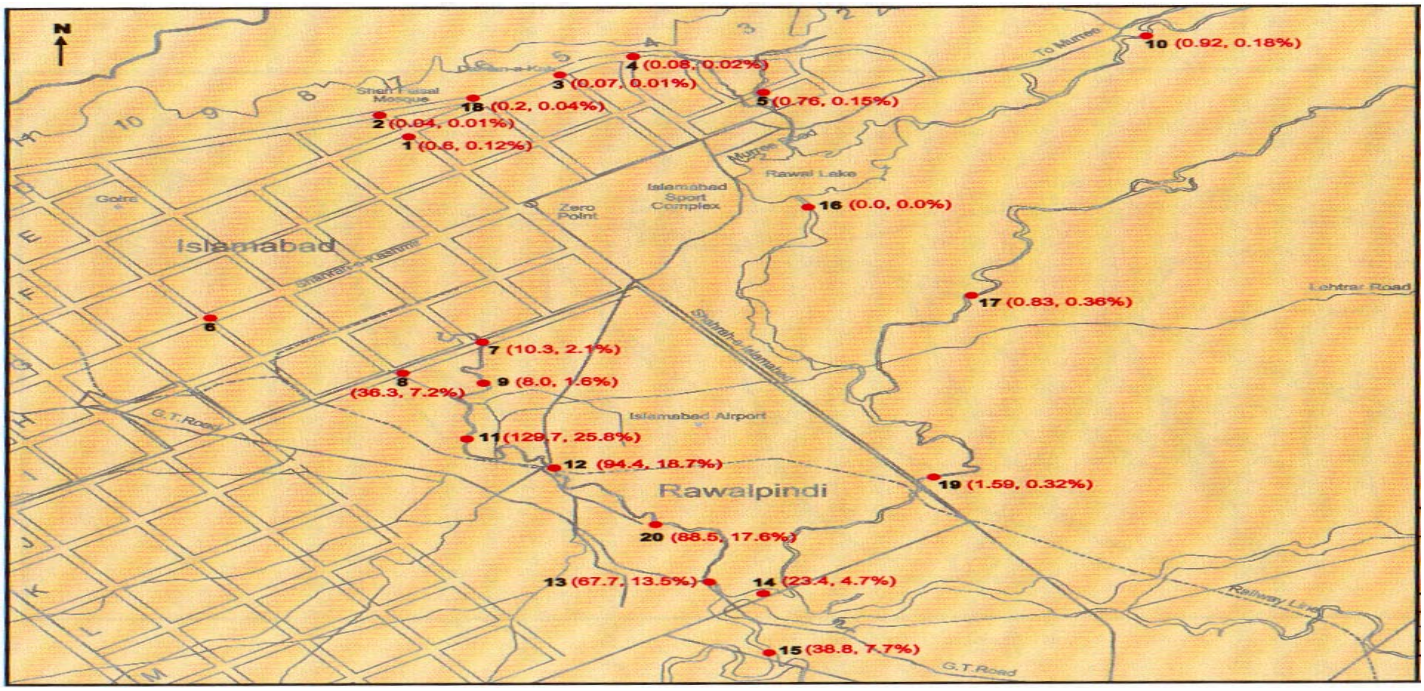
Islamabad has a small population compared with the other two investigated cities i.e. Lahore and Rawalpindi, but on the Margalla Hills there are densely populated villages whose domestic Wastewater fall into the small river which thus has a rather high BOD concentration. Even though the village population is some several thousands, the BOD concentrations in these rivers of Islamabad do not reach 100 ppm of BOD.

