

Ph.D Thesis On
**STUDY OF PHYSICO CHEMICAL AND BIOLOGICAL
TREATMENT FACILITIES FOR THE INDUSTRIAL
WASTE WATER OF HAYATABAD PESHAWAR,
PAKISTAN**

528P
By
ZAHID ULLAH



**DEPARTMENT OF ENVIRONMENTAL SCIENCES
UNIVERSITY OF PESHAWAR
NWFP, PAKISTAN
2009**

Ph. D Thesis On
**STUDY OF PHYSICO CHEMICAL AND BIOLOGICAL
TREATMENT FACILITIES FOR THE INDUSTRIAL/
WASTE WATER OF HAYATABAD PESHAWAR,
PAKISTAN**

By
ZAHID ULLAH



Supervised

By

Dr. HIZBULLAH KHAN
DEPARTMENT OF ENVIRONMENTAL SCIENCES
UNIVERSITY OF PESHAWAR

**DEPARTMENT OF ENVIRONMENTAL SCIENCES
UNIVERSITY OF PESHAWAR
NWFP, PAKISTAN**

2009

**STUDY OF PHYSICO CHEMICAL AND BIOLOGICAL TREATMENT
FACILITIES FOR THE INDUSTRIAL WASTE WATER OF HAYATABAD
PESHAWAR**

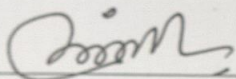
By

Mr. Zahidullah

**A thesis submitted in partial fulfillment of the requirements for the degree of
Doctor of Philosophy in Environmental Sciences.**

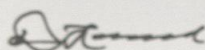
Approved by

Research Supervisor



Dr. Hizbullah Khan
Department of Environmental Sciences
University of Peshawar

External Examiner



Chairman,
Department of Environmental Sciences,
University of Peshawar

**DEPARTMENT OF ENVIRONMENTAL SCIENCES
UNIVERSITY OF PESHAWAR
NWFP, PAKISTAN
2009**

IN THE NAME OF

ALLAH

RAHMAN

&

RAHEEM

Dedication

- Dedicated to my ever loving parents, sisters and brothers whose love, support and affection, made me able to receive education up to this extent and whose prayers have always been a source of constant encouragement and success for me.
- Dedicated to my wife and two kids Abdur Rahman and Mohammad Arsalan.
- Dedicated to all those who are trying to keep this planet earth clean, healthy and want peace on it.

List of Contents

S.NO.	Chapter No/ Content	Page No.
1	Chapter 1 Introduction	1-7
1.1	Background Information	1
1.2	Objectives	4
1.3	Methodology/ Plans	4
1.4	References	6
2	Chapter 2 Description of The Study Area	8-21
2.1	Industrialization in NWFP	8
2.2	Location	10
2.3	Topography	12
2.4	Rivers	12
2.5	Climate	12
2.6	Forest Cover	13
2.7	History of Peshawar	13
2.8	Agriculture	14
2.9	Population and Area	14

2.10	Hayatabad Industrial Estate (HIE), Peshawar	14
2.10.1	Concept of Industrial Estate	14
2.10.2	Historical Background of Industrial Estate	15
2.10.3	“Industrial Estates in Pakistan”	15
2.10.4	Hayatabad Industrial Estate in Brief	16
2.10.5	Existing Infrastructure and facilities in Hayatabad Industrial Estate	19
2.11	References	20
3	Chapter 3 Literature Review	22-47
3.1	Background	22
3.2	Characterization of Industrial Effluents	22
3.3	Analytical Study of Heavy Metals	29
3.4	Analysis of Water Quality Parameters	31
3.5	Physico Chemical Characteristics of River Water	35
3.6	Concluding Remarks	40
3.7	References	41
4	Chapter 4 Materials and Methods	48-63
4.1	Background	48
4.2	Effluent Sampling	48

4.3	Collection and Description of Sample	49
4.4	Sample Analysis	52
4.5	Analytical Procedures	53
4.5.1	Discharge and Flow rate of Surface and Wastewater	53
4.5.2	Temperature	53
4.5.3	pH Measurement	54
4.5.4	Determination of Conductivity	54
4.5.5	Turbidity	54
4.5.6	Total Suspended Solids (TSS)	55
4.5.7	Total Dissolved Solids (TDS)	55
4.5.8	Total Solids (TS)	56
4.5.9	Alkalinity	56
4.5.10	Dissolved Oxygen (DO)	57
4.5.11	Biological Oxygen Demand (BOD)	59
4.5.12	Chemical Oxygen Demand (COD)	59
4.5.13	Nitrate	59
4.5.14	Sulfate	60
4.5.15	Chlorides	60

4.5.16	Determination of Heavy Metals in Effluents Samples by Atomic Absorption Spectrometry	61
4.6	References	62
5	Chapter 5 Results and Discussion	64-85
5.1	Physico Chemical Properties of Effluent/Wastewater of Hayatabad, Peshawar	64
5.1.1	Flow rate of Water and Wastewater	64
5.1.2	Temperature	64
5.1.3	pH	65
5.1.4	Conductivity	66
5.1.5	Turbidity	66
5.1.6	Total Suspended Solids	67
5.1.7	Total Dissolved Solids (TDS)	67
5.2	Chemical Characteristics	68
5.2.1	Alkalinity	68
5.2.2	Dissolved Oxygen	69
5.2.3	Biological Oxygen Demand (BOD)	70
5.2.4	Chemical Oxygen Demand (COD)	71
5.2.5	Nitrate	72
5.2.6	Sulfate	73

5.2.7	Chlorides	74
5.3	Heavy Metals	75
5.3.1	Chromium (Cr)	75
5.3.2	Copper (Cu)	75
5.3.3	Iron (Fe)	76
5.3.4	Nickel (Ni)	77
5.3.5	Lead (Pb)	77
5.4	Possible Pollution Control and Preventive Measures	79
5.5	Institutional Role in Pollution Abatement	82
5.6	References	84
6	Chapter- 6 Conclusions and Recommendations	86-92
6.1	Conclusions	86
6.2	Recommendations	88
6.2.1	General Recommendations	88
6.2.2	Specific Recommendations	89
	Tables 5.1 to 5.16	93
	Appendix 1: Water Quality Standards	109

	Map 2.1: Map of North West Frontier Province NWFP	9
	Map 2.2: Map of Peshawar	11
	Map2.3: Map of Hayatabad Industrial Estate Peshawar	18
	Table 4.1 Description of Sample Sites/locations.	49
	Figure 4.1 Diagram Showing Sample Sites of The Study Area.	52
	List of Abbreviations.	vii
	Acknowledgements	x
	Abstract	xi
	Field and Laboratory Slides	132

List of Abbreviations

BOD	Biological Oxygen Demand
TS	Total Solids
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
DO	Dissolved Oxygen
COD	Chemical Oxygen Demand
HIE	Hayatabad Industrial Estate
UNESCAP	United Nation Economic and Social Commission for Asia and Pacific
MTL	Mineral Testing Laboratory
SDA	Sarhad Development Authority
EPA	Environmental Protection Agency
GPS	Global Positioning System
WHO	World Health Organization
PCRWR	Pakistan Council for Research in Water Resources
PSI	Pakistan Standard Institutions
NEQS	National Environmental Quality Standards
uS/cm	Micro semen per centimeter

mg/L	Milligram Per Liter
ppm	Parts Per Million
AAS	Atomic Absorption Spectrophotometer
GOP	Government of Pakistan
SSA	Site Specific Analysis
LTA	Life Time Analysis
PCSIR	Pakistan Council for Scientific and Industrial Research
USPH	United State Public Health
NWFP	North West Frontier Province
DCR	District Censes Report
PDA	Peshawar Development Authority
DEPM	Department of Environmental Planning and Management
NTU	Nephelometric Turbidity Unit

USPH	United States Public Health
ETPI	Environmental Technology Program for Industry (A joint project of FPCCI and Government of the Netherland)
FPCCI	Federation of Pakistan Chamber of Commerce and Industry
OECC	Overseas Environmental Cooperation Centre Japan
IBWA	International Bottled Water Association
FDA	Food Development Authority
APHA	American Public Health Association
AWWA	American Water Works Association
WPCF	Water Pollution Control Federation
GT. Road	Grand Trunk Road

Acknowledgement

All praises for Almighty "ALLAH" the most merciful, kind, beneficent, compassionate and source of all knowledge, wisdom within and beyond our comprehension, who gave me the power to do, the sight to observe and mind to think and judge. All respects and possible tributes go to our Holy Prophet Mohammad (PBUH), who is forever guidance and knowledge for all human beings on this earth.

I am extremely grateful to my research supervisor Dr. Hizbullah Khan Department of Environmental Sciences University of Peshawar, for his patience, encouragement, friendly, supportive attitude and scholarly supervision in conducting the research work and completing this manuscript.

I am very grateful to Prof. Dr. S. Shafiq-ur-Rehman, Chairman Department of Environmental Sciences for providing all the required research and other facilities in the department. I have no words to express my sincere gratitude to Dr. Mohammad Nafees for his guidance, support, encouragement, and overall help in completion of this work. The painstaking efforts are gratefully acknowledged. Special thanks go to Mr. Khan Ghulam, Mr. Bashir Khan, Mian. Sajjad Ahmad, Mr. Mohammad Usman, and Mr. Shezad Akram for their cooperation's in finalizing this work.

I acknowledge the help and cooperation of faculty and supporting staff of Environmental Science Department University of Peshawar during my study period. I also express my sincere thanks of appreciation to my colleagues Prof. Dr. Abdulrauf Farooqi and Dr. Hina Fatimah for their encouragement and support they extended. Special thanks are due to Mr. Uzair Khan, for safe driving and a lot of help in collection of samples in spite of cold and hot weather. I am extremely grateful to Dr. Qudsia Riffat for her valuable guidance, input, moral support, and encouragement.

Finally, I would like to apologize to my parents, brothers, sisters; wife, sons and other family members for the many hours of my time spent on my research instead of being with them and thank all of them for their unlimited patience, cordial prayers, encouragement and sacrifices that gave me confidence to complete this difficult work.

