

## **PART 2**

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### **IMPLEMENTATION of THIS STUDY**

#### **1- URBANIZATION**

One of the striking features of modern time is that there is great migration of population from rural to urban areas. This rural exodus is precipitated by stagnant economic and cultural life of the villages and vast opportunities of good standard of living in the urban areas. This generates a series of social, political, administrative, environmental & economic problems to the planners, policy makers and the inhabitants of the cities.

Migration from country side to the town adversely affects agricultural output and ultimately leads to economic stagnation in the rural areas. As a result it floods the labour market, increases unemployment and socio-economic problems of varied nature in the cities.

If such situations are not handled carefully and on time they could develop into unhealthy and problem oriented issues as is evident in the big cities like Karachi, Lahore, Multan, Faisalabad & Peshawar.

One particular aspect of Peshawar is that due to influx of Afghan refugees since 1979, population pressure on Peshawar increases manifold as compared to other major cities. The housing need and cheap labour resulted in a booming industry of construction in Peshawar. It also brought pressure on civic agencies and accelerated the deterioration of natural resources.

##### **1-1 Area of Hayatabad**

According to documents of planning cell of PDA, the township is spread over 3299 acres. The first and the last phases are equal size spread over 388 acres each while the rest other phases are smaller or larger than this size. Phase II is spread over 615 acres while phase V is reserved for offices and housing colonies for various Government and non government organization

##### **1-2 Land Use**

From the land use analysis it can be observed that almost half (51%) of the total area is developed for residential plots. The second highest use of land is for roads which comes to 22% while the third and fourth category of land use is for the community services and open space. Details on land use are given in the following table.

**TABLE-7**

**LAND USE ANALYSIS OF HAYATABAD**

| Category           | Area (acres) | %age       |
|--------------------|--------------|------------|
| Residential        | 1682         | 51         |
| Road               | 726          | 22         |
| Open Spaces        | 297          | 9          |
| Commercial         | 132          | 4          |
| Community Services | 429          | 13         |
| Unassigned         | 33           | 1          |
| <b>Total</b>       | <b>3299</b>  | <b>100</b> |

Source: Planning Cell, PDA

The ratio slightly varies from one phase to another phase. Detail information are not available on all phases but one can get a fair idea by going through the documents available for phase II, V, VI stg-1 and Phase VII. A big chunk of land in Phase II and VII is occupied by Khawars or the hill torrents passing through these phases. Roads and streets have occupied around one fourth of the land while residential plots are ranging from 42-64% of land with an overall average of 51%. Details of acreage and percentage of land use available in each phase are given the following tables.

**TABLE-8**

**LAND USE ANALYSIS OF EACH PHASE**

| Land Use                          | Allotted Area in Each Phases (Acres) |              |          |          |            |            |           |            |
|-----------------------------------|--------------------------------------|--------------|----------|----------|------------|------------|-----------|------------|
|                                   | I                                    | II           | III      | IV       | V          | VI Stg-I   | VI stg-II | VII        |
| Residential                       | -                                    | 365          | NA       | NA       | 95.4       | 70.2       | NA        | 143.5      |
| Commercial                        | -                                    | 1.05         | NA       | NA       | 0.14       | 4.8        | NA        | 11.9       |
| Public Buildings                  | 7.08                                 | 8.50         | NA       | NA       | 6.9        | 16.9       | NA        | 32.2       |
| Road & Street                     | -                                    | 119          | NA       | NA       | 34.4       | 36.6       | NA        | 74         |
| Open Spaces                       | 1.79                                 | 32.7         | NA       | NA       | 7.8        | 8.46       | NA        | 32.6       |
| Community Services                | 9.29                                 | -            | NA       | NA       | -          | -          | NA        | -          |
| Service Industries                | -                                    | -            | NA       | NA       | -          | -          | NA        | -          |
| Khawars (Hill Torrents & Nullahs) | -                                    | 89.9         | NA       | NA       | 2.6        | -          | NA        | 43.9       |
| <b>Total</b>                      | <b>-</b>                             | <b>615.6</b> | <b>-</b> | <b>-</b> | <b>147</b> | <b>137</b> | <b>-</b>  | <b>338</b> |

Source: Respective PCs

**TABLE-9**

**PERCENTAGE DISTRIBUTION OF LAND USE ANALYSIS IN EACH PHASE**

| Land Use                          | Allotted Area (%age) |            |          |          |            |            |          |            |
|-----------------------------------|----------------------|------------|----------|----------|------------|------------|----------|------------|
|                                   | I                    | II         | III      | IV       | V          | VI         | VI       | VII        |
| Residential                       | NA                   | 59.3       | NA       | NA       | 64.8       | 51         | NA       | 42.4       |
| Commercial                        | NA                   | 0.17       | NA       | NA       | 0.09       | 4          | NA       | 3.5        |
| Public Buildings                  | 1.8                  | 1.38       | NA       | NA       | 4.7        | 12         | NA       | 9.5        |
| Road & Street                     | NA                   | 19.30      | NA       | NA       | 23.4       | 27         | NA       | 21.9       |
| Open Spaces                       | 0.5                  | 5.30       | NA       | NA       | 5.3        | 6          | NA       | 9.6        |
| Community Services                | 2.4                  | -          | NA       | NA       | -          | -          | NA       | -          |
| Service Industries                | NA                   | -          | NA       | NA       | -          | -          | NA       | -          |
| Khawars (Hill Torrents & Nullahs) | NA                   | 14.6       | NA       | NA       | 1.8        | -          | NA       | 13         |
| <b>Total</b>                      | <b>-</b>             | <b>100</b> | <b>-</b> | <b>-</b> | <b>100</b> | <b>100</b> | <b>-</b> | <b>100</b> |

Source: Respective PCs

**TABLE-10**

**LAND USE ANALYSIS OF HAYATABAD TOWNSHIP (5-PHASES)**

| Category                            | %age       |
|-------------------------------------|------------|
| Residential                         | 56.059     |
| Commercial                          | 1.009      |
| Public Buildings                    | 6.458      |
| Roads & Streets                     | 20.769     |
| Open Spaces/ Mosques                | 5.245      |
| Khawars (Hill Torrents and Nullahs) | 10.46      |
| <b>Total</b>                        | <b>100</b> |

Source: PC-I Phase-IV

### 1-3 Residential Area of Hayatabad

The residential area is divided in to plots of different sizes. The biggest plot size is 2 kanals (10800 sq.ft) and the smallest one is the 3 Marals (710 sq ft). The highest number of plots (7394) are of 5 Marlas (1350 sq.ft) category followed by 10 Marlas (2700 sq ft) category. The 14 Marlas scheme is introduced only in the last phase (phase VII). Detail about the residential area of Hayatabad is given in the following tables:

**TABLE-11**

#### DISTRIBUTION AND TOTAL NO. OF RESIDENTIAL PLOTS

| Sr. N.       | Plot Size   |                     | No. of Plots |
|--------------|-------------|---------------------|--------------|
|              | Kanal/Marla | Square feet (sq.ft) |              |
| 1.           | 2 Kanal     | 10800               | 1189         |
| 2.           | 1 Kanal     | 5400                | 5128         |
| 3.           | 14 Marla    | 3780                | 352          |
| 4.           | 10 Marla    | 2700                | 5480         |
| 5.           | 7 Marla     | 1890                | 1203         |
| 6.           | 5 Marla     | 1350                | 7394         |
| 7.           | 3 Marla     | 710                 | 1750         |
| <b>Total</b> |             |                     | <b>22496</b> |

*Source: Map of Hayatabad*

**Existing No. of Residential Plots of various sizes** **22503**  
**About 50% of the plots are developed and occupied by the people.**

*Source: Planning Cell*

**TABLE-12**

**DETAILS OF RESIDENTIAL PLOTS DISTRIBUTION IN  
HAYATABAD**

| Sr. N.       | Plot Size           | 2 Kanal     | 1 Kanal     | 14 Marla   | 10 Marla    | 7 Marla     | 5 Marla     | 3 Marla     | Total        |
|--------------|---------------------|-------------|-------------|------------|-------------|-------------|-------------|-------------|--------------|
| 1.           | Phase-I             | 425         | 545         | -          | 1201        | -           | 1556        | -           | 3727         |
| 2.           | Phase-II            | 698         | 1228        | -          | 386         | -           | 400         | -           | 2712         |
| 3.           | Phase-III           | -           | 751         | -          | 969         | -           | 1264        | 552         | 3536         |
| 4.           | Phase-IV            | -           | 519         | -          | 562         | -           | 793         | 193         | 2067         |
| 5.           | Phase-V<br>Stage-I  | 32          | 197         | -          | 468         | -           | 835         | -           | 1532         |
| 6.           | Phase-VI            | -           | 574         | -          | 947         | 1113        | 1777        | 737         | 5148         |
| 7.           | Phase-VI<br>Stage-I | -           | 413         | -          | 159         | 78          | 136         | 52          | 838          |
| 8.           | Phase-VII           | -           | 408         | 324        | 499         | -           | 835         | 364         | 2430         |
| <b>Total</b> |                     | <b>1155</b> | <b>4635</b> | <b>324</b> | <b>5191</b> | <b>1191</b> | <b>7596</b> | <b>1898</b> | <b>21990</b> |

*Source: PC-I Phase-VII*

**1-4 Green Area (Park area)/Open Space**

According to original Master Plan, the green areas/ open spaces phase-wise were as under:

**TABLE-13**

**PHASE WISE DISTRIBUTION OF GREEN AREA /OPEN SPACE**

| Sr. N.       | Phase     | No. of Green Areas/ Open Spaces | Area (Acres)  |
|--------------|-----------|---------------------------------|---------------|
| 1.           | Phase-I   | 17                              | 11.50         |
| 2.           | Phase-II  | 8                               | 8.228         |
| 3.           | Phase-III | 14                              | 10            |
| 4.           | Phase-IV  | 12                              | 17.37         |
| 5.           | Phase-V   | 3                               | 3.95          |
| 6.           | Phase-VI  | 5                               | 14.40         |
| 7.           | Phase-VII | NA                              | NA            |
| <b>Total</b> |           | <b>59</b>                       | <b>65.448</b> |

*NA: Not Available*

*Source: Planning Cell, PDA*

Although some of the green spaces have been converted for other land use, still a lot of green spaces are available such as Baghe Naran, Tatar Park, Khyber Park and Shalman Park, some of the famous recreational parks of Peshawar.

### 1-5 Population and Household

The population of Hayatabad township according to 1998 census is 45,000 with yearly growth of 3 %, while the estimated population according to Planning Cell of PDA is approximately 0.1 million. The main reason for this difference that more than 50% of the total houses in Hayatabad are occupied by Afghan refugees and therefore the estimated figure of the planning Cell of Peshawar Development Authority seem to be more realistic.

The average household size is estimated to be 8.5 but the actual may be slightly on higher side because it is very common that 2 to 3 families of Refugees share a single house. This was realized during the solid waste survey of the township where in 2 Kanal house the number of residents was 14 (Afghan refugees).