Figure 7.10: BOD Loading at Wastewater Sampling Sites in Lahore



No. in Table	No. in Map	Sampling Point	Flow Rate	BOD	BOD Loading (tons/day)
1.	**1.**	River Ravi BRB Siphon (Composite)	336.0	9.2	267.07
2.	**6.**	New Shadbagh Sewage Drain, Bund Road	6.8	110.0	64.62
3.	**2.**	River Ravi Bara Dari Near Boat Station	88.0	12.1	91.99
4.	**8.**	Babu Sabu Drain, Bund Road	9.0	110.0	85.53
5.	**3.**	Babu Sabu Outfall, (Before joining River Ravi)	7.3	102.0	64.33
6.	**7.**	Main Outfall Drain, Bund Road	2.2	109.0	20.71
7.	**11.**	Deg Nullah, Sheikhupura Road	1.9	159.0	26.10
8.	**12.**	Choti Deg Nullah, Sheikhupura Road	0.9	109.0	8.47
9.	**10.**	Bhed Nullah Sheikhupura Road	0.5	140.0	6.04
10.	**20.**	Hudiara Drain, From India	3.6	449.0	139.65
11.	**16.**	Hudiara Drain, Ferozepur Road	8.3	163.0	115.89
12.	**15.**	Satokatala Drain, Defence Road	6.5	103.0	57.84
13.	**9.**	Hudiara Drain, Multan Road	9.1	117.0	91.99
14.	**17.**	River Ravi at Junction of Hudiara Drain	78.9	63.0	429.46
15.	**4.**	River 1 KMD/S of Hudiara Drain	480.0	7.1	294.45
16.	**6.**	Baloki Headworks (Composite)	340.0	7.1	208.56
17.	**13.**	Chichokimalian Drain, Sheikhupura Road	0.4	73.0	2.52
18.	**14.**	Barian Drain 1 km off Sheikhupura Road	1.8	142.0	22.08
19.	**18.**	Deg Nullah II, before River after Baloki HW	1.0	105.0	9.07
20.	**19.**	Mundawana, Samundari Drain before Ravi	1.3	161.0	18.08

Figure 7.11: BOD Loading at Wastewater Sampling Sites in Rawalpindi / Islamabad



No. in Table	Sampling Point	Flow Rate	BOD	BOD Loading (tons/day)
1.	E-8 Near Navy House Karakuram Road	0.5	6.8	0.02
2.	E-7 Hill Side Road opp. St. 16	0.0	58.0	0.50
3.	F-8/2 Before Fatima Jinnah Park	0.1	60.1	0.05
4.	F-6/2 Near Alkhizar Mosque Margalla Road	0.1	17.0	0.01
5.	F-5/2 Near Azad Jammu Kashmir Secretariat	0.1	12.2	0.01
6.	Near American Embassy	0.5	16.3	0.07
7.	Peshawar Road	0.1	31.3	0.02
8.	I-10 Pirwadhai Crossing, Nullah 1	2.1	57.6	1.04
9.	I-10 Pirwadhai Crossing, Nullah 2	7.1	59.5	3.64
10.	I-10 Pirwadhai Crossing, 200 m After Joining	2.7	34.2	0.79
11.	Nullah Leh Near Gawalmandi Bridge	10.8	139.1	12.97
12.	Jahanda Chichi, Airport Road	7.8	139.3	9.38
13.	Nullah Leh at Gulistan Colony Line-1	8.6	118.8	8.82
14.	Nullah Leh Before Joining River Soan	9.6	81.7	6.77
15.	Chattar Park	0.8	14.2	0.09
16.	Rawal Dam	1.2	BDL	0.01
17.	Stream Water Korang Nullah Lehtrar Road	1.9	10.9	0.17
18.	Nullah Kura, Shahrah-e-Islamabad	1.2	16.0	0.16
19.	River Soan Before Soan Bridge	10.1	26.9	2.34
20.	Mix of Soan and Nullah Leh	10.5	42.6	3.86

7.5 Air and Water Pollution which affect on Human Health

Consideration of process which these 2 kinds of pollution factors make us trouble in our health, air pollution usually enter by our respiration organs that means affected organ might be throat, bronchus and lungs of the human beings, on the other hand, water pollution affect the drinking water, in both rivers and wells water.

To use the river water, as cleaning dished, preparing meals and sometime children like to swim in the summer may affect the digestive organs such as stomach and intestines that cause people to have continuous diarrhea very often, so water pollution is much directly affected to our living circumstances.

Another important characteristics is water quality in the river which is changeable by depending on the quantity of rainfall or quantity of using the irrigation water for agricultural usage that is affected some different water quality.

When the agricultural demands such as irrigation water from river, the river water flow rate must be very small, then the BOD concentration in the river might be high proportionally.

To compare with water pollution, concentration of air, contaminated substances in the atmosphere are much changeable by the meteorological conditions, for instance, if wind speed is more than 4 m/sec, wind power take pollutants out of the city area, therefore, the more important environmental factor is water pollution.