Zahidullah

Abstract

Water, being the basic physiological necessity, is vital to all life on the earth. We use water not only for drinking purposes but also for bathing, heating, agriculture, fishing, cooling and industrial processes. In Pakistan water quality is deteriorating day by day due to increase in population, and improper disposal of industrial waste water. Industries play a vital role in the socio-economic development of an area. Industries also have some adverse impacts on the human and physical environment in creating pollution problems due to mismanagement and lack of pre-planning. The untreated industrial effluents of Hayat Abad Industrial Estate (HIE) find their way to fresh water bodies of NWFP. Due to adverse effects caused by water pollution, therefore it is essential to give greater consideration to know the magnitude and strength of pollution in industrial waste water.

The present study was designed to characterize industrial effluents from HIE, to investigate the pollution load of these effluents and possible impacts on the surrounding area. Before collection of samples, a comprehensive industrial and field survey of the entire stretch of the main effluent drain up to the receiving water body (Shah Alam River) was conducted for the selection of sample sites and to identify the source and extent of pollutants. To obtain information about the degree of contamination caused by industrial effluents, samples were collected from forty sites. These sample sites included the drains of individual industries in HIE, Combined drains, sub drains, main effluent drain at various location, sewage and Nullah joining main effluent drain, (Confluence points), Nullah and the receiving water bodies i.e. Shah Alam River at Nakoba village and ultimately main Kabul River at camp Koroona (Akbarpura). To characterize pollution load, all the samples were analyzed for nineteen (19) water quality parameters; (seven physical, six chemical, one biological and five heavy metals). The analytical work was carried out in the laboratory by using the standard methods for the examination of water and waste water. The analyze parameter included flow rate, P^H , conductivity, temperature and Dissolved Oxygen (DO) were detected on the spot, while further analytical work was done immediately in the laboratory.

The results revealed that most of the samples were highly turbid with high solids content. Total Suspended Solids, Conductivity, Turbidity and Total Solids were the major pollutants contributed by industrial effluents. The values of all the analyzed samples exceeded the permissible limits specified by the National Environmental Quality Standards (NEQS) and International Standards. Temperature ranged from 17.1 C° to 38.2 C° while pH values ranged from 7.10 to 8.58 which were within the permissible limit. Similarly Nitrate, Sulfate, Chloride and Copper were also

found in safe range. The concentration of Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Chromium (Cr) and lead (Pb) in both industrial effluents and Sewage drains were above the permissible limit set by NEQS. A significant fluctuation was observed in Iron (Fe) and Nickel (Ni) Concentration. In most of the samples (Fe) concentrations were found below the limit of NEQS of 2.00 mg/L, while in some samples it exceeded than the safe limit and ranged from 4.021 to 6.288 mg/L. Similarly in most of the samples (Ni) content was in safe range of 1.0 mg/L prescribed by NEQS while in case of one sample No S12; effluent of Gulab Banaspati Ghee Mill, the value of (Ni) exceeded from the safe limit and was found in a range of 1.27 to 1.4879 mg/L. In all the industrial effluents Dissolved Oxygen (DO) values were negligible throughout the entire stretch of the main effluent drain up to the confluence Point of Shah Alam River consequently lowered the (DO) content of the receiving water body. The low (DO) content with high organic load (BOD and COD) adversely affected the water quality of Shah Alam River and ultimately of Kabul River. In addition to HIE, other important sewage drains of Peshawar (Pollution sources) and Budni Nullah, combining with main effluent drain further increase the pollution load and result deterioration of environmental conditions in the downstream area.

To minimize water pollution it was recommended to reduce the quantity and strength of waste water produced by industrial units. Pollution control is possible only through treating and reusing waste water produced. It was also suggested that to increase the availability and conservation of water the water used in industries of HIE for cooling and other purposes may be reused. Formica industry, AGE cable industry, Ghee Industry and Marble industry should reuse their used waste water for cooling purposes to reduce water consumption. Moreover there is a need for installation of waste water treatment plants, by product recovery, pollution control at source and aeration may also assist in the abatement of waste water pollution. Each industry in HIE should have the provision of at least primary treatment including screening, filtration, neutralization and Sedimentation on the premises of the factory to decrease the load of suspended material to minimize the extent of pollution load. In HIE industries may be categorized/grouped in terms of waste water disposal. Marbles factories effluents can be segregated and collected at one place for treatment. The industries should also be guided and helped in controlling pollution through advisory and consulting services for design and installation of pollution control facilities by research organizations and regulatory authorities. Beside enforcement of efficient environmental laws /regulations, social awareness among the masses for environmental friendly activities and periodic monitoring of industries for pollution assessment were recommended.

Chapter 1

Introduction

CHAPTER-1

Introduction

1.1 Background

Water is a precious and essential natural resource for the survival of any form of life. Indeed it is a part of life itself. We use water in many ways like for drinking, cleaning, washing, heating, agriculture, cooling and for industrial processes. Every activity of man involves some use of water; the used water return to the environment either with pollutants or with an increase in heat (temperature) or both, which changes its natural composition in the environment. Water is the basic essential need of living things including human beings. All the life processes are dependent on water, since water is not only a major constituent of living bodies but essential for all the body functions.

Hence water is too precious a resource to be left untreated or to affect other water resources. In developing countries like Pakistan water quality is deteriorating due to increase in population, excessive use of pesticides and fertilizers in agricultural activities, poor drainage system and improper disposal of industrial/waste water. (Mohammad, 1998)

The establishment of industries plays a vital role in the socio-economic development of an area. Industries provide job opportunities and other basic amenities of life such as health, education transport, communication, electricity etc; but along with the above mentioned beneficial impacts industries also have some adverse impacts on the human and physical environment of the area mainly in the form of air, soil and waste water (pollution) problems. Industrial proliferation is an important environmental problem, resulting in different kinds of gaseous emissions, liquid effluents, obnoxious smell, solid waste and toxic materials, which deteriorate the environment in many different ways. These discharges ultimately find their way into the fresh water streams and rivers and cause eutrophication due to high Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrogen and Phosphorus which in turn cause disruption in bio-diversity of aquatic organisms and proliferate unchecked growth. There is great need to assess their impact on the aquatic life, potable water and the aesthetic look of the area.

The foul smell and bad odor that they turn out also need utmost attention. Beside this all sort of water borne pathogens may be found in wastewater. Thus it has become essential to give greater consideration to the development of physicochemical and biological treatment technologies. Physicochemical and biological treatment methods are employed in lowering of pollutants from wastewater. These methods are studied for lowering of the Suspended Solids, Nitrogen, Phosphorous, carbon, BOD and COD. All wastewater treatments involve the removal of solids, bacteria, algae, plants, inorganic compounds, and organic compounds. Removal of solids is usually done by filtration and sedimentation, while microbial digestion is an important process to remove harmful pollutants, converting used water into environmentally acceptable water. If wastewater contains large amount of suspended solids/matter, then Physico chemical method can be utilized to reduce the suspended solid portion of the wastewater. Physico-chemical method is economical, effective and is also useful for reducing a minor part of the organic compounds by the process of adsorption. The physicochemical methods comprise pH adjustment, the use of flocculants and coagulants e.g. $\text{Ca}(\text{OH})_2$, Alum etc.

The organic portion including the compounds of Nitrogen and Phosphorus can be removed by biological methods. The wastewater is characterized chemically for BOD, COD and other Physico chemical properties. Biological wastewater technique can be employed for the removal of Phosphorus, Carbon and Nitrogen. This also requires the establishment of optimized conditions and the assessment of efficiency of the treatment system for the wastewater. The biological wastewaters treatment processes are based mainly on utilizing heterotrophic and autotrophic organisms (bacteria, fungi, and zooplanktons), and providing different configurations of anaerobic environmental conditions to these organisms, to remove Carbon, Sulfur Nitrogen and Phosphorus. Under aerobic condition organic carbon and nitrogen are utilized and phosphorus uptake occurs. Under anoxic condition, the nitrates are reduced to nitrogen by a series of reactions, releasing nitrogen (denitrification). The formation of N_2 thus reduces the Nitrogen concentration in wastewater. Besides this the Carbon is also utilized. In anaerobic conditions the Phosphorus is released. To achieve high quality effluents with regards to Carbon, Nitrogen and Phosphorus compounds, this can be very effective for a range of wastewater including domestic sewage. To ensure

safe water quality, it is essential to analyze wastewater for different physicochemical and biological parameters.

The constructed wetland has been paid more attention to remove nutrients from small waste stream as they are relatively low cost, list energy and maintenance requirements (Reed and Brown, 1992). However, there is ample need to study other advanced processes keeping in view large size and short life span of the constructed wetland technological developments and the increasing knowledge of the advanced processes have made high loading treatment possible. Since its introduction in the early 80s (Lettinga et al. 1980) The Up flow Anaerobic Sludge Blanket (UASB) system has gone through a lot of improvement and has been used to treat a variety of industrial effluents (Lettinga and Hulshoff, 1991).

The concept of industrial estate emerged in industrialized countries toward the end of 19th century, as a mean to promote, plan and manage industrial development. It was industrial development that made it possible for this earth to sustain billion of people. (Mc. Eldowney, 1993). Experience has shown that in the absence of pre-planning and organization, industries grow in haphazard manner. The rational of industrial estate was to make base for industrial growth on certain sound principles so as to avoid and check the haphazard growth of industries (Khan, 1994).

At present there are more than 8000 industrial units in Pakistan falling in the category that employees ten (10) or more persons (NCS, 1997). NWFP has a small industrial base with only eleven industrial units in 1947. Today NWFP has nearly 1500 industrial units employing about 60000 people (SPCS, 1995). Most of them are small units and due to lack of land use planning, these are situated in and around the major cities of NWFP. All these industries are producing wastes of various kinds to the nearby sink without any treatment (Sanaullah, 1992).