**TABLE-14**

### POPULATION AND HOUSEHOLD SIZE

| No. of Households               | 11250                              |
|---------------------------------|------------------------------------|
| Average household size          | 8.5                                |
| Present population of Hayatabad | $11250 \times 8.5 = 95625$ persons |

*(Source: Planning Cell, PDA)*

**Population of Hayatabad:** 0.1 Million *(Source: Micro Municipal Services Proposal)*

**Constructed Houses:** 12000 Approx. *(Source: Micro Municipal Services Proposal)*

### 1-6 Percentage/Coverage of Flush Toilet

Hayatabad is well Planned Township in Peshawar. So underground sewage pipelines are laid down for flush toilets and for the discharge of domestic and commercial used water. Therefore the coverage of flush toilets in township is 100%.

### **1-7 Water Supply Population/Coverage**

|                                         |                 |
|-----------------------------------------|-----------------|
| <b>No. of Installed Tube Wells</b>      | <b>53</b>       |
| <b>Discharge rate of each tube well</b> | <b>1 cusec.</b> |

Since January 2004, 53 tube wells are operating for water supply purpose in Hayatabad. The City and Municipal Development Department is responsible for the installation of new tube wells while the existing tube wells are operating by the Water Supply Section of the Town-III. No dug wells are operating in Hayatabad Township but there are many dug wells in the surrounding unplanned settlement all under the jurisdiction of town –III.

On average the tube well has capacity for the withdrawal of water ranging from 102-153 m<sup>3</sup>/hr. Approximately 13 hours/day operational time for a tube well.

These 53 tube wells were planned to cater water supply demand of the entire Hayatabad. As only 50 % of the residential area is occupied, therefore only 50 % of the tube wells are in operation and are fulfilling water supply demands of the consumers.

Water supply to all population in the Hayatabad township is being met by the Municipal water supply but in bigger homes (2 Kanals or 1 Kanals) with greater number of inhabitants required more water for usage.

So there are number of private bore holes in some homes. Exact numbers are not known because there is no such figure available with Municipal Department. Separate surveys are required for this purpose.

### **1-8 Hayatabad Industrial Estate**

Hayatabad Industrial Estate is situated near Hayatabad Township. The infrastructure facilities like power supply and line communication are available. Besides all these other facilities like internal roads, drainage, and water supply network available. Some basic information are given below:

|                           |            |
|---------------------------|------------|
| <b>Total No. of Plots</b> | <b>230</b> |
|---------------------------|------------|

In industrial estate Hayatabad, majority of the units are of very small size, which normally works on order basis from the local market of Peshawar. These are few industries, which can be called medium industries otherwise all of them fall into category of light industries.

Most of the industrial units do not use the water in their regular process or do not keep record of the water use except some major units.

The following Tables give the detail of sector wise industrial units and individual industries situated in Hayatabad industrial area

**TABLE-15**

**SECTOR WISE DISTRIBUTION OF INDUSTRIES IN HAYATABAD  
INDUSTRIAL ESTATE PESHAWAR**

| S. No                        | Name of Sector                                                                                                            | No. of Industries | No. of Workers   | Production Capacity                                                                                          |
|------------------------------|---------------------------------------------------------------------------------------------------------------------------|-------------------|------------------|--------------------------------------------------------------------------------------------------------------|
| 1.                           | Pharmaceutical Industries                                                                                                 | 19                | NA               | 69000 Bottles, 14756000 tabs, 9000 bags, 40000 I/V sets, 4-5 tons Sod. Silicate/ day                         |
| 2.                           | Iron Steel Industries                                                                                                     | 14                | 152 <sup>1</sup> | 35885 Kg steel/day, 27 ton cables & conductors /year, 250 sqft Tube well /day, 37155 kg home appliances /day |
| 3.                           | Food Industries                                                                                                           | 9                 | 264              | 750 ctn/day, 8100 bakery Kg/day, 40 bag food/day, 40000 Brand cock/day, 10 b/s spices /day                   |
| 4.                           | Furniture Industries                                                                                                      | 12                | 269              | 40432 boards/year, 1430 sheet/day, 500 screws <sup>2</sup>                                                   |
| 5.                           | Package Industries                                                                                                        | 3                 | 56               | 3000 ctn/day (2 factories)                                                                                   |
| 6.                           | Printing Industries                                                                                                       | 2                 | 76               | 30000 sheet/day (1 factories)                                                                                |
| 7.                           | Paper & Board Industries                                                                                                  | 1                 | 110              | 25 ctn/day                                                                                                   |
| 8.                           | Match Industries                                                                                                          | 11                | 1188             | 5707 ctn/day                                                                                                 |
| 9.                           | Marble Industries                                                                                                         | 14                | 131              | 13400 sqft                                                                                                   |
| 10.                          | Textile Industries                                                                                                        | 5                 | 761              | 2000 Kg/day (2 factories)                                                                                    |
| 11.                          | Ghee Industries                                                                                                           | 3                 | 80               | 170 ton/day                                                                                                  |
| 12.                          | Ceramic Industries                                                                                                        | 2                 | 425              | 50 pieces & 1800 sqft tiles/day                                                                              |
| 13.                          | Plastic Industries                                                                                                        | 3                 | 61               | To be verified                                                                                               |
| 14.                          | Rubber Industries<br>(Two tyre Ind.)                                                                                      | 2                 | checked in IIDP  | 700 tyre/day                                                                                                 |
| 15.                          | Adhesive Tape Industries<br>(2 adhesive Ind.)                                                                             | 2                 | checked in IIDP  | 1500 Kg adhesive tape/day                                                                                    |
| 16.                          | Plastic Shopping Bag Industries<br>(Twin Star & Shafi Ind)                                                                | 2                 | checked in IIDP  | 3100 Kg shopping bags/day                                                                                    |
| 17.                          | Other Plastic and PVC Pipe Industries<br>(Royal PVC, MKB Ind., Prime Star, Aryan petro, Ropeman Ind. Pvt, Shershah Engg.) | 6                 | checked in IIDP  | 2600 Kg PVC /day, 500 ton plastic/day, 500 kg plastic ropes/day.                                             |
| 18.                          | Concrete Industries                                                                                                       | 1                 | -                | 100 units/day                                                                                                |
| 19.                          | Fiber Glass Industries                                                                                                    | 1                 | 7                | 5 tubs/day                                                                                                   |
| <b>Individual Industries</b> |                                                                                                                           |                   |                  |                                                                                                              |
| 20.                          | Chemical Industries                                                                                                       | 1                 | 10               | -                                                                                                            |
| 21.                          | Roofcool Ind. Pvt. Ltd.                                                                                                   | 1                 | 13               | 1-20 lak sqft                                                                                                |
| 22.                          | Frontier Foundry Pvt. Ltd.                                                                                                | 1                 | 100              | -                                                                                                            |
| 23.                          | Abaseen Pvt. Ltd.                                                                                                         | 1                 | 4                | -                                                                                                            |
| 24.                          | Shamshad Flour Mills Pvt. Ltd.                                                                                            | 1                 | 13               | -                                                                                                            |

<sup>1</sup> No. of Workers for 5 industries only

<sup>2</sup> Production data for 5 industries only

|                                    |   |     |
|------------------------------------|---|-----|
| Total Sector wise Industrial Units | = | 110 |
| Total Individual Industrial Units  | = | 5   |
| Total Units                        | = | 115 |



## **1-9 Urban Planning (Control of Urbanization)**

Government is taking number of measures for Urban Planning. Different problems are confronting the Government due to rapid population growth and urbanization, especially in the mega cities of Pakistan. Although there is neither a coherent urban development policy nor an efficient and responsive mechanism for the delivery of municipal services. NWFP is the least urbanized province in Pakistan, where only 16.9 percent population lives in cities. The most populated city of NWFP is Peshawar, where rapid urbanization is taking place as compared to the other cities of the province.

Ministries of Housing/Environment and Urban Affairs Division of the Federal Government have prepared the three policy documents related to urban sector development. These documents are as follow:

- 1- National Human Settlement Policy Study (1990)
- 2- Management of Cities Policy (1990) and
- 3- National Housing Policy of Pakistan (1992)

Brief description about these government policies on urban planning are given below:

- **National Human Settlement Policy**

This study advocates a re-orientation towards professionalism in urban management, formulation of an urban land policy forming public-private partnership. Dismantling Housing and Physical Planning (H & PP) Departments and devolving all their functions to local governments.

A major finding of the study is that, “all the large cities of the country have high urban absorption costs compared to selected medium sized towns, which out perform them on efficiency-cost criteria.” However, conceding that the large cities will have to absorb a “substantial proportion of the forthcoming urbanization”, the study puts forward the following, efficiency based recommendations; (a) developing low-cost cities; (b) investing in selected large cities like Karachi, Hyderabad, Faisalabad, Sialkot and Peshawar while controlling growth of cities like Lahore, Quetta, Multan, and Gujranwala; (d) encouraging concentration in growth corridors of Peshawar, Nowshera-Mardan-Jahangira-Taxila-Haripur and Jhelum-Sialkot-Gujrat; and (e) developing rural service towns.

- **Management of Cities Policy**

The policy emphasizes the following strategic initiatives:

- Strengthening urban local governments as an institution by introducing planning as a key innovation; changing laws and rules to allow city-wide perspective, greater local initiative and an improved decision making structure; introducing plan-oriented accounting and facilitating availability of trained manpower.
- Devolving those functions to local governments which would increase administrative efficiency, equity and citizen welfare, commensurate with national and provincial systems integrity.

- Increasing inter-governmental coordination by, inter alia, creating an umbrella institution for local governments, enabling inter-agency and inter-departmental coordination by evolving effective partnerships, inculcating good conventions and clear systems for case processing responsibilities.

- **National Housing Policy**

The policy aims at; (a) Accelerating housing production in urban and rural areas; (b) Making available suitability, located land and at affordable price; (c) Developing effective strategies for preventing formation of slums and katchi abadies; (d) Mobilizing resources for housing through personal savings; and (e) Developing new strategies and undertaking revision of policies from time to time.

Based on the policy objective outlined above the following initiative are recommended; (i) Housing to be a “highest priority sector” in the national development plans; (ii) Government to confine its role to providing sites and services, ensuring availability of building materials and to promote housing finance institutions, whereas actual construction of houses shall generally be left to the private sector; (iii) Greater emphasis on affordability, personal savings, self-help and cost recovery; (iv) No more katchi abadies recognition; (v) Ensuring wider application of low cost technology and optimum use of resources at the individual and national levels; and (vi) Coordinating the National Housing Policy with other development policies e.g. population, employment, social welfare, fiscal and monetary.

- **National Conservation Strategy, (NCS)**

Approved by the Pakistan Government in March, 1992, the document advocating; (a) greater public partnership in development and management; (b) merging environment and economics in decision and making; and focusing on long term improvements in the quality of life in Pakistan. For this purpose, it puts forward recommendations in 14 core areas, two of which are most relevant to Urban Environmental Sanitation Service (UES). They include

- (a) Preventing and abating pollution and
- (b) Managing Urban Wastes

The next important step following approval of the NCS, was the formulation in 1993 of the National Environmental Quality Standards, (NEQS). The NEQS, inter alia relate to municipal and industrial liquid effluents.