However, it should be considered that it is found high concentration are very high which is considered to reach the critical condition to compare with International Air Quality Standards.

It should be investigated those SPM comes from natural or artificial sources such as emission gas from mobiles. And fortunately, most dangerous air pollutants such as SO_2 and Ozone concentration are relatively low in 3 cities. It makes avoid the most critical condition affected by both sides with SO_2 and SPM together.

Because most big air pollution episodes in the world usually caused by SO_2, SO_3 and mixed aerosol such as London smoke. Yokkaichi Asthma, those are bigger numbers of residential people died by these pollutants.

7.6 Comments on Approaching to the Solution for High BOD

- **To Install the Sewer and Sewage Treatment Facilities**

It is not useful to install the simple system in sewage treatment process without any facility of de watering of sludge system, even the reason of cheep installation capital. I recommend adapting the system which purification system by activated sludge method which process including anaerobic digester of sludge and mechanical system of dewatering process.

It is costly but it is expecting to get stable removal rate, which can recover the big investment amount to be considered easier handling of operation and enough removal efficiency to meet the water emission quality standard. Then it is a good balance for cost and performance.

- **To Consider Simple Treatment Facility for Waste from Animals Which Enter to the River**

Simple treatment facility will be available to separate liquid and solid of their waste. Solid waste might be reused for fuel of cooking mixed with straw and dried. Liquid should be entering the river to consider BOD loading, the solid has much high BOD than liquid part.

Considering animal health, such as buffaloes, the person feeding them must be informed by the environmental protection agency to allow entering the river water less than 50 ppm of BOD for instance, because if buffalo entered to polluted river water, the milk or meat might be contaminated condition for the human health.

- Minimizing the house waste
- Separated Sewer of Irrigation Water and Wastewater

In the Lahore area, the small rivers are also used for the open sewer with the mixed domestic waste discharge, when the agricultural demand for irrigation water, that sewer water be often taken out from the sewer system.

7.7 Necessary Important Implementation for improving Environmental Troubles

- **Establishment of Environmental Training Course**

It is most important matter to improve the level up of environmental technologies such as investigation, enforcement and countermeasures for training and educational programs in central, local governments and public sectors.

It is a most suitable organization for promoting on this purpose to program and implement by the Pak-EPA activity, because of the environmental institutional function of Pak-EPA has a role of realization will be expected in the future.

- The first, necessary function of Pak-EPA achieving on this purpose is strengthen of the Laboratory function.

- Secondly, through to the environmental analytical methodologies is necessary for transferring to the analytical measurements, such as measurement method, data analysis and grasp of the actual contaminated conditions including accuracy of data, to the central and local governments people which they required to take an action for the determination of high priority for improving the faced troubles.

- It should be prepared by the Pak-EPA for training program to the government and public sector, who are touching with enforcement, countermeasures and investigating organizations for the purpose of promoting on improving environmental tasks which have been reaching to the critical conditions in urban and rural environment. The contents of training program are not including on the field of global environment and natural conservation matters at the first stage.

- **Waste Quality Monitoring System**

It is necessary to have more water quality monitoring system or investigation as well as underground water. Almost all domestic waste enters the river near by, therefore, two monitoring stations should be installed one is located before entering of the waste into the river and the other, after.
Frequency of the sampling is at least 2 times in a month and measurement parameters are pH, turbidity, DO, color at sampling points and BOD, COD, TSS, N-T, E-Coli and necessary kinds of heavy metals concerning industrial wastes.

- **Awareness System on Environment Information**

Results of this investigation show a lot of important polluted information that should be provided to the residents to inform them and how to protect them from critically contaminated circumstances by the awareness of Ministry of Health, Pak-EPA and the provincial EPA's.

- **Data Collection**

Environmental data bank in Pak-EPA is very important. Getting knowledge and data of water pollution, analysis and technologies from the government bodies and private sectors that will be useful for implementing on air and water pollution administration.

- **Establishment of Air and Water Quality Emission Standard**

It is very important to set these emission standards for each open area where using those sewer or river water which should be determined by requirement condition for the users requested such as drinking water, agricultural and industrial usage, irrigation water quality, for example, the standard item as mentioned in Table 7.28 using in Japan.