In Hayatabad Peshawar there is no discrimination between the municipal waste water /solid waste generated from residential, commercial, institutional sources and hazardous waste generated from the hospitals and industrial sources. Therefore, all types of waste and waste water generated from any source falls in the category of municipal waste. (Pak. EPA, 2004)

The untreated industrial effluents of Hayatabad Industrial Estate, find their way first into the local streams and finally into the River Kabul. This can seriously disturb the ecological hierarchy of the aquatic organism, resulting in eutrofication, high BOD and COD. Their ill effects on potable water are expected and the aesthetic scenario being tarnished by the emission of objectionable smell and dark coloration imparted to the wastewater. Water treatment is rarely practiced in this region. The untreated wastewater from the residential area of Hayatabad, which also hosts the Hayatabad Medical Complex, can become a source of infectious diseases. Due to these hazards it has become essential to give greater consideration to the development of cost-effective indigenous technologies regarding the Physico chemical and biological treatment.

1.2 Objectives

The study was focused on the achievement of the following objectives.

1. Characterization and evaluation of effluents from individual industries, combined effluents (cluster industries), sub drains and main drains up to the confluence point of the receiving water bodies.
2. Segregation of industries for the development of ultimate treatment technologies.
3. Selection of Physico chemical methodologies of treatment for the cluster industries (combine effluents.)
4. To know the impacts of these effluent on domestic and agriculture use of the receiving water of the area.
5. To find out ways and means to reduce burden of pollution and to suggest measures for reducing further environmental degradation in the area.

1.3 Methodology/Plans

The industrial effluents/wastewater of Hayatabad Industrial Estate (HIE) were characterized and evaluated. Routine analysis including pH, Electric Conductivity, Turbidity, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Alkalinity, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Chloride, Nitrate and Sulfate were performed using procedure

outlined in the standard methods (APHA 1996), while for heavy metal analysis atomic absorption spectrometry method was used.

Comprehensive literature survey was conducted to get a clear picture about the background information's, change water used and its quality. Field survey was conducted for selection of sample sites and for selection of various locations to identify the source and extent of pollutants.

The analytical work was done in the laboratory by using the standard methods for the examination of water and wastewater for various parameters. (APHA, 2005)

To conduct survey, Geography of Peshawar, especially the area of industrial Estate of Hayatabad, was reviewed to find out environmental fragility and sensitivity.

Remote sensing and GIS system was used wherever needed to quantify the use, importance and related problems of industrial effluent in the vicinity.

The results of physical, chemical and biological analysis were compared with previous studies for evaluation of the trend.

Various methods were employed and a comparative record regarding their efficiencies was maintained. Finally the method, which was best regarding efficiencies of waste removal and cost were recommended. The methods reviewed were of preventive and curative nature. Among those preventive (clean processing) were identified the best for processing in industries. For industries like paper mill and marble recycling were identified as suitable and offered for practical use.

1.4 References

- American Public Health Association Inc., (APHA), (2005) "Standard Methods for the Examination of Water and Wastewater." Twenty-first (21st) edition, American Public Health Association; 1015 Fifteenth Street Washington, D C 20005 USA.
- APHA. , AWWA, WPCF, (1996). "Standard Methods for the Examination of Water and Wastewater." Nineteenth (19th) edition, American Public Health Association, American Water Works Association and Water Pollution Control Federation; 1015 Fifteenth Street Washington , D C 20005.
- Eldowney, Mc. (1993). "Pollution Ecology and Bio-treatment" Longman Scientific and Technical Series, John Wiley and Sons Inc. New York.
- IUCN (1995). "Sarhad Provincial Conservation Strategy, International Working Draft-III" Govt. of NWFP, Pakistan.
- IUCN and GOP (1997). "The National Conservation Strategy" Environment and Urban Affair Division Islamabad.
- Khan, B.R. (1994). "Environmental Examination of Industrial Estate Hayatabad Peshawar with Special Reference to Vegetable Ghee and Oil Mill". M.Sc. thesis Department of Environmental Planning and Management (DEPM) University of Peshawar.
- Lettinga, G. and Hulshoff, L.W. (1991). " Up flow Anaerobic Sludge Blanket (UASB) processes design for various types of waste water" water science and technology, Vol. 24, No.8, pp. 87-107
- Lettinga, G., Vanvelsen, A.F.M. and Homa S.M. (1980). "Use of the Up flow Anaerobic Sludge Blanket (UASB) reactor concept for biological waste water treatment, Biotech. Bio-eng. Vol. 22 pp 699-734.
- Mohammad, S. K. (1998) "On site Waste Reduction in Gadoon Amazai Industrial Estate". Unpublished M.Sc. thesis Department of Environmental Planning and Management (DEPM) University of Peshawar.

- Pak. EPA, (2004) "Urban Environmental Problems in Pakistan: A Case Study for Urban Environment in Hayatabad, Peshawar" Pakistan Environmental Protection Agency (EPA) Islamabad.
- Reed, S.C. and Brown, D.S. (1992). "Constructed Wetland Design" - the first generation. *Wat. Env. Res*; 64 (6) 776—781.
- Sanaullah, (1992). "Solid Waste Disposal Practices in NWFP". Provincial Environmental Protection Agency (EPA) Peshawar.

Chapter 2

Description of the Study Area

Description of the Study Area

CHAPTER-2

Description of the Study Area

This chapter covers all those aspects which have a direct or indirect relation to the physical environment of the project area. Among these aspects, agriculture, hydrology (river and streams), forest, climate, flora, fauna and industries have a direct impact on the living environment of the project area, while location, topography, education, history, historical places and roads, etc., have an indirect impact on the project area.

Keeping in view the study area and its location, an attempt has been made to discuss it with reference to North West Frontier Province (NWFP). As the name indicates, NWFP located in the North Western mountainous area of Pakistan (Map. 2.1). bordered by the territories of Gilgit, and Jammu and Kashmir in the north, the province of Punjab in south east, Baluchistan in the south west and in the north, it has a long boundary of 1100 Km with Afghanistan (map 2.2) (UNESCAP, 2002).

Peshawar is the main city and capital of NWFP covering an area of 74521 Km² excluding the 27229 Km² of Federally Administered Tribal Areas (FATA). Area wise it is the smallest province having 9.4% of Pakistan's total area (Govt. of Pak, 1985) and stands 3rd in terms of population (12.18%) (Govt. of Pakistan 1998 and (Zaid & Matthew, 2000) in all the four provinces. There are two types of administration practiced in NWFP: settled areas consisting of 24 districts and tribal area, which has further two divisions -Provincially Administered Tribal Area (PATA) and Federally Administered Tribal Area (FATA) (Govt. of FATA 2008).

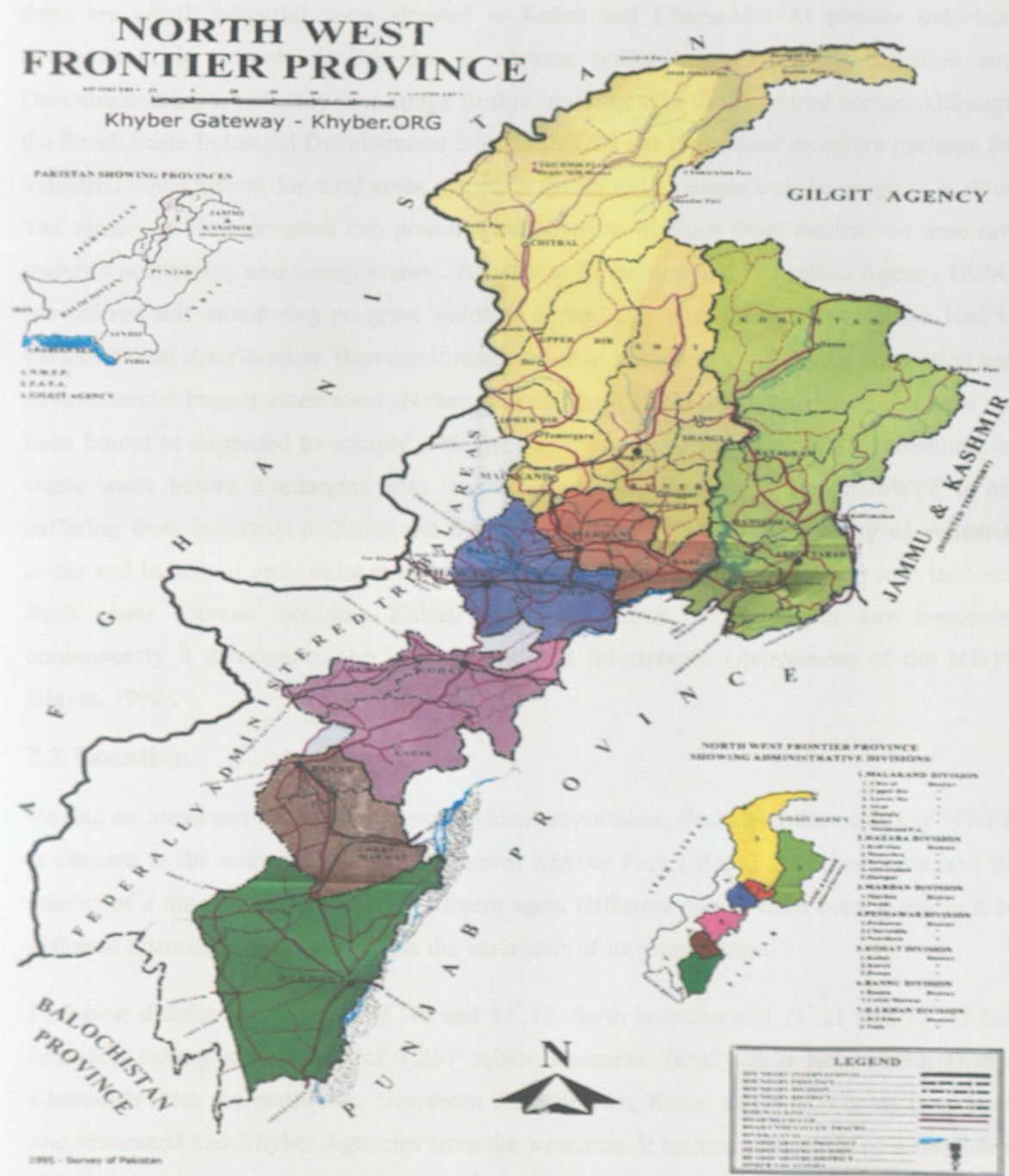
2.1 Industrialization in NWFP

Industries serve as a major economic activity in the socio economic uplift of a society. Industrial activities were weak in the province of NWFP. In 1947 when Pakistan came into existence there were only 11 industries in NWFP. Industrial development got accelerated during the last two decades (80s and 90s) during which new industries were established. According to Sarhad Development Authority there are 1848 industries of various natures with sixty thousand employees (Govt. of Pak. 1996, The Nation, 2003 and SDA, 2008). Most of the industries are situated in scattered form in the surroundings of cities or villages attributed to ill planning and mismanaged land uses. There are various industries in which food

processing is the common with twenty five percent shares. Textile is another big industries found with almost the same percentage. Other industries include Paper, Marbles and wood.