- **Role of provincial Department/Agencies**

At the provincial level there is a host of line departments and specifically established agencies for the management of urban environment. Planning and Development (P&D) Department is the prime coordinating and monitoring agency in NWFP. The Department of local Government is overseeing the affairs of district, city and union councils. Department of Housing & Physical Planning and Public Health Engineering are responsible for developing and executing schemes related to site and

services as well as those related to water supply, sewage and drainage. Department of Excise and Taxation involves in the collection of urban immovable property tax.

- **NWFP-Building Regulations, 1985**

Provincial Urban Development Board-NWFP has notified NWFP-building Regulations on 7<sup>th</sup> April,1985. This is a complete document comprising twelve chapters. Chapter wise headings of these regulations are given below:-

- Chapter 1: Preliminary
- Chapter 2: Submission of Plans for Approval
- Chapter 3: Space requirement in and around building
- Chapter 4: Internal Lighting and Ventilation including mechanical ventilation
- Chapter 5: Building structure-constructional requirements
- Chapter 6: Drainage and Sanitation
- Chapter 7: Fire resistance and fire precautions
- Chapter 8: The Activities of Builders and Developers
- Chapter 9: Demolition
- Chapter 10: Relaxation
- Chapter 11: Penalties and Appeals
- Chapter 12: Licensing of Professional Architects/Civil Engineers/Structural Engineer and Town Planners

Further Amendments were made in these regulations by Provincial Urban Development Board-NWFP through notification on 20<sup>th</sup> February, 1989.

- **Urban Planning and Development –Management System**

Government of NWFP has approved a project “Urban Planning and Development Management System” for Peshawar in 1999. Study on this project has already been completed and now Government is planning to utilize this project.

- **Land Use and Land Development Ordinance 2002**

NWFP-EPA has drafted an ordinance for Land use and Land Development in the light growing human population and urbanization. This ordinance is still under process and has not been notified yet.

- **Design Land Use Planning Process and its Legal Status in NWFP**

NWFP-EPA has prepared a project proposal on “Design Land Use Planning Process and its Legal Status in NWFP”, the purpose of this project is to develop digital base maps for the entire NWFP at an appropriate scale by using remote sensing and GIS technologies. Also to assess the existing land use situation in NWFP and to prepare a provincial land use policy/Act.

## 2- WATER CYCLE

### 2-1 Rainfall

Pakistan receives rainfall in summer and winter. In the transition period, the pattern and character of summer and winter rains over the northern parts of the county gets so intermixed that it becomes difficult to identify the dominant character. However, it can be generalized that the province of Punjab and Sindh get more rainfall in summer, while the provinces of Balochistan and NWFP get more rainfall in winter. Altitude also plays an important role as it affects the amount of precipitation on the windward and leeward side of the mountains.

Peshawar, representing wide range of semi-arid sub mountainous plains, normally does not receive monsoon precipitation but mainly from western disturbance in winter.

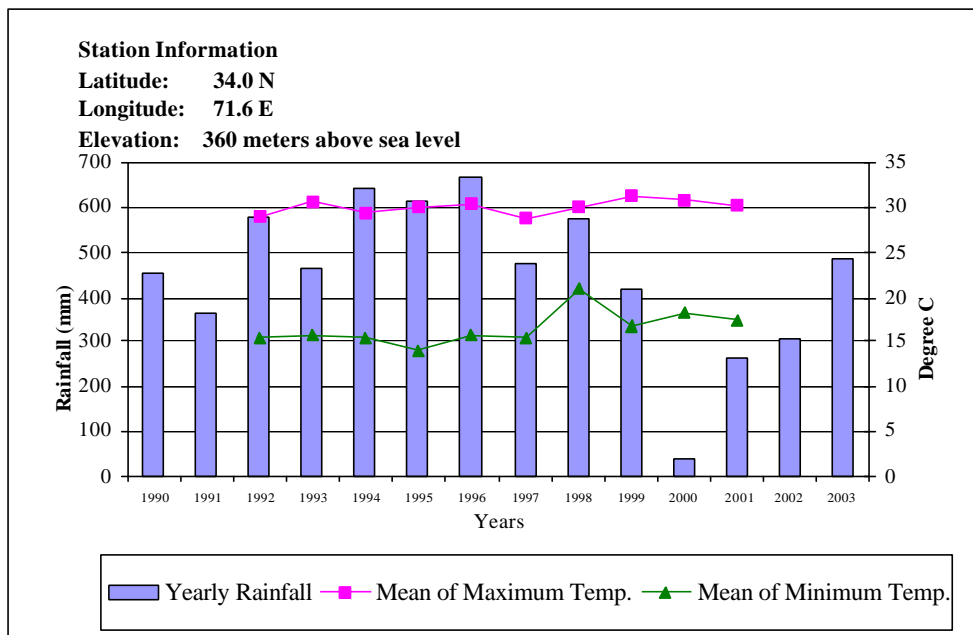
Table-16 shows the monthly rainfall data since 1990 to year 2000. Total annual rainfall data for this period is also given. As described above, more rainfall was observed during winter period.

Average annual rainfall in Peshawar area is around 480mm. Table-17 shows the mean of maximum and minimum temperature of Peshawar.

Figure-3 shows total annual rainfall with mean of maximum and minimum temperature at Peshawar. Mean of maximum and minimum temperature over year show a uniform pattern except some increase in mean of minimum temperature was observed in the year 1998. In the year 2000, the rainfall was very low, 40mm, compared to the average annual figures.

**FIGURE-3**

### TOTAL ANNUAL RAINFALL WITH MEAN of MAXIMUM AND MINIMUM TEMPERATURE AT PESHAWAR



**TABLE-16**

**MONTHLY TOTAL RAINFALL (mm) DATA for PESHAWAR**

|      | Jan   | Feb   | March | April | May  | June | July  | Aug.  | Sept. | Oct. | Nov.  | Dec.  | Total Annual |
|------|-------|-------|-------|-------|------|------|-------|-------|-------|------|-------|-------|--------------|
| 1990 | 49.7  | 67.1  | 31.2  | 26.2  | 17   | 2.4  | 9.4   | 74.5  | 45    | 52   | 8.5   | 46.9  | 453.8        |
| 1991 | 8.7   | -     | 53.5  | -     | 71.4 | 1    | 13    | 20    | 5     | 2    | 3     | 8     | 364.3        |
| 1992 | 64.8  | 61.8  | -     | -     | 58.4 | 2    | 4     | 102.9 | 28.7  | 10   | Trace | 30    | 579.5        |
| 1993 | 38.7  | 4.5   | 176.5 | 34.4  | 12.  | 35.4 | 55.4  | Trace | 56    | 11   | -     | -     | 466          |
| 1994 | 17    | 77.5  | 60    | 80    | 25.5 | 14   | 162.5 | 37.8  | 55.1  | 55   | 1     | 56    | 642.3        |
| 1995 | 0     | 49    | 126.2 | 130.4 | 25.3 | 1    |       | 99    | 65    | 13   | 13    | 3     | 613          |
| 1996 | 20    | 74    | 75.8  | 38    | 14.5 | 12   | 17.8  | 110   | 51    | 203  | 42    | Trace | 667.1        |
| 1997 | 16    | 21    | 28.5  | 143.3 | 29   | 38   | 45.5  | 13    | 12    | 93.8 | 4     | 28.5  | 473.6        |
| 1998 | 44.6  | 114   | 97    | 69    | 31.5 | 25.5 | 97    | 85    | 21.5  | 7.5  | Trace | -     | 572.3        |
| 1999 | 150   | 28    | 73.5  | 12.5  | 6.5  | 48   | 24.5  | 36.5  | 15    | 11   | 24    | 0     | 417.5        |
| 2000 | 0     | Trace | 10    | Trace | 0    | 0    | 3     | 14    | 5     | 0    | Trace | 3     | 40           |
| 2001 | Trace | 0.6   | 22.1  | 19.4  | 16.7 | 4.3  | 53.6  | 11.1  | 7.2   | Nil  | 16.5  | Trace | 263          |
| 2002 | 2.0   | 58.3  | 46.2  | 14.5  | 7.5  | 18.0 | 1     | 116.6 | 14.9  | 1.0  | 6.8   | 20.0  | 306.8        |
| 2003 | 21.0  | 83.2  | 59.9  | 71.6  | 12.8 | 8.7  | 73.2  | 51.6  | 45.2  | 32.0 | 8.6   | 19.0  | 486.8        |

Source: Pakistan Meteorological Department

**TABLE-17**

**MEAN of MAXIMUM and MINIMUM TEMPERATURE °C at PESHAWAR**

| Year            | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|-----------------|------|------|------|------|------|------|------|------|------|------|
| Mean of Maximum | 29   | 30.5 | 29.4 | 29.9 | 30.4 | 28.8 | 30.0 | 31.2 | 30.9 | 30.2 |
| Mean of Minimum | 15.6 | 15.7 | 15.5 | 14   | 15.7 | 15.5 | 20.9 | 16.8 | 18.2 | 17.3 |

Source: Pakistan Statistical Year Book, 2003

Survey in Hayatabad was conducted w.e.f. 12 January 2004 to 20 January 2004 for water and solid waste quality study. Table-18 shows daily rainfall data for the month of January. Data shows no rainfall was observed before one week of study period. Only rainfall was observed during Solid Waste Study on 18<sup>th</sup> January 2004, which is 21.2 mm.

**TABLE-18**

**DAILY RAINFALL DATA from 1<sup>st</sup> to 31<sup>st</sup> JANUARY, 2004**

|                                  | Date       | Rainfall (mm) |
|----------------------------------|------------|---------------|
|                                  | 01-01-2004 | Trace         |
|                                  | 02-01-2004 | 4.0           |
|                                  | 03-01-2004 | Nil           |
|                                  | 04-01-2004 | Nil           |
|                                  | 05-01-2004 | Nil           |
|                                  | 06-01-2004 | Trace         |
|                                  | 07-01-2004 | Nil           |
|                                  | 08-01-2004 | Nil           |
|                                  | 09-01-2004 | Nil           |
|                                  | 10-01-2004 | Nil           |
|                                  | 11-01-2004 | Nil           |
| Water Quality Study Period       | 12-01-2004 | Nil           |
|                                  | 13-01-2004 | Nil           |
| Solid Waste Quality Study Period | 14-01-2004 | Nil           |
|                                  | 15-01-2004 | Nil           |
|                                  | 16.01.2004 | Nil           |
|                                  | 17.01.2004 | 21.2          |
|                                  | 18.01.2004 | 1.0           |
|                                  | 19.01.2004 | Nil           |
|                                  | 20.01.2004 | Nil           |
|                                  | 21.01.2004 | 5.0           |
|                                  | 22.01.2004 | 14.2          |
|                                  | 23.01.2004 | 10.8          |
|                                  | 24.01.2004 | 7.8           |
|                                  | 25.01.2004 | Nil           |
|                                  | 26.01.2004 | Nil           |
|                                  | 27.01.2004 | Nil           |
|                                  | 28.01.2004 | Nil           |
|                                  | 29.01.2004 | Trace         |
|                                  | 30.01.2004 | 3.7           |
|                                  | 31.01.2004 | 0.3           |
| <b>TOTAL RAINFALL</b>            |            | <b>68.0</b>   |

Source: Meteorological Office, Peshawar

## 2-2 Field Survey on Water Quality

Table-5 (on page 9) shows the water survey points with their location beside the quality of Leachate collected from solid waste dumping site.