Map 2.1: Map of NWFP, Pakistan Showing Peshawar and its Surroundings

Source: Survey of Pakistan



Being responsible for planning and promoting industries and commercial ventures, the Sarhad Development Authority (SDA) manages five industrial estates in NWFP. Large industrial estates include Gadoon, Peshawar, Hattar, Nowshera and Dera Ismail Khan, while there are small industrial areas situated in Kohat and Charsadda. At present industrial development is towards decline due to various policy matters like Privatization and Decentralization, which may discourage further investment in the industrial sector. Although the Small Scale Industrial Development Board (SSIDB) has introduced incentive package for industrial development for rural areas, which is still in initial stages and the progress is slow. The reason of slow progress can possibly attributed to distance from market, on time raw material availability and transportation. At present Environmental Protection Agency (EPA) has offered self monitoring program which is termed as "no regulation" which can lead to environmental deterioration. Because it result delay in initial environmental examination and environmental impact assessment (Nafees and Ghulam, 1992) the industrial estates have not been bound or supposed to comply with the requirements of recycling and pretreatment of waste water before discharging into the receiving water bodies. Although NWFP is not suffering from industrial pollution yet the problem of pollution in the vicinity of industrial estate and industrial units exist remarkably. Industrial effluents find their way into land and fresh water sources including Kabul, Swat and Indus rivers without any treatment, consequently it deteriorates the hydrospheric and lithospheric environment of the NWFP (Hayat, 1992).

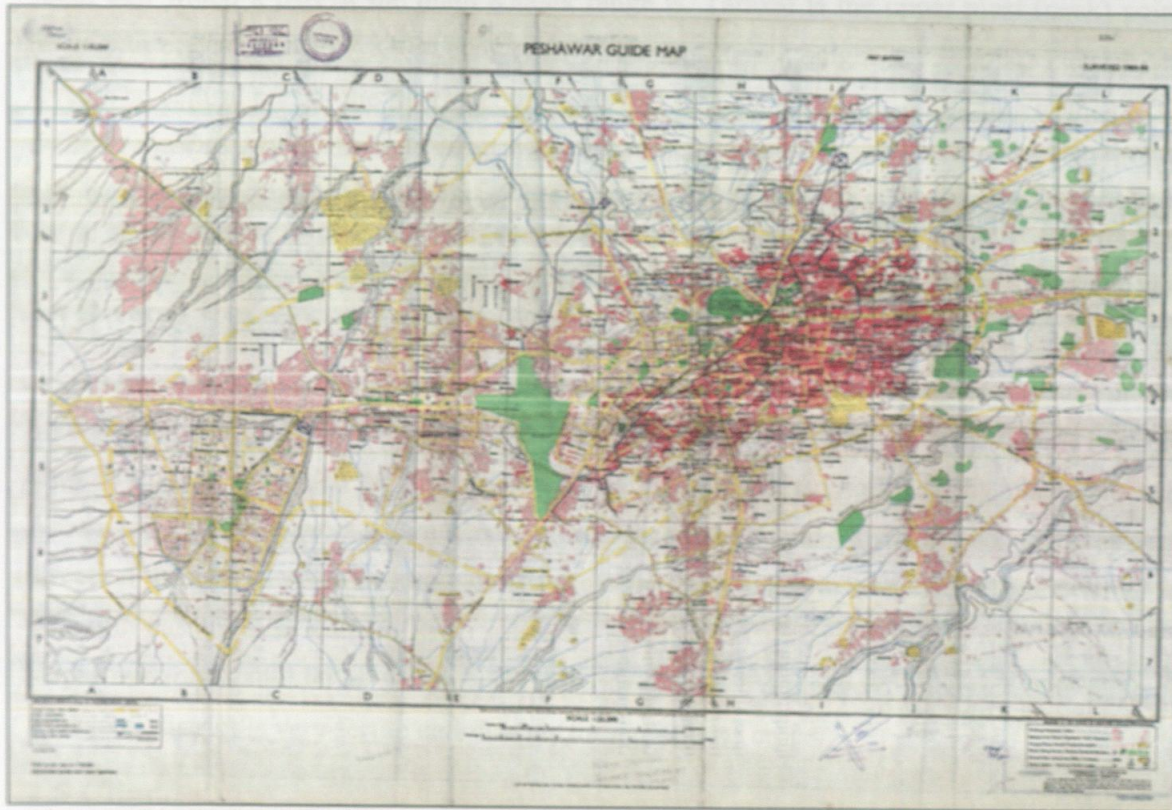
2.2 Location

Having an important strategic and geographical importance, Peshawar, the capital of NWFP, is situated at the entrance of the well-known Khyber Pass (Map 2.2). It has witnessed the attacks of a number of invaders in different ages. Different names have been given to it by different historians, which are in fact the variations of its present time.

Peshawar district lies between 33°.44 and 34°.15 North latitudes and 71°.21 and 71°.42 East latitudes, having a total area of 1,257 square kilometer (km²). It is linked with District Charsadda from the north side, Nowshera from the east, Kohat and FATA areas from south and Mohmand and Khyber Agencies from the west side. It locates in the west of a small river (Bara) that enters into the main Kabul River. (GOP DCR Peshawar, 1999)

Map 2.2: Map Showing Peshawar City, Hayatabad and “Hayatabad Industrial Estate”

Source: Survey of Pakistan, 2002



Peshawar is linked with Afghanistan from the West and North side. The valley of Kashmir lies to the North East side while Punjab and Baluchistan Provinces lay South East and South West respectively. Peshawar has a vast and expanse Airport adjacent to its Cantonment area, a wide double G.T. road and West East railway line passes from Peshawar and leads to the Province of Punjab. Being a large and significant/famous hub of trade as businessmen travelled through it to Afghanistan and Central Asia for the sake of business. These days Peshawar the provincial capital of NWFP is linked to Lahore, Rawalpindi, Hyderabad and Karachi by a vast G.T. road and railway track, while with Chitral and Kabul by Air. The majority of people living Peshawar is Pashto speakers and is mostly Pushtoons. The neighboring areas of Peshawar comprised of fertile and irrigated lands. Kabul River irrigates these fertile lands, while also serve as a receiving or dumping ground for the sewage of Peshawar city. (Isfandyar and Minallah. 2006)

2.3 Topography

Most of the Peshawar district is almost a fertile plain however, with only a small hilly area in south east which a part of the main Khatak range is. Tarakai is the upper most (peak) point having an elevation of 0.7 Kilometers (Km). Its approximate height is 358 meters above sea level. The central part of the district consists of fine alluvial deposits. According to the (GOP *DCR Peshawar 1999*), the cultivated tracts of Peshawar district consist of a rich, light and porous soil, composed of a pretty even mixture of clay and sand which is good for cultivation of wheat, sugarcane and tobacco.

2.4 Rivers

Well known Kabul River enters the region at Warsak and flow South Eastward in the northern portion of Peshawar. When the Kabul River enters Peshawar area, it split in three branches. Nearest branch of River Kabul is called Shah Alam followed by Naguman and Adezai or Hajizai Rivers. Bara River enters the district and flows in the south eastern direction through the district into Nowshera district, where it joins the Kabul River. While in the north eastern side Kalpani River joins the Kabul River. From south and west the country slopes towards Kabul River which takes practically whole drainage of the tract. The plain of Peshawar district is very fertile and famous for agriculture crops.

2.5 Climate

Both the seasons, summer and Winter of Peshawar District are very harsh (severe). The warmer period ranges from the month of May to September while winter begins in October. June with an average of above 40 Degree Celsius and average temperature of below twenty five degree Celsius is the hottest month of the year. July to September is monsoon season. The months of July and August are hot and humid. The turn of winter season comes in September and up to mid November it is cool and pleasant. From December to mid February it is cold and the mean maximum and minimum temperature for January, the coldest month, has been recorded as low as 18.35°C and 4.00°C respectively. The spring season comes somewhere around the middle of March which is the most pleasant period of the year. The region received showers both in winter and summer. Western atmospheric turbulences caused winter rains, which mainly happen in February, March and April. Winter rainfall is usually higher than the summer one. Highest rainy periods occur in both the periods. The mean highest rainfall of summer happened in August, while the mean highest rainfall of winter

occurred in the month of March every year. A mean annual maximum and minimum temperature, precipitation and relative humidity are given below.

Mean annual temperature: Max.29.44°C. Min.15.87°C Mean annual rainfall: 403.83mm.
Mean annual relative humidity: 54.73% (Atta Ur Rehman, 2006)

2.6 Forest Cover

Water quality is affected in terms of erosion and suspended solids by the Forest covers. As regards the forest cover, the province of NWFP is better endowed with a rich forest cover of 17% (Khan and Rafiq, 1997). Some of the common trees include the Mesquite, Ber, Acacia and Jhand. Some common shrubs like Spynda, Akk, small red poppy, Spera, Camel thorn, paighambari Gul and Drab grass are also found in NWFP. All kinds of roses, Gul-e-Dawoodi, Chamba (white and yellow), Rambel, Nargis, Kashmalo, Ganderi, Mori and other seasonal flowers are planted and sown in the district. (GOP DCR 1999) Forests are renewable and important source of revenue. Forests covering the Kabul River water system are natural and are mostly found at high elevation in the north on the mountains. However, poor management and over exploitation of the forest cover produce adverse effects on the ecology of the area.