Table-19 shows the methodologies and instruments used during water survey and laboratory analysis of collected samples for different parameters. Temperature, pH, Dissolved oxygen, Odor, Turbidity and flow were determined on sampling points. While these collected samples were analyzed for rest of the parameters in the laboratory.

**TABLE-19**

**METHODOLOGIES AND INSTRUMENTS USED FOR THE  
ANALYSIS OF WATER SAMPLES**

| <b>Parameters</b>           | <b>Test Method</b>                                      | <b>Instrument used</b>                               |
|-----------------------------|---------------------------------------------------------|------------------------------------------------------|
| Temperature                 | Centigrade scale mercury thermometer                    | Zeal, England                                        |
| pH                          | Electrometric using combination electrodes              | D-25, HORIBA, Japan                                  |
| Dissolved Oxygen            | Membrane electrode Method                               | DO-219, DKK-TOA, Japan                               |
| Color                       | Visual comparison method (2120 B)*                      | -                                                    |
| Conductivity                | Electrode method                                        | PW 9526 Digital Conductivity Meter, Philips, England |
| Odor                        | Threshold Odor number (TON) by dilution method (2150B)* | -                                                    |
| Turbidity                   | Comparison of intensity of light                        | Turbidity meter, Orbeco Hellige, USA                 |
| Flow                        | Digital current meter                                   | Tamaya, UC-204, Japan                                |
| BOD <sub>5</sub>            | 5 days incubation, reduction on DO is measured          | -                                                    |
| COD                         | Colorimetric method                                     | DR/2000 spectrophotometer, HACH, USA                 |
| TSS                         | Gravimetric, dried at 105°C                             | -                                                    |
| Total Nitrogen              | Digestion and colorimetry                               | HV-1601, SHIMADZU, Spectrophotometer.                |
| Bacteriological Examination | Total viable count per gram                             | -                                                    |
| Oil & Grease                | Extraction, evaporation and gravimetry                  | -                                                    |
| Lead                        | Atomic Absorption Spectrophotometry (AAS)               | AS-929, UNICAM, England                              |
| Chromium                    | AAS                                                     | -do-                                                 |
| Zinc                        | AAS                                                     | -do-                                                 |
| Arsenic                     | AAS                                                     | -do-                                                 |
| Cadmium                     | AAS                                                     | -do-                                                 |
| Copper                      | AAS                                                     | -do-                                                 |

*\*Standard Method for the Examination of water and wastewater, 18<sup>th</sup> Edition, 1992.*

The sampling procedures followed by Pak-EPA team throughout field testing are briefly outlined:

- The water sampling and spot testing team was given complete instructions on the importance and significance of correct sampling procedures.
- Standard Sampling Procedures (SOP) was followed for the water sampling.
- Samples were collected at locations where water was well mixed, homogenized and flowing samples were taken at the middle of the channels.
- Samples were preserved in an ice box at or near 4°C immediately after collection.
- Nitric acid (HNO<sub>3</sub>) was added to the sampling bottles in quantities sufficient to lower the pH of the samples to just below 2 to stabilize the concentration of dissolved metals.
- Sampling bottles were given identification numbers immediately after the samples were collected
- For E-Coli sampling, sterilized glass container was used and the sample was shifted immediately under control temperature to National Institute of Health (NIH) for bacteriological analysis.

### **2-2-1 Testing Methods and Procedures**

Certain physical and chemical properties of water/such as color, odor, pH, temperature, conductivity and dissolved oxygen, tend to change significantly with time and therefore requires on site testing. A brief description and calibration procedures for field equipments is given below

#### **Temperature:**

Temperature measurement was made with calibrated mercury thermometer of Zeal, England.

#### **pH:**

pH was measured using D-25 HORIBA, Japan. The meter was calibrated at three points against buffer solutions of 4, 7 and 9.2 pH prior to measurement.

#### **Dissolved Oxygen:**

Dissolved Oxygen (DO) measurement were made using DO-219, DKK-TOA, an instrument of Japan make. The manufacturer's calibration procedure was followed to obtain the guaranteed precision and accuracy. The DO meter was calibrated before each measurement.

#### **Conductivity:**

Conductivity of spot samples were measured with PW9256, Digital conductivity meter, PHILIPS, England. The manufacturer's calibrated procedure was followed to obtain the guaranteed precision and accuracy. The conductivity meter was calibrated by keeping an electrode in ambient air for some time. The conductivity should be displayed between 1.066-1.071 mS/cm.



Conductivity meter was also calibrated against Standard solution of Potassium Chloride (KCl) of known conductivity of 1.413 mS/cm.

**Color:**

“True Color” measurements were made by visual comparison of the samples with Platinum Cobalt Standards. Wastewater samples were filtered before the measurements were made for color.

Standard solutions prepared for on-site color measurements are presented in Table- 20. The standard color solution was kept in an air-tight brown reagent bottle and proper dilutions were made before the color measurement.

**TABLE-20**

**STANDARD SOLUTION for COLOR MEASUREMENT**

| Standard solutions Diluted to 50 ml with Distilled water | Color in Chloroplatinate units |
|----------------------------------------------------------|--------------------------------|
| 0                                                        | 0                              |
| 0.5                                                      | 5                              |
| 1.0                                                      | 10                             |
| 2.0                                                      | 20                             |
| 5.0                                                      | 50                             |
| 7.0                                                      | 70                             |
| 9.0                                                      | 90                             |
| 10.5                                                     | 105                            |
| 12.0                                                     | 120                            |

**Odor:**

Odor is recognized as a key quality parameter. For odor measurement “Threshold Odor Number” method was used, which is based on dilution of the sample with odor free water until the odor is barely perceptible to each tester.

**Turbidity:**

The Nephelometric method was used for turbidity measurement. This method compares the intensity of light scattered by the sample with the intensity of light scattered by a Standard reference suspension under defined conditions. The manufacturer’s operating and calibrated instructions were followed for accuracy and precision of results.

**Flow:**

Digital current meter of Tamaya UC-204, Japan was used to measure the flow of the stream. Besides measuring the velocity of water, depth and width of the stream was also measured for the determination of water flow in m<sup>3</sup>/sec (cubic meter per second).

## **2-2-2 Laboratory Test Methods and Procedures**

Test methods given in Table-20 were used for laboratory testing of the leachate and wastewater.

### **Biological Oxygen Demand (BOD)**

The Biological Oxygen Demand (BOD) method entails a 5-day incubation of the sample at 20°C. DO was measured before and after incubation and BOD was computed from the difference between the initial and final Dissolved Oxygen.

### **Chemical Oxygen Demand (COD)**

The COD is a measure of the oxygen equivalent of organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant. The sample was digested at 150°C for two hours in a strong acid solution with a known excess of Potassium dichromate. Then by using the DR-2000 spectrophotometer, the sample was analyzed at 435nm.

### **Suspended Solids:**

A well mixed known volume of sample was filtered through a weighed glass fiber filter. The residue was dried to a constant weight at 105°C. The increase in weight of the filter represented the total Suspended Solids.

### **Oil and Grease:**

For the determination of oil and grease, an absolute quantity of a specific substance was not measured. Rather, groups of substances with similar physical characteristics were determined quantitatively on the basis of their common solubility in an organic extracting solvent. N-hexane was used as solvent for the extraction of oil from the leachate and polluted water samples.

### **Total Nitrogen:**

Sample was digested using autoclave at 120°C temperature and 15 PSI pressure for 30 minutes. After filtering through filter paper, the filtrate was acidified at a control pH (2-3). Absorbance of the sample was checked using HV-1601 SHIMDZU Spectrophotometer. Instrument was calibrated before actual run with Standard solutions.

### **Heavy Metals Analysis:**

Requirement for determining metals by Atomic absorption Spectrophotometry (AAS) vary with metal and/or concentration to be determined. The method was used according to the concentration of different metals. Method 3 III (Metals by Flame Atomic Absorption Spectrometry) was used for the analysis of Lead, Chromium, Zinc, Cadmium and Copper. For Arsenic, Method 3114 (Metals by Hydride Generation) was used. These methods are taken from the "Standard Method for the Examination of water and wastewater, 18<sup>th</sup> Edition, 1992".

## **2-2-3 Analytical Results and Discussion**

Water samples collected from different sites of Hayatabad along with a leachate sample collected from the solid waste dumping site were analyzed for different parameters in Central Laboratory for Environmental Analysis (CLEAN) at Pak-EPA, Islamabad. Bacteriological examination of leachate sample was performed at National Institute of Health (NIH), Islamabad. Table-21 Shows the analytical results of these samples.

**TABLE-21**

**ANALYTICAL RESULTS OF WATER AND LEACHATE SAMPLES  
FROM HAYATABAD, PESHAWAR**

Unit: (mg/l, otherwise mentioned)