2.7 History of Peshawar

Peshawar occupies a prominent position in the history of this part of the world. The city has seen the rise and fall of several dynasties. The mounds of Shahji-ki Dheri located (fall) to its east because the archeologists discovered in large amount the oldest relics (ruins) of the principal Buddhist stupa in subcontinent. These findings confirmed the close relationship of the people living here with the Budha and its religion. At times of the Buddhists rule with the name of Gandhara kingdom, the people called the city as Parasawara and Purusapura. The current name Peshawar was given to the city in 1556-1605 when Mughals ruled the subcontinent. It was the reign (time) of King Akbar. (Isfandiyar and Minallah 2006)

The Valley of Peshawar and adjoining areas were controlled by the state of Gandhara in ancient times; Khyber Pass to western side adds importance to the city because of its leading and unique position for having an easy access to central Asian States. Sabuktigin, conquered Peshawar in AD 988 and thus it was brought under Muslim control for the first time. Mahmood Ghaznavi, son of Sabuktigin attacked India several times during 1001 to 1027. In those attempts he succeeded in including major part of this region to his Ghaznavid state (Empire). Till the 12th century, the region was ruled by different Muslim rulers. These were

Ghurids, Afghans and Mughals. When Nadir Shah made control in 1738, it remained under loose form of control of rule of Afghan Durranis. From the early years of 19th century, till the British control in 1849, Indian Sikhs kept control of the whole frontier region. After the Sikh war in 1849, the British merged this region with the India. With that merging, this whole frontier area or region became part of the Punjab. Then again the Northwestern territories of the frontier's region obtained the provincial status as NWFP in 1901. Till this time the region enjoys that status even after division of subcontinent in 1947 into Pakistan and India, which became part of Pakistan. (*Isfandyar and Minallah 2006*)

2.8 Agriculture

The Valley of Peshawar is famous for its fertile and densely cultivated lands. It is also known for producing both food and cash crops. The main food crops are wheat, maize and barley, while the main cash crop is sugarcane. There is an important institution in the field of agriculture, the Agriculture Research Institute, Tarnab about 16 km from main city towards Nowshera and is playing a very important role in the field of agricultural research. Another institute namely Nuclear Institute for Food and Agriculture (NIFA) is also contributing in the agriculture sector by conducting research on various crops. Agriculture Training Institute Peshawar is producing trained manpower. (*DCR Peshawar, 1999*)

2.9 Population and Area

Total area of Peshawar district is 1257 square kilometer (Km^2) which is 1.7% of NWFP with a total population of 2556000 thousands. In terms of population, its percent share is about 12% of the total count of NWFP with a population density of 2113 person per square kilometer (Km^2) (Govt. of Pak., 2006)

2.10 "Hayatabad Industrial Estate" (HIE) Peshawar

2.10.1 Concept of Industrial Estate

It basically refers to the method of organizing a community of industrial enterprises. Generally speaking, an industrial estate may be described as a compact block of land developed in accordance with a comprehensive plan for accommodation of a large number of factories. An area or a piece of land is acquired primarily by a public authority or by any other private agency for the purpose and is developed and sub-divided in accordance with a comprehensive plan designed to accommodate large number of industrial units so as to provide them special facilities and common services. The sponsoring agencies are responsible

for providing the basics requirements like water supply, power, transportation and communication facilities. Besides these street lighting and fire protective services, sewerage system and treatment plant etc., are the responsibility of the public authority or other private agency. The sponsoring agency may also provide free belt factory building to the occupant through direct sale or on rental basis. In certain cases, faced capital equipment is also made available to the entrepreneurs however; the degree of facilities provided in a state varies from country to country, depending of course, upon the economic and political condition of different countries.

In this study, therefore, an attempt has been made to describe the status of "Hayatabad Industrial Estate" and to identify deficiencies if any and suggest remedial measures for further improvements.

2.10.2 Historical Background of Industrial Estate

The idea of industrial estate originated in UK where the first estate was established in Manchester in 1886 (Trafford Park Estate Limited). It was followed by Industrial estate in Chicago USA in 1899. It was after second (2nd) World War, the idea became popular and several industrial estates were developed one after the other both in developed and developing countries throughout the world (Khan, 1976). It was, however, found out that the problem of environmental pollution associated with the improper and untreated waste disposal of industrial effluent and used waste water in the receiving water bodies, causing serious nature of water pollution and ecological problems in the industrially developed countries.

Serious environmental incidents and accidents contribute to the adverse impacts on human health and environment, which are the results of industrialization and economic development. Further, the development of technology and improper use of wastes can deteriorate the already dismal situation and condition (UNEP., Environ. 1993-94)

2.10.3 Industrial Estates in Pakistan

It was decided both in the first five years plan (1955-1960) and the second in (1960 to 1965) that separate industrial estates have to be established in the country. Establishing these estates were also re-emphasized by the third five-year plan 1965 - 1970. (Khan, 1976)

In total, fourteen (14) industrial estates, 3 big and eleven (11) small, were established in NWFP. Among those, Hayatabad Peshawar, Industrial Estate Hattar and Gadoon Amazai

Swabi are major industrial estates, while small industrial estates include Peshawar Phase-II, Kohat Road Peshawar, Mardan Phase-I, Mardan Phase-II, Kalabat-Haripure, Abbottabad Charsadda, Mansehra, Nowshera, Bannu, and DI Khan.

On 30th October 1963, "Hayatabad Industrial Estate" (HIE) Peshawar was established by the department of industries Govt. of Pakistan and its possession of the area was taken on 30th June 1965. It was given over to the Industry Department in 1970 and its management was handed over to Sarhad Development Authority (SDA) in 1973. (Jadoon, 1996)

The following objectives were considered for the establishment of "Hayatabad Industrial Estate" (HIE), Peshawar.

The developments of industrial sector in the less developed areas of Peshawar district.

The creation of employment and other facilities in order to improve the socio-economic status and quality of life of the people in the area

The provision of infrastructure facilities, other services and incentives for the industrialist in order to avoid over crowding and haphazard industrial development

To bring the barren and unproductive land under useful purpose

To make the area assessable and to reduce the transportation cost for industrial goods as well as for raw material.

2.10.4 "Hayatabad Industrial Estate" in Brief

Located between 6 to 7 miles of the Peshawar Jamrood Kabul Highway in the North West of Peshawar (Map 2.3), the railway line from Peshawar to Landikotal near the border with Afghanistan in the Khyber Agency pass through it on the north and the Warsak high level canal passes from the west side of the estate. A vast non-irrigated barren land surrounds it from the eastern southern (Rafiullah, 1994).

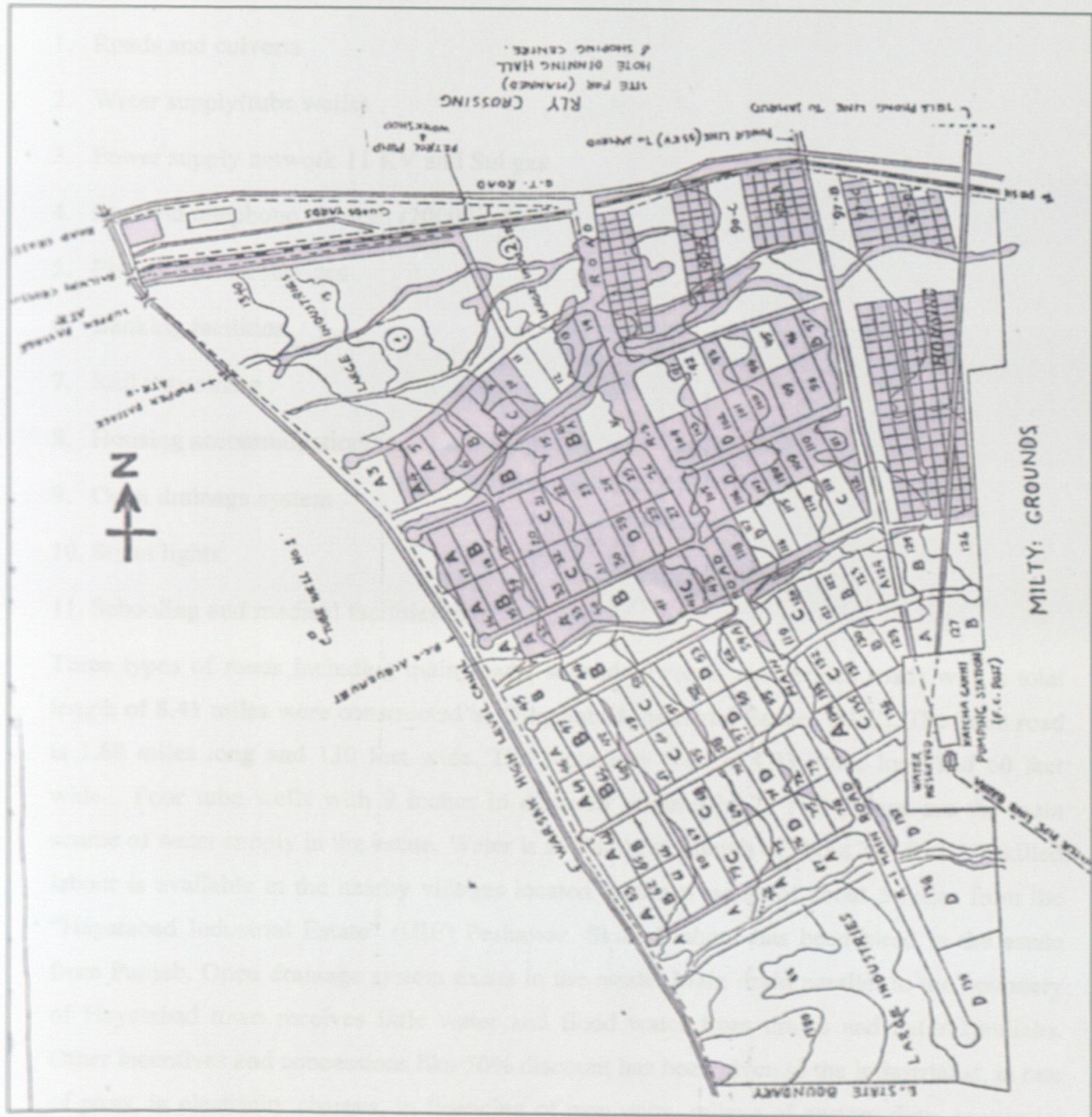
According to Sarhad Development Authority (SDA, 2003), the "Hayatabad Industrial Estate" housed 92 operational units and 31 sick units with 125 under construction units in 1994, while in 2003, the numbers of operational units increased up to 133. The estate, spread over an area of 884 acres, can be divided into six main domains namely, Match, vegetable ghee/oil mill, pharmaceutical, marble tiles, chemicals and woolen mills. Brief land use utilization is given in table 2.1

Table 2.1: Land Utilization of Industrial Estate Hayatabad Peshawar

S No	Description	Area (in acres)	Percent share of land
1	Area under plots	580	73.7
2	Area under Road	70.26	8.9
3	Area under housing	106. 9	13.6
4	Area under administration Ancillary building	17.5	2.2
5	Area under Park and open spaces	11.3	1.6
Source: Banaras, 1994			

Map 2.3: Map of “Hayatabad Industrial Estate” Peshawar
Source: Peshawar Development Authority (PDA)

Source: Peshawar Development Authority (PDA), 2005.



2.10.5 Existing Infrastructure and facilities in “Hayatabad Industrial Estate”

The following are the existing infrastructure and facilities in the “Hayatabad Industrial Estate” Peshawar.

1. Roads and culverts
2. Water supply(tube wells)
3. Power supply network 11 KV and Sui gas
4. Post and telephone services (2000 line)
5. Fire protection services
6. Banking facilities
7. Rail way siding
8. Housing accommodation/hostel
9. Open drainage system
10. Street lights
11. Schooling and medical facilities exist

Three types of roads including main roads, secondary roads and service roads with a total length of 8.41 miles were constructed in “Hayatabad Industrial Estate” (HIE). The main road is 1.68 miles long and 130 feet wide. The secondary road is 4.93 miles long and 60 feet wide... Four tube wells with 9 inches in diameter strainer in 75 H.P pumps are the main source of water supply in the estate. Water is available at a depth of about 300 feet. Unskilled labour is available in the nearby villages located within a radius of about 5 miles from the “Hayatabad Industrial Estate” (HIE) Peshawar. Skilled labour has been hired in the estate from Punjab. Open drainage system exists in the estate. Main drain parallel to the boundary of Hayatabad town receives little water and flood water from drains and natural nullahs. Other incentives and concessions like 50% discount has been given to the industrialist, in rate of plots, in electricity charges, in financing of new units, relieve of custom duty, provincial duty and lease facilities (Rafiullah, 1994 and Google Khyber, 2003).

2. 11 References

- Atta-ur-Rehman, (2006). "Survey of Water Supply and Sanitation in Hayatabad Peshawar", Water Supply and Sanitation, CD and MD, PDA Site Office Hayatabad, Phase-1 Peshawar.
- Banaras, M. (1994). "Environmental Monitoring of Industrial Estate Hayatabad Peshawar. Unpublished M.Sc. Thesis Department of Environmental Sciences, University of Peshawar. pp-21
- Google Khyber, (2003). "Industrial Estate in NWFP" Khyber web page <http://www.khyber.org/articles/2003/IndustrialEstatesinNWFP.shtml>
- Government of the Federally Administered Tribal Areas (Govt. of FATA) (2008.) "Administrative System" Wikipedia web page <http://en.wikipedia.org/wiki/Peshawar>. And FATA web page <http://www.fata.gov.pk/index.php?link=3>.
- Govt. of Pak. (1999). "District Censes Report (DCR) of Peshawar" Population Censes Organization Statistical Division, Islamabad.
- Govt. of Pak., (1985). "Environmental Profile of Pakistan" Ministry of Environment and Urban Affair Division Islamabad, pp 31-35.
- Govt. of Pak., (1998) "Population Census of Pakistan" Population Census Organization Statistical Division Islamabad Pakistan.
- Govt. of Pak., (2006). "NWFP statistics 2005-06" Bureau of Statistics, Islamabad.
- Govt. of Pakistan, (1996). Bureau of Statistics, "NWFP development statistics 1995 and 1996". Planning, Environment and Development Department (NWFP), Peshawar.
- Hayat, H., (1992). "Environmental study of Hattar Industrial Estate District, Haripur", M.Sc. thesis, Department of Environmental Planning and Management (DEPM) University of Peshawar, Pakistan.
- Isfandyar, Shah and Minallah, (2006) "City Report of Peshawar" Vehicular emission testing station, Environmental Protection Agency (EPA) NWFP, Peshawar.
- Jadoon, H. S. (1996). "Chemical Investigation of the Selected Atmospheric and Hydrosphere Environments of NWFP". Unpublished Ph.D. thesis Department of Chemistry, University of Peshawar. Pp-216-17.
- Khan, J. (1976). "Development of Industrial Estate in Peshawar" Institute of Development Studies, Agriculture University Peshawar NWFP Pakistan.
- Khan, Y. M., and Rafiq, M. (1997) "*Forestry in NWFP*" A National Publication of Forest, Fisheries and Wildlife Department, Peshawar, pp-14.

- Nafees, M. and Ghulam, K. (1992). "Environmental Impact Assessment (EIA)/ (Monitoring) of Amangrah Industrial Estate, Nowshera", M.Sc thesis, Department of Environmental Planning and Management (DEPM), University of Peshawar Pakistan.
- Rafiullah, K., (1994). "An Environmental Examination of Industrial Estate Hayatabad Peshawar with special reference of Paper and Board Mills". DEPM University of Peshawar.
- Sarhad Development Authority (2008) "Achievements in Industrial Sector" Government of NWFP, Peshawar web page www.sda.org.pk
- SDA, (1994). "Annual Report, Sarhad Development Authority" Govt. of NWFP, Pakistan.
- The Nation, Daily News Paper "Econo-List, Directory of Industrial Establishment in NWFP" Islamabad, March 6, 2003.
- UNEP, (1993-94) "United Nation Environmental Data Report" United Nations Environment Programme Blackwell Publishers, London.
- UNESCAP. , (2002). "Integrating Environmental considerations into the Economic Decision Making Process" United Nations Economic and Social Commission for Asia and the Pacific, Vol. 11, pp-16
- Zaid, A.A. and Matthew, R.A., (2000) "Environment and Security: A Strategic Role for IUCN: Environmental Stress, Livelihood Insecurity and Conflict_ Interlinking Crises: Pakistan, North-West Frontier Province" IUCN, The World Conservation International Union for Conservation of Nature and Natural Resources, World Congress Oman, Jordan, Web page: www.iucn.pk.

Literature Review

CHAPTER-3

Literature Review

3.1 Background

Industrial promotion, protection of environment and resource conservation are the major priorities of developing nations of the world. Industrial development may impart significant, beneficial contribution to a country's overall economic development through providing jobs, promoting socio economic infrastructure and so forth. However, by its very nature industrial development can also result in profound adverse impacts on the sustainability of the environment. In this connection a great deal of work has been carried out. Pervious researchers have attempted to investigate the problem from different aspects. Hence, for a clear picture and scope of study and the problem is pre-requisite to ponder in to the practical aspect of the present study and it is necessary to collect literature on previous findings and research work of different researchers in the field of water, waste water and industrial effluent analyses. To facilitate researcher/reader literature survey has been classified in the following sub heading.

3.2 Characterization of Industrial Effluents

- Sial et al. (2006). Investigated the "Quality of effluents from Hatar Industrial estate" They characterized industrial effluents and sewage samples for BOD, COD, pH, electrical conductivity, total nitrogen, total dissolved salts and heavy metals. The study revealed that the concentrations of TDS, EC, Iron, BOD and COD in all industrial effluents were above the National Environmental Quality Standards (NEQS) of

Pakistan. Copper content in the sewage and textile effluents and Manganese (Mn). In ghee effluents were above the Pak NEQS limits. They concluded that these effluents should not be used for irrigation without prior treatment, as it may result in pollution problems like salinity, toxicity of soil, water, plants and animals.

- Jadoon, (1996). Analyzed industrial effluents of Industrial Estates Hayatabad Peshawar, Gadoon Amzai and Hattar. The results indicated that some industries were the source of water pollution. The pollutants contributed by industrial effluents in all industrial estates were Suspended Solids, Dissolved Solids and heavy metals like Pb, Cd, Cr, Zn, Fe, Cu, and Ni. He concluded that marble crushing, ceramic, ghee mills, match industries, paper mill, sugar mill, food products and chemical industries were the main contributor to Total Suspended Solids (TSS) and Total Dissolved Solids (TDS) burden. It was also concluded that heavy metals (Ni) was contributed by the effluents of ghee mill and steel mill raised the concentration of copper. Manganese (Mn) was imparted by glass industry, ghee mills, chemical industry and paper mill. The lead (Pb) concentration was raised by effluents of frontier ceramic industry, while the effluent of match factories contributed chromium (Cr) in industrial waste water.
- Ahmad and Saleem, (1982). Determined the water pollution status in Peshawar, Nowshera, Amangrah Industrial Area and Kabul River. They analyzed parameters including Potassium, Iron, Manganese, Copper, Zinc and Dissolved Oxygen. They found that industrial wastewater including Ghee Mill, Textile Mill, Ferozsons Labs. and Paper Mill pollute the Kabul River. Thus the DO content decreased due to direct discharge of industrial

wastewater.

- Ahmad, et al. (1986). Worked on drinking water quality of various localities of Peshawar city and industrial effluents of Amangarh Industrial Estate Area, and found that the Azakhail water showed very high pH due to presence of various dissolved salts. While the paper mill revealed the maximum values for alkalinity and conductivity. The maximum alkalinity and specific conductivity were found in Peshawar city water, while that of Nowshera water had the maximum concentration of chlorides. Similarly, high content of Chemical Oxygen Demand (COD) was found in paper mill's effluent. They concluded that the industrial waste water contributed to the pollution load.
- Khalid, (1989). Worked on primary productivity and Dissolved Oxygen content in relation to Biological Oxygen Demand (BOD). A decrease in Dissolved Oxygen was observed near Nowshera city from November to January that reached below 7.5 mg/L with the increase in BOD, which exerted adverse effects on fish population. The negative impacts were further accelerated by suspended load and release of untreated industrial effluent and wastewater from Industrial Estate of Aman Garh Nowshera NWFP, Pakistan.
- Bahadar and Zahidullah, (1991). Investigated the aquatic pollution levels caused by industries in Kabul River at Amangarh (Nowshera). The effluents of Ghee and Paper Mills were analyzed. They found that flow rate of waste water was 2.4 km/h. Analytical data revealed that temperature, pH, Total Suspended Solids, and Total Dissolved Solids were 25°C, 8.5, 12305 mg/L, and 2893.5 mg/L, respectively. A strong

correlation of pollution load with the industrial effluents was observed.