| Survey Points                           | P1                        | P2    | P3    | P4    | P5    | P6    | P70   | Leachate Sample       |
|-----------------------------------------|---------------------------|-------|-------|-------|-------|-------|-------|-----------------------|
| <b>Items (Units)</b>                    |                           |       |       |       |       |       |       |                       |
| Ambient Air Temp. (°C)                  | 20.45                     | 22.65 | 19.6  | 17.7  | 21.2  | 19.25 | 22.7  | 22.7                  |
| Relative Humidity (%)                   | 26.25                     | 24.35 | 25.2  | 27.2  | 24.35 | 28.25 | 24.8  | 24.8                  |
| Temperature (°C)                        | 17.3                      | 19.60 | 20.3  | 16.4  | 15.80 | 19.7  | 20.8  | 26.70                 |
| pH                                      | 7.34                      | 7.66  | 7.43  | 7.91  | 7.55  | 7.85  | 8.89  | 9.25                  |
| Dissolved Oxygen                        | 0.77                      | 0.59  | 0.71  | 4.93  | 2.46  | 1.48  | 1.41  | 1.20                  |
| Color (color unit)                      | -                         | 105   | -     | 30    | 60    | 120   | 90    | -                     |
| Odor (TON)                              | 200                       | 70    | 200   | 8     | 17    | 50    | 140   | 24                    |
| Conductivity (mS/cm)                    | 2.06                      | 1.034 | 1.856 | 0.602 | 0.956 | 1.053 | 1.193 | 20.8                  |
| Turbidity (NTU)                         | 241                       | 114   | 307   | 316   | 54.5  | 153   | 131   | 296                   |
| Flow (m <sup>3</sup> /sec)              | 0.22                      | 0.24  | 0.10  | 0.007 | 0.002 | 0.36  | 0.07  | -                     |
| BOD <sub>5days</sub>                    | 323.5                     | 75.5  | 224.0 | 51.5  | 47.5  | 150.5 | 88.25 | 805.0                 |
| COD                                     | 2240                      | 606   | 1394  | 329.5 | 221.0 | 570   | 614   | 2840                  |
| TSS                                     | 400.0                     | 500.0 | 700.0 | 335.0 | 200.0 | 900.0 | 320.0 | 300.0                 |
| Total Nitrogen                          | 10.294                    | 8.82  | 9.20  | 6.95  | 9.5   | 8.97  | 9.8   | 10.3                  |
| Bacteriological Examinations (per gram) | Total viable count        | -     | -     | -     | -     | -     | -     | 7.6 x 10 <sup>4</sup> |
|                                         | Coliform organisms        | -     | -     | -     | -     | -     | -     | 2 x 10 <sup>4</sup>   |
|                                         | Faecal coliform organisms | -     | -     | -     | -     | -     | -     | Negative              |
|                                         | Salmonella                | -     | -     | -     | -     | -     | -     | 6 x 10 <sup>3</sup>   |
|                                         | Staphylococcus            | -     | -     | -     | -     | -     | -     | 6 x 10 <sup>4</sup>   |
| Fungus                                  | -                         | -     | -     | -     | -     | -     | -     | -                     |
| Oil & Grease                            | 600                       | 80    | 260   | 50    | 40    | 80    | 120   | 820                   |
| Lead                                    | 0.395                     | 0.374 | 0.514 | 0.692 | 0.494 | 0.297 | 0.198 | 0.593                 |
| Chromium                                | 1.62                      | 0.83  | 1.21  | 0.82  | 0.4   | 0.79  | 0.75  | 2.82                  |
| Zinc                                    | 0.145                     | 0.285 | 0.073 | 0.251 | N.D   | 0.318 | 0.313 | 1.062                 |
| Arsenic                                 | N.D                       | N.D   | N.D   | N.D   | N.D   | N.D   | N.D   | N.D                   |
| Cadmium                                 | N.D                       | N.D   | N.D   | N.D   | N.D   | N.D   | N.D   | N.D                   |
| Copper                                  | 0.070                     | 0.075 | 0.080 | 0.149 | 0.087 | 0.045 | 0.090 | 0.381                 |

*Note: N.D means not detected, below detection limit*

Temperature of a water body has a number of indirect effects on the biota because a change in temperature changes the solubility essential gases, including Oxygen.

Temperature at the seven sampling sites in Hayatabad was within the range of 16.4 to 20.8°C. Where as the temperature of the leachate sample coming from the solid waste dump was 26.70°C. High temperature was noted at P7, which is next to the dumping site. So the possibility of mixing of leachate with water body is ascertain. The second highest temperature was noted at P3, which is due to the industrial discharges.

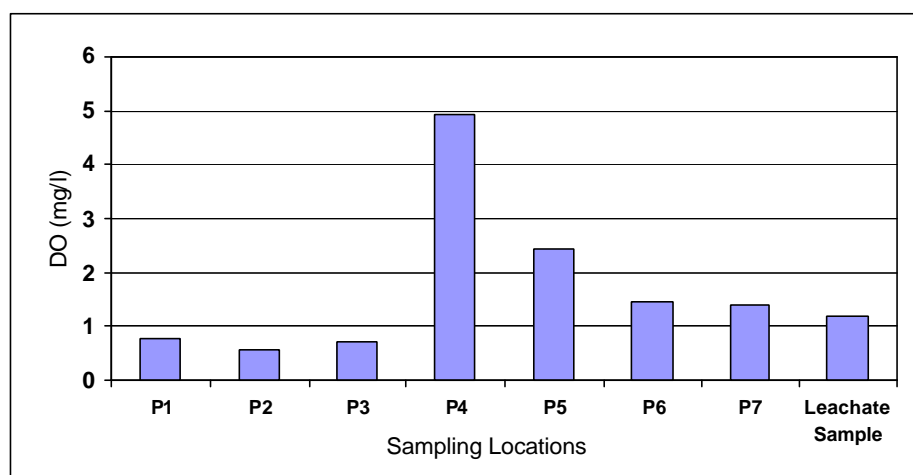
pH basically the buffering capacity of the  $\text{CO}_3\text{-HCO}_3$  system in water. The pH rises when the carbonates in the water are utilized by the microorganisms, while the decomposition of organic pollutants causes pH to drop to the acidic range. pH in this study ranges from 7.34 to 8.89, while the pH of leachate sample is 9.25. Maximum pH in sampling sites was noted at P7 sampling point. The reason is obviously same as discussed for water temperature. pH of leachate influences chemical and biological processes of precipitation, sorption and methanogenesis.

Dissolved oxygen (DO) determine whether or not biological changes are brought about by aerobic or anaerobic microorganisms in water body. DO in water depend upon the physical, chemical and biochemical activities taking place in water body. DO concentration noted during spot test ranged from 0.71 to 4.93 mg/l. Minimum DO values were observed at P2 and P3. The water on these sampling locations is mostly comprised of industrial effluents. Maximum value of DO was observed at P4, which is 4.93mg/l. this sampling point is on a water channel before entering the industrial estate, Hayatabad.

The DO level of the leachate was 1.20 mg/l. A comparison of DO concentration at different points in Hayatabad is shown in Figure-4.

**FIGURE-4**

### COMPARISON OF DISSOLVED OXYGEN AT SAMPLING POINTS IN HAYATABAD

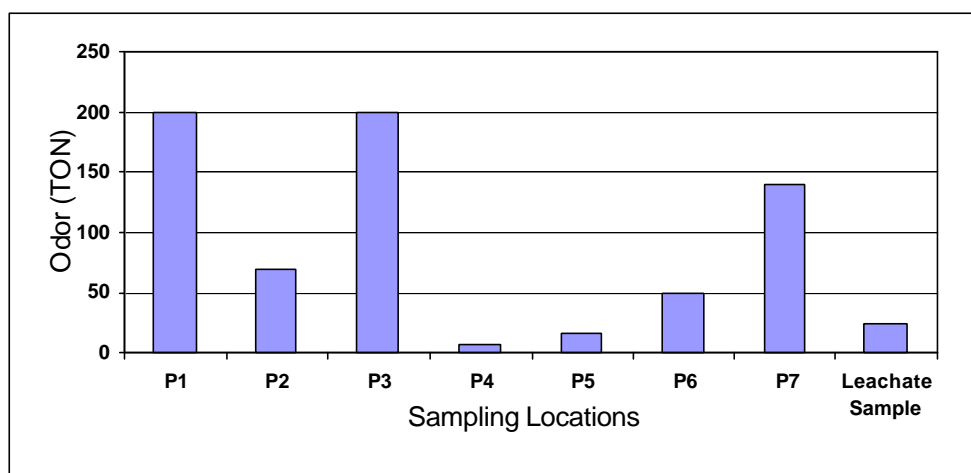


Color in water is caused by the natural metallic ion (iron and manganese). Many industrial wastes are colored. The true color of the samples collected was measured by the visual comparison method using the Platinum Cobalt Standard method. This method is useful for measuring color of potable water and of water in which color is due to naturally occurring materials. This method is not applicable to most highly colored industrial wastewater. Therefore no color comparison was carried out for the water samples collected at P1 and P3 sampling sites and also the leachate sample because these samples are highly colored. The results of color measurement varied from 30 to 120 True Color Unit (TCU). The highest measurement was 120 TCU, sample taken from P6 (sewage disposal plant). The minimum value was 30 TCU (water before entering the Hayatabad industrial estate).

The threshold odor test was carried out at sampling sites using odor-free water for comparison. Results are reported in TON (Threshold Odor Number). Results of the odor tests at seven sampling sites and leachate sample varied from 8 to 200 TON. The maximum value was 200 TON at sampling points P1 and P3. Water flow on these sampling points comprise excessive amount of industrial effluents. A comparison of odor noted at different sampling points is shown in Figure-5.

**FIGURE-5**

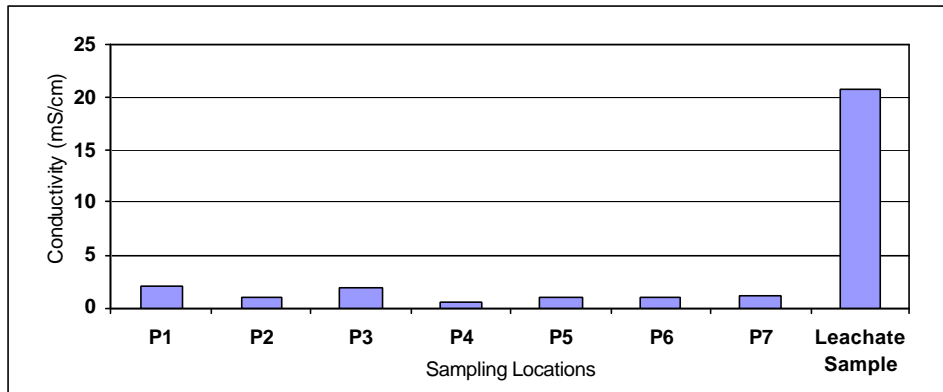
### COMPARISON OF ODOR AT SAMPLING SITES IN HAYATABAD



Conductivity characterizes the gross chemical position of water and is a measure of ability of water to conduct an electric current. A rise in the concentration of ions results in an increase in the conductivity. Conductivity values of the water samples and leachate range from 0.602 to 20.8 mS/cm. The highest conductivity was observed in leachate sample, which is 20.8 mS/cm. This means leachate sample has high concentration of dissolved solids. Figure-6 shows a comparison of conductivity noted at different sampling locations and leachate.

**FIGURE-6**

**COMPARISON OF CONDUCTIVITY AT DIFFERENT SAMPLING SITES IN HAYATABAD.**

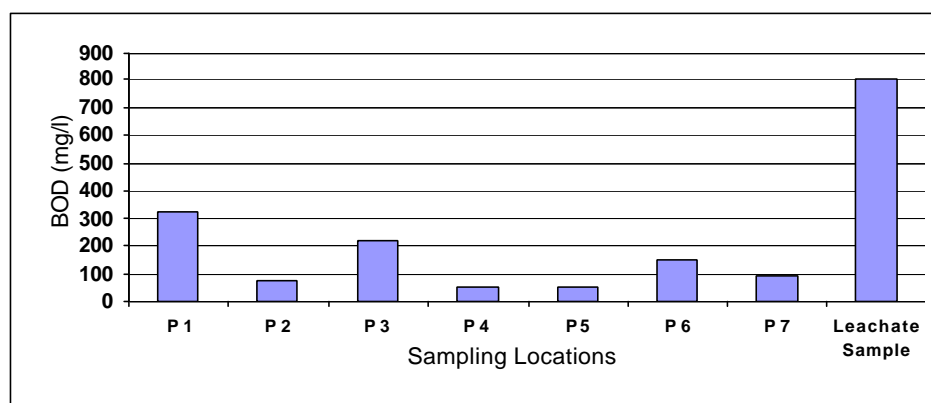


BOD represents the quantity of oxygen required by bacteria and other microorganisms during biochemical degradation and transformation of organic matter present in waste water or leachate under aerobic condition. The BOD test is important in the analysis of sewage, industrial, polluted water and leachate coming from solid waste dumping site. It is best available method for accessing organic pollution and the most important parameter used in stream pollution control. BOD and BOD/COD ratios give valuable input regarding the difficulty to degrade the organic substances, the supply of carbon source in identification, or the maturity phase dominating the dumping site or landfill site.