- Zahidullah et al. (1991). Worked on Environmental Impact Assessment (EIA), Initial Environmental Examination (IEE) and surveyed various industries situated in Peshawar Pakistan and found that industrial wastewater was one of the major causes of water pollution. They suggested EIA and environmental monitoring program on regular basis for all sort of industrial units.
- Shah, (1991). Worked on Saleem Tannery Pvt (Ltd), situated at Jehangira for pollution abatement measures. The effluent drains in to Kabul River directly without any prior treatment, which produces negative impacts on aquatic flora and fauna. While the situation in the vicinity also reported as unsatisfactory; for which three types of treatment facilities were recommended, i.e. primary, secondary and advanced treatment for particulate matter, removal of Biological Oxygen Demand (BOD) and Chromium (Cr), respectively.
- Nafees and Ghulam, (1992). Carried out environmental monitoring of Amangarh Industrial Estate Nowshera (Pakistan). They worked for the first time with special reference to water pollution analysis of the industrial effluents in NWFP. The physicochemical analysis of different parameters of industrial wastewater like pH, Conductivity, Dissolved Solids, Suspended Solids, Biological Oxygen Demand (BOD), Sulphide and Chloride were conducted and found in higher concentration as compared to the recommended standards for industrial effluents. While the analysis of heavy metals like Lead (Pb), Nickel (Ni), Copper (Cu), etc were below permissible limits.

- Banaras, (1994). Carried the environmental monitoring of Industrial Estate Peshawar with special reference to Ghee and Oil Mills. All parameters except COD were found within permissible limits set by Pakistan National Environmental Quality Standards (NEQS) for Industries. He found very high COD concentration in the industrial effluents of Hayatabad Industrial Estate Peshawar.
- Bahadar, (1994). Carried out the Environmental Examination of Industrial Estate Hayatabad with Special Reference to Vegetable Ghee and Oil Mill. The analytical results revealed that effluent had high BOD, Total Suspended Solids, Chlorides and Temperature, discharged to the nearby natural stream "*Khawar*", ultimately found its way entering through Shalam River into Kabul River.
- Rafiullah, (1994). Worked on Environmental Examination of Industrial Estate Hayatabad, Peshawar with Special Reference to Paper and Board Mills. The effluents coming from the paper and board mills carried high Biological Oxygen Demand (BOD) load, Suspended Solids, Conductivity, and Total Alkalinity, for which no treatment facility existed. The effluents flowed through the natural stream to the main "*Ganda Khawar*" and ultimately found its way into Kabul River. It was suggested that these industrial effluents needed proper treatment to avoid adverse impact on the downstream area.
- Iqrar, (1995). Studied Khazana Sugar Mill Peshawar, whose effluents entered in Shalam River (One of the tributary of Kabul River). Four types of pollution problems were reported in qualitative terms. Those included

Water pollution, Noise pollution, Soil Pollution and Air Pollution. To overcome pollution problems, recycling, reuse and wastewater treatment was recommended.

- Sardar, (1998). "On Site waste reduction in Gadoon Amazai Industrial Estate" The study revealed that the drainage system was not adequate to meet compliance with the NEQS for industrial effluents. Untreated wastewater was being directed to open drains and finally to Indus River. Extravagant quantity of solid waste was generated from Textile, Steel, Ghee and Marble industries. Steel units were the main source of air pollution in industrial estate due to lack of chimneys and posed the serious hazards for the workers and surrounding community.
- Govt. of Pakistan, EPA, Peshawar, (1999). Analyzed the effluents of Shakeel Marbel Factory, Olympia Paper Mill and Mohsin Match Factory. The concentration of different parameters were found as pH (7.82), Total Suspended Solids (2400 mg/L) and Total Dissolved Solids (2617 mg/L) for Shakeel Marbel Factory, Total Suspended Solids (1272 mg/L), COD (1733 mg/L) and Fe (2.64 mg/L) for Olympia Paper Mill and pH (6.57), Total Suspended Solids (2170 mg/L), Total Dissolved Solids (3800 mg/L), COD (292 mg/L) Chromium (11 mg/L) and Iron (11.76 mg/L) for Mohsin Match Factory. All the three industries studied contributed a lot of pollution load in the area.
- Hamid, (1999). Introduced an integrated approach for sustainable industrial development in Hayatabad Industrial Estate. It was revealed that main collector drain was carrying higher BOD and Total Suspended Solid (TSS) concentrations than the NEQS while, Total Dissolved Solids, and

pH were found within permissible limits. The average flow rate of Hayatabad collector drain was 13799 m³ /day.

- Kayani, (1999). Worked on 32 factories mainly located in Gujranwala, Lahore, Multan and Sheikhpura in Punjab, Karachi in Sindh and Nowshera in NWFP, involved in various productions such as sugar, paper, pharmaceuticals, food, leather etc. To avoid pollution hazard, these industries need shifting to chlorine free bleaching processes, solid waste management, and recovery of chemicals.
- Asif and Noor, (2000). Studied effluents of Polyfine Pharmaceutical Industry (Pvt.) Ltd., Bryon Pharmaceutical Industry (Pvt.) Ltd. and Saydoon Pharmaceutical Industry (Pvt.) Ltd in Hayatabad Industrial estate for pH, Temperature, Total Suspended Solids, Total Dissolved Solids, Chemical Oxygen Demand (COD), and Biological Oxygen Demand (BOD). The study showed that effluent flow rate was 107.627 m³/ day, 108 m³ /day, and 107.52 m³/ day respectively. Among the parameters investigated COD and Total Suspended Solids were found above the NEQS permissible limits. Heavy metal found above the NEQS for Industrial liquid discharge was Lead (Pb), which was 0.7, 0.6 and 0.8 mg/L, respectively for each industry.
- Wasim, (1995). Conducted a research on toxic inorganic chemical in Amangarh Industrial Estate, River Kabul and Peshawar University Campus. Various inorganic chemicals related to quality control parameters of drinking water and effluent have been determined and reported. Water samples collected were analyzed for different parameter like Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total

Dissolved Solids (TDS), Dissolved Oxygen (DO), Zinc, Iron, Magnesium, Cadmium, Alkalinity, Hardness and Chlorides and the relevant data obtained for drinking water of Peshawar University Campus was compared with available data. All samples were free from Lead, Copper and Cadmium except Calcium and Iron, which were in high concentration than standards set by WHO. All other parameters were found within the permissible limits. However COD, Chlorides, Phosphates and Sulfates were above the desired level in various samples. All toxic inorganic chemicals along with Manganese were found to be absent in drinking water of Peshawar University Campus.

3.3 Analytical Study of Heavy Metals

- Zhou et al. (1997). Investigated the trace metal concentration (Zn, Pb, Cu, Cr and Mn) in soil samples from industrial, residential and nature reserve area in Singapore. They used Flame Atomic Absorption Spectrometric (FAAS) method for the analysis of heavy metals. The study concluded that the heavy metal concentration in nature reserve area was lower than the residential area. While the concentration of trace metals in area of heavy traffic and industrial area was high. They concluded that vehicular emission due to heavy traffic and industrial activities were the main causes of trace metal pollution.
- Nawab, (1992). Studied the sewage water pollution in Peshawar city. He analyzed the effluents for heavy metals, (Cd, Cr, Ca, Pb, Cu, Fe, Mn, Ni and Zn) Electrical Conductivity, Chloride, Nitrate, Nitrite, Sulfate, DO and BOD. The sewage water of Peshawar city discharged to Budni Nullah and

Shalam River by two major drains without any treatment, which was ultimately received by Kabul River, and disturbed its ecological status. The analysis of these effluents showed high concentration of Cd, Cu Fe, E. Conductivity, BOD and fecal coli form bacteria and less amount of DO level. To avoid negative impacts on Kabul River, closed sewerage system and proper biological treatment (secondary treatment) were recommended. Besides, awareness was also recommended to avoid dumping of solid waste in sewerage system.

- Khattak and Rehman, (1992), worked on the impacts of industrial effluents on the Kabul River at Pirsabak. According to the study various industrial effluents showed high concentrations of Cu, Zn, Fe, Cd, Pb and Ni. The concentration of most of the trace elements were found above the permissible limits for drinking water and some exceeded the limits for irrigation water. They found that the water quality degraded due to industrial effluents being discharged untreated.
- Shahina, (2001). Investigated surface and subsurface water of Peshawar Basin for various cations and anions; included Calcium, Magnesium, Potassium, Sodium, Bicarbonate, Sulfate and Chloride. The water samples were also analyzed for Oxygen Isotopes and trace elements, such as Iron, Manganese, Chromium, Nickel, Copper, Cobalt, Lead and Cadmium. The water quality parameters were within the permissible limits recommended by various International Agencies for drinking, domestic and Agricultural uses. The surface water of Akbarpura in its vicinity (Near Kabul River) was unsuitable for domestic uses. The Oxygen Isotopic data for the underground water system of Peshawar Basin indicated that the aquifers in

the Peshawar Basin were recharged both by rainwater and water from the Kabul and Swat rivers. In this respect the Kabul River remain dominant over the Swat River. This also indicated that the shallow waters in the basin were more contaminated than deep water. The pollution problems were associated with urbanization and industrialization in and around the major cities of NWFP. Therefore, pre-treatment, legislation, awareness and regular monitoring were recommended for water pollution control in the area.

- Kamala-kannan et al. (2008) assessed three heavy metals Cd, Cr, And Pb in water, sediment and sea-weed in Phlicate Lake, South of East India. This lake was receiving industrial effluents. According to their study, concentrations of Cr and Cd were high in sediment samples while that of Pb was high in sea-weed. In sediment and sea-weed the order of concentration was $Cd > Cr > Pb$, while in waste water the ratio was $Cr > Pb > Cd$. The low flow and high flow seasons had an impact on water quality, however, it did not affect sediment and see-weed remained the same.