Test results of BOD at different sampling locations in Hayatabad varied from 47.5 to 323.5 mg/l. Whereas the BOD of the leachate sample is 805.0 mg/l. Figure-7 shows the comparison of BOD noted at the different sampling points and the leachate sample.

**FIGURE-7**

**COMPARISON OF BOD AT DIFFERENT SAMPLING SITES IN HAYATABAD**



The highest concentration of BOD in water sample was noted at sampling site P1, which has the highest concentration of industrial waste. The second highest concentration was observed at P3, which is 224 mg/l. Water flowing through this site dominantly constituted by the industrial waste. The leachate sample has the highest BOD concentration. This is due to the kitchen waste dumped directly to the landfill site. This high BOD of leachate deteriorating the environment.

Chemical Oxygen Demand (COD) is the measure of oxygen equivalent to the portion of organic matter in wastewater that is susceptible to oxidation by Potassium Dichromate. COD is an important test and gives a quick measure of pollution load of the stream, river, sewage, industrial wastewater and the leachate samples in Hayatabad varied between 221.0 to 2240.0 mg/l. Here also like BOD the highest concentration of COD was measured at P1 sampling site. The second highest concentration was noted at P3. Minimum concentration was observed at sampling site P5, which is 221.0 mg/l.

COD concentration of the leachate was 2840.0 mg/l. The leachate of waste from the landfill sites in Germany usually contains higher BOD, higher COD and relatively lower salt compared to those in Japan. The following Table-22 gives the relative biodegradability of leachate:

**TABLE-22**

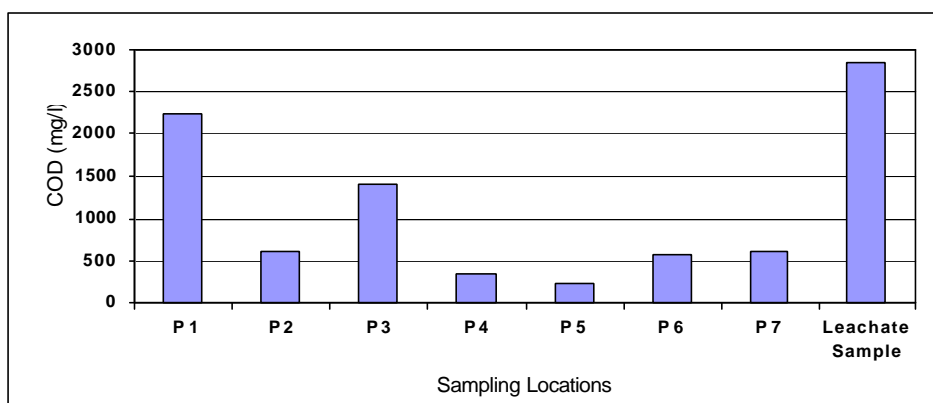
**RELATIVE BIODEGRADABILITY OF LEACHATE**

| Biodegradability | BOD/COD    |
|------------------|------------|
| Low              | < 0.5      |
| Medium           | 0.5 – 0.75 |
| High             | > 0.75     |

BOD/COD ratio of the leachate sample collected from the solid waste dumping site in Hayatabad is 0.28. Which shows biodegradability of leachate sample is very low. Figure-8 shows a comparison of COD noted at different sampling locations in Hayatabad.

**FIGURE-8**

**COMPARISON OF COD AT DIFFERENT SAMPLING SITES IN HAYATABAD**

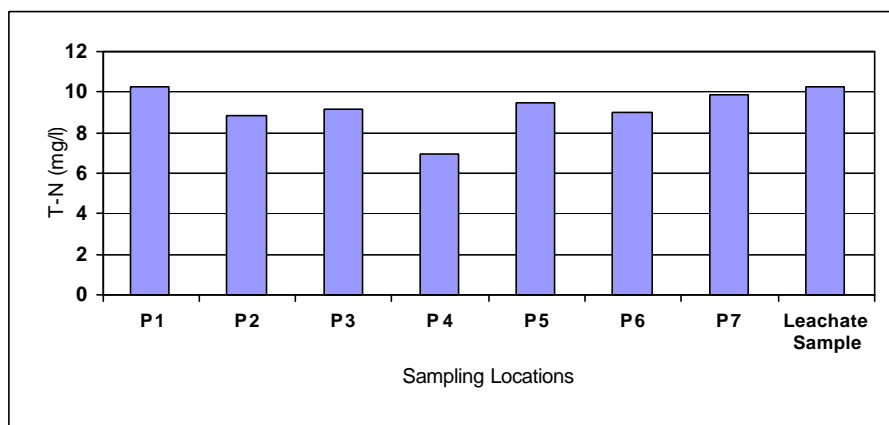


Total nitrogen (T-N) compounds in river and wastewater are important pollution indicating parameters. Nitrogen is considered a pollutant since it requires oxygen for oxidation in its unoxidized state, and because it contributes to the eutrophication of natural waters. The values of T-N detected from the different sampling locations in Hayatabad varies from 6.95 to 10.294 mg/l.

The highest concentration of T-N was observed at P1 and P3, which is 10.294 mg/l and 9.20 mg/l respectively. The minimum T-N value was 6.95 mg/l, which was detected in the sample collected from P4 location. The leachate sample also shows high T-N value, which is 10.3 mg/l. The T-N value in leachate indicates the nutrient availability. Nitrogen in leachate present for long period of time. Figure-9 presents a comparison of T-N values noted at different sampling points in Hayatabad.

**FIGURE-9**

### COMPARISON OF T-N AT SAMPLING SITES IN HAYATABAD



Oil and grease (O&G) in the water interfere with the oxygenation. While testing the water and leachate samples, 600mg/l was observed at P1 sampling locations. This high O&G concentration in the Ganado Khawar is caused by heavy industrial discharges. Number of Ghee and Food industries and automobile workshops in the vicinity are also discharging their waste in this stream without any treatment leachate sample also shows highest O&G concentration, which is 820 mg/l.

Heavy metals are found in industrial wastes in a variety of forms. Lead, Chromium, Zinc, Arsenic, Cadmium, and Copper were determined in water samples and leachate sample. Arsenic and Cadmium were not detected by Atomic Absorption Spectroscopy (AAS) method. Which show the concentration of these metals are below detection limits of AAS. Chromium presence is very high in water as well as in leachate sample. Maximum concentration of chromium was found at P4 and P3 sampling locations, which were 0.692 mg/l and 0.514 mg/l respectively. High concentration of chromium in North Nallah passing through the industrial estate of Hayatabad reveals that industrial effluents contain high concentration of Chromium.

A Researcher from the Department of Chemistry, University of Peshawar found in his detail study that this Chromium is mostly coming from the match industries. There are about eleven (11) match factories, discharging their effluents directly in this Nallah.



The concentration of Chromium from the match factories effluent was found to be in the range of  $11.0 \pm 0.01$  mg/l. Some match factories have chromium concentration as high as 38.91 mg/l. He further added that this concentration of Chromium is not total Chromium but Chromium (VI). Cr (VI) is more toxic than Cr (III). Therefore the Chromium concentration at sampling location P1, P3 and P4 are mostly comprised by Cr (VI).

In leachate, heavy metals may act as inhibitors of biological stabilization process. High concentration of Zinc is present in leachate sample, which is 1.062 mg/l. concentration of lead, Zinc and Copper also vary on different sampling locations.

Bacteriological Examination was performed for leachate sample and some drinking water samples collected from Municipal water supply system and one from private bore hole. No faecal coliform was found in drinking water samples. Leachate sample shows high total viable count and coliform organisms, which are  $7.6 \times 10^4$  and  $2 \times 10^4$  respectively. Faecal coli form organisms is negative in leachate sample.

#### **2-2-4 National Environmental Quality Standards (NEQS) by Pak-EPA (Municipal and Liquid Industrial Effluents)**

Pak-EPA with the prior approval of Pakistan Environmental Protection Council has notified NEQS for Municipal and Industrial Effluents in 1993. With further amendments, revised NEQS was notified in August, 2000.

Annexure-A shows the 32 Standards of liquid effluents.

If we compare the values of different parameters observed at sampling points P1 to P7 in water channels in Hayatabad area, most of the parameters are well above the permissible limits of NEQS set by Government of Pakistan.

#### **2-2-5 Pollution Load in Hayatabad Water Channel**

Concentrations of BOD and COD in river and wastewater are the most significant pollution indicators. Results from different sampling sites in Hayatabad show that BOD and COD loads calculated at these points varies from 0.01 to 6.15 t/day and 0.20 to 42.58 t/day respectively.

Pollution load at different sampling locations are listed in Table-23

**TABLE-23**

**BOD and COD LOAD at DIFFERENT SAMPLING LOCATIONS in HAYATABAD**

| Locations<br>Parameters    | P1     | P2    | P3     | P4    | P5    | P6    | P7    |
|----------------------------|--------|-------|--------|-------|-------|-------|-------|
| Flow (m <sup>3</sup> /sec) | 0.22   | 0.24  | 0.10   | 0.007 | 0.002 | 0.36  | 0.07  |
| BOD5 (mg/l)                | 323.5  | 75.5  | 224.0  | 51.5  | 47.5  | 150.5 | 88.25 |
| COD (mg/l)                 | 2240.0 | 606.0 | 1394.0 | 329.5 | 221.0 | 570.0 | 614.0 |
| BOD Load (t/day)           | 6.15   | 1.56  | 1.93   | 0.03  | 0.01  | 4.68  | 0.53  |
| COD Load (t/day)           | 42.58  | 12.57 | 12.04  | 0.20  | 0.04  | 17.73 | 3.71  |

Maximum pollution load was noted at P1 sampling, where BOD and COD loading are 6.15 t/day and 42.58 t/day respectively. This sampling site receives the maximum pollution load of Hayatabad. The second highest pollution load location in terms of BOD and COD is P6 (effluents coming from domestic sewage disposal plant). Here the BOD and COD loading are 4.68 t/day and 17.73 t/day respectively. This Treatment Plant is non-operational since 1996. Therefore domestic sewage without any treatment as such are being disposed off from this Plant. That's why the BOD and COD loading are very high.

The third highest pollution loads locations are P2 and P3. The BOD and COD loadings at sampling points P2 and P3 are 1.56 t/day and 12.57 t/day, 1.93 t/day and 12.04 t/day respectively. At both these locations the pollution loads are more or less the same.

Same pollution load was noted at sampling point P7, which is next to the solid waste dumping site. Comparative high BOD and COD loadings at P7 site with P4 and P5 sampling sites are due to the mixing of leachate coming from the solid waste dumping site.

### **3- Sewage Treatment Plant in Hayatabad**

#### **3-1 Existing System**

The Peshawar Development Authority had laid sewerage network for all the Phases of Hayatabad Township. The sewerage network for Phase I to V were constructed to carry the sewage from these Phase upto the site of Sewage Treatment Plant constructed in Phase-III ranging in diameters from 6 to 24 inches. This Sewage Treatment Plant was constructed initially for treatment of 1.2 MGD (Million Gallons per Day) of sewage from the initial development of population from first five Phases to be extended for an ultimate capacity of 4.0 MGD.

The development in first five Phases had occurred at an accelerated rate resulting in increased population, increased quantity of sewage production and over loading of the Sewage Treatment Plant, which was not extended by Peshawar Development Authority. The development works of Phase-VI and VII had lagged. However, the sewerage networks for Phase-VI and VII were constructed but due to problem of pollution encountered at the previous Sewage Treatment Plant, the proposed Sewage Treatment Plant for Phases-VI and VII was constructed. The Sewage from the population in Phase-VI and VII entering into the sewerage network is at present flowing into the adjacent natural storm water nallah without treatment and is a source of pollution and environmental hazard for the surrounding areas.

#### **3-2 Deficiencies of Existing Sewage Treatment Plant**

As already explained, the existing Sewage Treatments Plant had been working over loaded due to increased flow of raw sewage over and above the designed capacity and is causing environmental pollution in the adjoining areas. Foul smell is being emitted from the Sewage Treatment Plant and is disturbing the traffic on adjacent main roads.

The defused aeration could not be done due to damage to machinery. This plant had been operating for about 15 years without adequate maintenance and operation. There is no record of the testing of raw sewage or treated effluent. The flow measuring equipment has worn out and damaged and not working since unknown period. There is no record of flow measurements ever carried out for this plant. It is therefore not possible to comment on the performance of this Sewage Treatment Plant even during the initial stages of construction and commissioning as no design report or detail construction drawings for this Sewage Treatment Plant are available. No records of analysis of raw sewage or treated effluent are available with Peshawar Development Authority. As such the extent of treatment achieved in this plant during initial stages or thereafter cannot be commented upon.

### **3-3 Present Situation**

The present Sewage Treatment Plant at Hayatabad located on main road in Phase- III is causing environmental problem in the adjoining areas with foul smell and disturbing the traffic on main road. The quality of treatment had been effected due to following reasons:

- a) Overloading of the plant
- b) Damages to machinery due to inadequate operation and maintenance.
- c) Mechanical equipment is quite old and need extensive repairs and rehabilitation.

This Sewage Treatment Plant was designed for biological treatment through oxidation ponds (Facultative and Maturation) in addition to diffused aeration using helixor tubes. The increased rate of development in the area resulted in larger flows of sewage overloading the Sewage Treatment Plant while the inadequate operation and maintenance resulted in damages to the machinery and degradation of the treatment process. The worn-out components of mechanical equipment need repairs and replacement.

The present sewage flow from first five phases has been assessed as 2.4 MGD against the designed capacity of 1.2 MGD. The population-based calculations of sewage inflow for first five phases of Hayatabad has been estimated as 3.105 MGD while the ultimate sewage flow has been assessed as 8.25 MGD.

Design parameters of the original design of this Sewage Treatment Plant are not available. The detailed construction drawings or as built drawings are also not available. The area available at site for extension of the treatment plant is inadequate for even the present flow of sewage on the basis of oxidation ponds for upgrading the existing plant.

### **3-4 Design Parameters adopted for existing sewage Treatment plant.**

On the basis of available information, we have assessed the criteria / design parameters adopted in the original design of existing Sewage Treatment Plant.

These design parameters are summarized in Table-24

**TABLE-24**

**DESIGN PARAMETERS ADOPTED FOR EXISTING SEWAGE TREATMENT PLANT.**

|    |                                                     |                       |
|----|-----------------------------------------------------|-----------------------|
| a) | <b>Designed population</b>                          | <b>32,000 persons</b> |
| b) | <b>Retention period in aeration lagoon</b>          | <b>2.4 days</b>       |
| c) | <b>BOD loading on facultative pond</b>              | <b>250 kg/ha</b>      |
| d) | <b>Retention period in facultative pond</b>         | <b>12 days</b>        |
| e) | <b>Retention period in maturation pond</b>          | <b>8.4 days</b>       |
| f) | <b>Total area of site at Sewage Treatment Plant</b> | <b>28 acres</b>       |
| g) | <b>Area already utilized</b>                        | <b>17.6 acres</b>     |
| h) | <b>Area available for extension</b>                 | <b>10.4 acres</b>     |

The Peshawar Development Authority will be required to provide Sewage Treatment of 8.25 MGD (for full development) in case the existing Sewage Treatment Plant is shifted from its present site or 6.55 MGD capacity in case the existing Sewage Treatment Plant is upgraded and extended to 1.7 MGD capacity.

As already the PDA has decided to shift the existing the STP to another STP already constructed on Warsak road, Peshawar.

The above design parameters are quite conservative in comparison to the normally adopted parameters. The problem had arisen due to overloading and lack of proper operation and maintenance. We are of the opinion that this existing treatment plant can be upgraded with the following:

- i) Rehabilitation of aeration equipment
- ii) Restrict of flow of sewage in to the existing Sewage Treatment Plant to its designed capacity i.e 1.2 MGD only.
- iii) Provide adequate operation and maintenance to keep the plant in good operating condition.
- iv) Provide extension to the Sewage Treatment Plant on the basis of oxidation ponds to the extent of area available and capacity according to conservative design parameters adopted in the original design.

As the area available at the site of Sewage Treatment Plant is small, calculation of capacity and dimension of the ponds proposed for extension are assessed on the basis of conservative criteria and aerated lagoons have been proposed to be changed to anaerobic pond to economize in the capital cost and also operation and maintenance costs of electrical and mechanical equipment. However, for additional safety a small curtain wall has been proposed to be constructed around aeration lagoons and anaerobic pond to restrict the fould smells, if any, spreading to adjoining areas.

According to the design calculation, the extension work at the site of existing Sewage Treatment Plant Hayatabad will be capable of treatment of 0.5 MGD of sewage from a population of 14,000 persons while the total treatment plant capacity of upgraded and extended plant will be about 1.7 MGD. The upgraded existing Sewage Treatment Plant will treat sewage from a population of 46,000 persons satisfactorily.

## 4- Water Supply

### 4-1 City Water

Description about the water supply to the Hayatabad Area is given previously in section 1-7. Number of Tube wells installed so far in Hayatabad and the average run of each tube well per day, give an approximate water supply to the Hayatabad residential and commercial areas, which is about 87,847 m<sup>3</sup>/day. Locations of the tube wells in Hayatabad is given on the map of Hayatabad in Annexure-B.

The following Table-25 shows the yield of tube wells operated by various agencies in Peshawar region.

**TABLE-25**

### YIELD OF TUBE WELLS OPERATED BY VARIOUS AGENCIES IN PESHAWAR REGION.

| No | Responsible Agency/<br>Organization:  | Total No.<br>of Tube<br>wells | Average<br>Discharge<br>(m <sup>3</sup> /hr) | Average<br>Operating<br>Time (hrs) | Amount of<br>water being<br>Extracted<br>(m <sup>3</sup> /day) |
|----|---------------------------------------|-------------------------------|----------------------------------------------|------------------------------------|----------------------------------------------------------------|
| 1. | Town-III<br>Hayatabad Township        | 53                            | 127.5                                        | 13                                 | 87847                                                          |
| 2. | Town-I, Walled city                   | 32                            | 62.43                                        | 15                                 | 29965                                                          |
| 3. | Town-II Outside<br>Walled City        | 84                            | 60.10                                        | 15                                 | 75726                                                          |
| 4. | Cantonment Board                      | 7                             | 68.07                                        | 12                                 | 5718                                                           |
| 5. | MES                                   | 16                            | 73.27                                        | 20                                 | 23446                                                          |
| 6. | PDA                                   | 18                            | 104.77                                       | 13                                 | 24516                                                          |
| 7. | Town-IV, Rural Area                   | 27                            | 71.10                                        | 15                                 | 28795                                                          |
| 8. | PHD for Afghan<br>Refugees Tube wells | 6                             | 27.22                                        | 16                                 | 2613                                                           |
| 9. | Shallow Wells                         | 131                           | 6.29                                         | -                                  | 824                                                            |

The above table does not cover all parts of Peshawar. This table shows how much water is being extracted from various parts of Peshawar per day. There are so many other agencies operating their tube Wells in Peshawar. Shallow wells data given in the table are much lower than the expected tube wells operating in the city. It is very difficult to get a precise data about the shallow wells being operated in Peshawar region because no such survey has been conducted by any agency in the past.

This figure is reproduced from the survey conducted by the Engineering University, Peshawar two years back. Data about the number of tube wells being operated by the city Government (Town –I—Town-IV) do not reflect the total number of tube wells.

#### **4-2 Industrial Water**

Hayatabad industrial estate was established in early 1980s. At that time Hayatabad Township was not established. To arrange the water supply to the industry is the responsibility of the owner of the industry himself. Town-III government is not responsible to supply the water to the industrial estate. Therefore each industry has its own water supply system. No such data exist to know the usage of water by each industrial unit. Each industry extracts water from its own tube well. The only way to know approximately how much water is being used by the Hayatabad industrial estate. The flow of combined industrial units were monitored and found that approximately 8,640 m<sup>3</sup>/day industrial water is being used.

#### **4-3 Tube wells location and their discharge for Public Service**

Tube wells locations are given on the map of Hayatabad township in Annexure-B. Each phase of Hayatabad is covered by the water supply through tube wells. Town-III is responsible to provide water connections to residential houses, Public and Commercial areas. Town-III charged water consumers on monthly basis on flat rates fixed for each category of houses as well as for commercial activities.

#### **4-4 Ground Water Quality of Hayatabad**

A team comprising teachers and students from the University of Engineering and Technology, Peshawar has conducted a study on ground water quality of Hayatabad last year. The following Table-26 shows the results of ground water quality of Hayatabad.

**TABLE-26**

## GROUND WATER QUALITY OF HAYATABAD

Units: mg/l otherwise mentioned

| Parameters           | Sampling Points | Medical Complex | Phase-I | Phase-II | Phase-III | Phase-IV | Phase-V | Phase-VI |
|----------------------|-----------------|-----------------|---------|----------|-----------|----------|---------|----------|
| Temperature (°C)     | Source          | 25              | 28      | 23.4     | 25        | 27.0     | 20.0    | 22.1     |
|                      | Intermediate    | 25              | 28.5    | 22.9     | 26        | 26.0     | 20.0    | 22.1     |
|                      | Consumer        | 25              | 28.7    | 23.2     | 25        | 26.6     | 22.4    | 22.1     |
| pH                   | Source          | 7.20            | 7.03    | 7.33     | 7.5       | 7.29     | 7.10    | 8.22     |
|                      | Intermediate    | 7.20            | 7.07    | 7.27     | 7.5       | 7.31     | 7.07    | 8.17     |
|                      | Consumer        | 7.30            | 7.05    | 7.44     | 7.5       | 7.39     | 7.11    | 8.31     |
| Conductivity (mS/cm) | Source          | 0.54            | 0.54    | 0.65     | 0.62      | 0.60     | 0.50    | 0.63     |
|                      | Intermediate    | 0.55            | 0.52    | 0.66     | 0.62      | 0.60     | 0.50    | 0.63     |
|                      | Consumer        | 0.55            | 0.52    | 0.65     | 0.63      | 0.61     | 0.49    | 0.61     |
| TDS                  | Source          | 270             | 222     | 330      | 300       | 300      | 250     | 320      |
|                      | Intermediate    | 270             | 195     | 320      | 300       | 300      | 250     | 310      |
|                      | Consumer        | 280             | 199     | 330      | 310       | 310      | 260     | 310      |
| TSS                  | Source          | 20              | 27      | 29       | 30        | 27       | 28      | 28       |
|                      | Intermediate    | 20              | 27      | 28       | 33        | 28       | 30      | 27       |
|                      | Consumer        | 22              | 30      | 30       | 30        | 30       | 30      | 27       |
| Turbidity (NTU)      | Source          | 2.0             | 1.5     | 1.4      | 4.0       | 1.8      | 1.4     | 0.3      |
|                      | Intermediate    | 2.1             | 1.6     | 1.5      | 4.1       | 1.7      | 1.7     | 0.9      |
|                      | Consumer        | 2.3             | 1.8     | 1.6      | 4.2       | 2.5      | 1.4     | 0.7      |
| Alkalinity           | Source          | 120             | 203     | 60       | 135       | 56       | 52      | 56       |
|                      | Intermediate    | 125             | 204     | 40       | 125       | 52       | 50      | 50       |
|                      | Consumer        | 125             | 207     | 62       | 120       | 58       | 46      | 52       |
| Dissolved Oxygen     | Source          | 4.5             | 8.7     | 19.9     | 6.0       | 12.2     | 12.4    | 5.1      |
|                      | Intermediate    | 4.9             | 8.1     | 15.6     | 6.1       | 12.0     | 12.1    | 4.9      |
|                      | Consumer        | 4.8             | 8.1     | 20.4     | 6.0       | 12.3     | 11.7    | 5.1      |
| Total Hardness       | Source          | 290             | 87      | 300      | 280       | 280      | 250     | 266      |
|                      | Intermediate    | 280             | 103     | 270      | 285       | 182      | 324     | 222      |
|                      | Consumer        | 285             | 107     | 266      | 290       | 218      | 202     | 246      |
| Hardness as Ca       | Source          | 120             | 53      | 76       | 120       | 51       | 101     | 53       |
|                      | Intermediate    | 120             | 71      | 74       | 125       | 55       | 79      | 51       |
|                      | Consumer        | 120             | 73      | 77       | 130       | 77       | 72      | 51       |
| Hardness as Mg       | Source          | 170             | 35      | 224      | 160       | 229      | 149     | 213      |
|                      | Intermediate    | 160             | 33      | 196      | 160       | 127      | 245     | 171      |
|                      | Consumer        | 165             | 34      | 189      | 160       | 141      | 130     | 195      |

| Parameters       | Sampling Points | Medical Complex | Phase-I | Phase-II | Phase-III | Phase-IV | Phase-V | Phase-VI |
|------------------|-----------------|-----------------|---------|----------|-----------|----------|---------|----------|
| <b>Potassium</b> | Source          | 5.00            | 2.05    | 3.60     | 3.15      | 2.80     | 2.30    | 2.0      |
|                  | Intermediate    | 5.25            | 2.10    | 3.20     | 3.35      | 2.60     | 1.70    | 1.8      |
|                  | Consumer        | 5.15            | 2.08    | 3.10     | 3.70      | 2.70     | 1.60    | 1.6      |
| <b>Iron</b>      | Source          | 3.00            | 0.34    | 0.10     | 2.02      | 0.60     | 0.45    | 0.80     |
|                  | Intermediate    | 3.15            | 0.36    | 0.20     | 2.50      | 0.70     | 0.50    | 0.50     |
|                  | Consumer        | 3.20            | 0.36    | 0.15     | 2.70      | 0.70     | 0.65    | 0.50     |
| <b>Chlorides</b> | Source          | 145             | 25      | 14       | 142       | 13       | 10      | 15       |
|                  | Intermediate    | 144             | 38      | 14       | 144       | 17       | 9       | 17       |
|                  | Consumer        | 147             | 39      | 13       | 142       | 14       | 10      | 17       |
| <b>Nitrates</b>  | Source          | 7.50            | 4.30    | 9.10     | 8.20      | 8.40     | 8.60    | 5.10     |
|                  | Intermediate    | 8.00            | 4.15    | 8.70     | 8.20      | 8.50     | 8.10    | 5.00     |
|                  | Consumer        | 8.10            | 4.15    | 8.60     | 8.20      | 8.20     | 8.50    | 5.10     |

#### 4-5 Estimation of Number of Private Borehole/Dug wells

Very few private bore holes are present in Hayatabad Township area. As mentioned earlier, Hayatabad Township is a well Planned city with all civic amenities. Presently, water supply for domestic and commercial usage is sufficient. Secondly the water table is also very deep; therefore to make a private bore hole is expansive. Only few houses of 2 or 1 kanal sizes with maximum inhabitants have private bore holes. Exact numbers are not known but the general survey conducted by Pak-EPA reveals that these private bore holes are very few. No dug wells are present in Hayatabad Township.

#### 4-6 Current Water Use and Future Trend

Pakistan, once a water surplus country, is now water deficient country. The rainwater is neither sufficient nor regular, to meet the growing needs of water. About 70% of annual rainfall occurs in the months of July to September. Table-27 gives the comparison of per-capita of water availability in some selected countries of the world.

**TABLE-27**

#### PER-CAPITA WATER AVAILABILITY IN SELECTED COUNTRIES (m<sup>3</sup>)

| Country            | 1955          | 1990         | 2025         |
|--------------------|---------------|--------------|--------------|
| <b>China</b>       | <b>4,597</b>  | <b>2,427</b> | <b>1,818</b> |
| <b>Mexico</b>      | <b>11,396</b> | <b>4,226</b> | <b>2,597</b> |
| <b>Philippines</b> | <b>13,507</b> | <b>5,173</b> | <b>3,072</b> |
| <b>USA</b>         | <b>14,934</b> | <b>9,913</b> | <b>7,695</b> |
| <b>Pakistan</b>    | <b>2,490</b>  | <b>1,672</b> | <b>837</b>   |

*Source: Population action International*



The situation in Pakistan indicates that country is nearing conditions of chronic water-stress below 1,000 m<sup>3</sup>.

In Hayatabad and Peshawar region depends almost on the ground water resources. With rapid population growth and urbanization, the water usage also increased many fold. Water requirement increases day by day. The continued abstraction of ground water has resulted in over-pumping and consequent lowering of ground water table in many areas. Efforts to recharge the depleting aquifers need to be undertaken immediately.

## **5-Hydro-Geological Characteristics**

### **5-1 Hydrology**

Hayatabad township is bound by Malagori and Khyber hill in west and south, in the east is Peshawar City and in north are small villages and recently developed townships. A very large township under development is the Regi Lalama which is double in size as compared to Hayatabad. On south is the Bara River while down north is River Kabul. Ground water is the major source of public water supply. The Peshawar Municipality, and its surrounding areas like cantonment and other settlements form a part of main hydrological basin. The aquifers, which are encountered here are the parts of the major aquifer system of Peshawar valley basin. As the sediments play an important role in hydraulic and geometric nature of aquifer, hence it is imperative to have a brief understanding about the deposition of alluvial sediments. Peshawar is a closed basin surrounded by hills on all sides, which have made it an intermountain basin. The sediment from the hills were brought into the basin by the stream originating in them and finally terminating into the basin. The basin exhibited semi lacstrin environments of deposition resulting in accumulation of thick clays in the central part, however, Hayatabad township is different than other parts of the basin because there the proximity of the hills resulted in the deposition of coarser material like gravels and boulders.

There are two major aquifer systems: Phratic (water table) aquifer system and Confined (artesian) aquifer system. Water table aquifer is found to a depth of 125 meters below ground surface and is mainly composed of coarse sand and gravels. Pumping test data of various tube wells in Hayatabad satellite town indicate good hydraulic properties of this aquifer system.

### **5-2 Bore hole logs**

The following Table-28 shows information about bore hole logs of several tube wells with in the various Phases of Hayatabad and Peshawar.

**TABLE-28**

**WATER TABLE DEPTH AND DRAW DOWN WITHIN PESHAWAR  
REGION**

| <b>Location of Tube wells</b> | <b>Water Table depth (m)</b> | <b>Limit of depth from which water (m)</b> | <b>Length of well screen (m)</b> | <b>Discharge (m<sup>3</sup>/hr)</b> | <b>Draw down</b> |
|-------------------------------|------------------------------|--------------------------------------------|----------------------------------|-------------------------------------|------------------|
| PMC office                    | -                            | 45-86                                      | 2                                | 45                                  | 12               |
| Chan Agha Colony              | 14                           | 42-64                                      | 22                               | 67.5                                | 3                |
| Khyber Colony                 | 12                           | 37-61                                      | 18                               | 22.5                                | 1                |
| Shahi Bagh Well-1             | 2                            | 24-67                                      | 10                               | 45                                  | 15               |
| Shahi Bagh Well-5             | 3                            | 21-86                                      | 17                               | 32.4                                | 9                |
| Hayatabad Phase-II            | 47                           | 64-125                                     | 43                               | 134                                 | 7                |
| Hayatabad Phase-III           | 36                           | 78-149                                     | 28                               | 101                                 | 6                |
| Hayatabad Phase-IV            | 40                           | 72-149                                     | 30                               | 101                                 | 6                |
| Hayatabad Phase-V             | 45                           | 91-145                                     | 29                               | 101                                 | 6                |

The aquifer in Hayatabad Town is deeper as compared to other parts of Peshawar City and yield from the individual tube well is generally greater. Recently drilled tube-wells in Hayatabad Town have an average yield of about 102m<sup>3</sup>/hour, where as the Peshawar city area has an average yield of about 43 m<sup>3</sup>/hour. The gravel aquifer is interspersed with clay and its total depth from water is about 43 meters. Water table depth of shahi Bagh, Peshawar city ranges between 2-3 meters.

There is appreciable amount of ground water available in form of storage in pore spaces of the sediments. Transitivity values of the aquifer vary depending upon the lithology and storing between 500 to 2000 m<sup>2</sup>/day. This suggests that sufficiently porous and permeable strata lie beneath the ground surface. The water-depth in Hayatabad is recorded to be around 45 meters near the hills and about 1 meter near Kabul river (10-15 km away) where logged conditions exist.