3.4 Analysis of Water Quality Parameters

- Zubair, (1993). Worked on Kalpani River for ten different parameters (Temperature, pH, Conductivity, Dissolved Oxygen, Alkalinity, Hardness, Chloride, Nitrate, Dissolved and Suspended Solids. According to the study, the water was not suitable for drinking purposes. Besides, the ever increasing population, which doubled every 35 years, industrialization and increase in domestic and industrial effluent was expected that would harm the ecology of Kalpani River. Hence, as a preventive measure, treatment

facilities were suggested. For industrial effluent, the government was required to initiate regular monitoring program.

- Rehman et al. (1997). Analyzed the available surface water potential of the important rivers of North West Frontier Province (NWFP) including Kabul River, Swat River, Chitral River and Punjkora River. Bara River was the smallest river in terms of discharge and sediment load. Chitral River was considered as the most significant river in the study area (NWFP) in terms of its annual sediment yield. It yielded the highest sediment load per square Kilometer of the drainage basin ($1842 \text{ tKm}^2\text{a}^{-1}$) which indicating a very high denudation rate in the Chitral Valley. The Swat River was found with the lowest sediment load in the region. It was found that the amount of Total Suspended Solids (TSS) being very high in most of the rivers and have resulted in rapid silting and subsequent loss in the storage capacity of the existing reservoirs. Kabul River was found as the largest tributary of the Indus River in NWFP.
- Masood, (2000). Studied socio economic and environmental impacts on Warsak dam. According to the study, the Warsak dam constructed on Kabul River in 1960 has two major components including the provision of irrigation facilities and electricity generation. A questionnaire survey was conducted in five different villages during the study. The results showed that living standard was improved. The various negative impacts arose as: (1) Decrease in irrigation intensity, which was associated with non-availability of water on regular basis or availability of water unevenly, (2) Increase in water logging, which were observed in Surizai Payan and Aza Khail Bala and Suffaid Sung, (3) Loss of agricultural land to Warsak

Canal due to water erosion. and (4) Increase in land disputes/Litigations. Environmental aspects like water quality deterioration. and pollution load also increased due to industrialization and improper swage and industrial waste water disposal.

- Amjad, (2002). Studied surface water resources and sediment load in Indus and Swat Kohistan in North Pakistan. The Swat River water was contributed by Gabral River by 43% followed by Ushu River 34%, Daral Khawar 11% and Batal Khawar by 12%. It was concluded that Swat River stand to be the noblest river in the region regarding sediment load. In this study a rational had been established between sediment load and catchments area, discharge and suspension of rivers. While, to overcome the problem of Suspended Solids reforestation was recommended in the catchments area. The sediment contributed by the Swat River to the Kabul River was mostly dependent on Punjkora River that joins it before it falls in the Kabul River.
- Imran and Sayyar, (2006). Conducted a research on water quality of Budni Nullah (Peshawar) and its effects on ground water. Results of the study revealed that values of Turbidity, Total Suspended Solids (TSS), Alkalinity and Phosphate were higher than the permissible limits while Dissolved Oxygen (DO), Total Dissolved Solids (TDS), Chlorides, Nitrates, Sodium, Potassium and Coli-form bacteria were within the permissible limits of NEQS.
- Kanwal, (2003). Carried out research on drinking water quality of Hayatabad Phase 1-6 (Peshawar). The parameters such as Color, Odor, Taste, Hardness, Conductivity, pH, Total Dissolved Solids (TDS) and

Chlorides were studied for 36 water samples collected. All the parameters were found within the permissible limit as set by WHO except conductivity which was beyond the permissible limit in some Phases of Hayatabad. The study suspected that there were chances of contamination through breakage of pipelines and illegal connections.

- Haider, (2001). Conducted a research work on drinking water quality in Peshawar. The parameters which considered were Color, Odor, Taste, Temperature, pH, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Conductivity, Hardness, Alkalinity, Chlorides, Sulfides, Potassium, Phosphates, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD) and Coli-form Bacteria. All the parameters were within the permissible limit as set by WHO and US-EPA except in some areas the Coli-Form Bacteria, Hardness and Suspended Solids were above the permissible limit.
- Fauzia and Nargis, (1999). Observed the whole profile of drinking water at Peshawar University Campus. The average mean concentration of sulfide and sulfate were 1.726 and 44.36 mg/L, which showed that sulfide concentration in all samples, were above the permissible limits as set by World Health Organization (WHO) and US-EPA.
- Shaheen, (1998). Conducted a research on drinking water quality of Gadoon Amazai Industrial Estate (NWFP). Lack of planned control measures, discharge of untreated wastewater through open drainage system was serious threat to the receiving water bodies. To evaluate the pollution load of ground water in Gadoon Amazai Industrial Estate, one hundred and twenty one water samples were collected from the area in

three months from five Tube wells, one Hand Pump and a Dug well. These samples were analyzed for Biological Oxygen Demand (BOD), Nitrites-Nitrogen, Nitrate-Nitrogen, Chlorides, Conductivity, Sulfates, Sulfides, following the standard methods of examination of water and wastewater. The results showed that the concentration of all the parameters were within the permissible limits as recommended by WHO. The industrial effluents were potential sources of ground water pollution.

3.5 Physico Chemical Characteristics of River Water

- IUCN-DEPM, (1994) International Union for Conservation of Nature and Natural Resources and Department of Environmental Planning and Management (DEPM) in 1994 conducted a comprehensive study of Kabul River and its tributaries including Chitral River in NWF, Pakistan. They analyzed physical parameters (Temperature, Conductivity, pH, Total Solids, Total Suspended Solids, Total Dissolved Solids and Dissolved Oxygen), chemical parameters (Alkalinity, Hardness, Ammonia, Nitrites, Nitrate, Sulfide, Sulfate, Phosphate Chloride and Chemical Oxygen Demand COD), Biological parameters (Biological Oxygen Demand BOD, fecal coli form) and heavy metals (Zn, Cr, Cd, Pb, Fe and Ni). The concentration values of Conductivity, Sulfide Organic Pollution and Chromium Cr were found high in most of the samples. They also found that the amount of Suspended Solids being very high 10-800 ppm during low flow condition, which was associated with industrial activities along the bank of Kabul River. Pollution control measures for industrial effluent and waste water were recommended
- Nafees et al. (2002). Carried out an ecological study of Adezai branch of Kabul River. They analyzed the water of Adazai River; main tributary of

Kabul River for pH, Temperature, Dissolved Solids, Electric Conductivity, Suspended Solid, Biological Oxygen Demand (BOD) Nitrate and Chloride. They found that all the parameters studied were within the permissible limit of drinking water quality. The only problem was of higher Suspended Solids that were due to deforestation, soil erosion and municipal waste water. They suggested that a forestation, reforestation and proper embankment of river might result in the control/reduction of Suspended Solids.

- Nazaneen and Begum, (1988). Determined pH, Dissolved Oxygen (DO), Temperature, and turbidity in the Lyari River Karachi. They collected samples from various points over a length of 50 Km of river and found that water pollution was strongly co-related with the entry of various industrial effluents having high turbidity and alkaline pH concentration level.
- Canadian Govt. (1952-54). A Canadian company carried out an aerial photographic survey of Kabul River for the feasibility of Warsak Dam. The aerial photo interpretation showed high turbidity in river water and was found silty when compared with the surrounding rivers.
- Larry, (1977). Studied pollution control of Kabul River. It was shown that the discharge of biodegradable organic compounds appears to have only a minor impact on the major streams. The study showed that the cause of anaerobic conditions in the drain was organic discharges. He also found the adverse impacts due to the discharge of Chromium and Sulphides by Textile Mills and a major problem in the Kabul River was resulting from the discharge of DDT and phenols from Nowshera DDT factory. Moreover unhygienic conditions for the health of workers prevailed at Nowshera factory and Adamjee chemical works. The need of strict legislation

was recommended for the effective regulation as a control measure of industrial effluents in NWFP.

- Ahmad and Khan, (1983). Analyzed water samples of Kabul River for parameters including Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD) and found that Azakhail Bala river bank had DO values of 3.55, while DO concentrations at Nowshera bridge, Akora Khattak and Khairabad Kund were 4.02, 3.86 and 3.73 mg/L, respectively. The BOD of the same sample sites were 0.40, 0.40, 0.35 and 0.56 mg/L respectively. They also found that Kabul River has nearly the same Dissolved Oxygen concentration at various sites. Further decrease in DO in various receiving water bodies was found associated with untreated industrial discharges which had adverse effects on aquatic fauna and flora.
- Kamin, et al. (1985). Studied pollution status of Kabul River and Khashki Lake. The analysis of effluent samples showed significant amount of Total Dissolved Solids (1550-1820 mg/L), Sulfate (768-816 mg/L) and Sulphide (0.75-3.31mg/L). The presence of high concentration of oxidizable matter like sulfide decreased the Dissolved Oxygen (DO) level greatly. The concentration of Sulphide was well above the permissible limits causing water pollution in both Kabul River and Khashki Lake.
- Javed, (1989). Worked on various physical, chemical and biological parameters of Kabul River near Nowshera city and found that the water of main river channel was affected to a lesser extent by pollutants of industries in the area.
- Suhail, (1989). Worked on the bottom fauna and organic matter at the bottom mud of Kabul-Indus drainage system. Due to heavy organic load and low flow

rate in winter, comparatively more mud was found in Nowshera area. The discharge of industrial sewage and quantity of decomposable matter was higher at Nowshera, thus resulting in an increase in the concentration of organic matter in the river water, which increased the rate of decomposition in the river ecosystem that had direct influence on dissolved oxygen content. If large number of fish has to be maintained in the 120 km stretch of Kabul-Indus (Length of Kabul River from Warsak to Attock) drainage system, the natural food of fish will have to be supplemented with artificial food.

- Ali, (1993). Investigated Bara River for pollution load and analyzed pH, Dissolved Oxygen, Conductivity, Total Solids, Dissolved Solids, Suspended Solids, Chloride, Alkalinity, Hardness, Chemical Oxygen Demand, Biological Oxygen Demand, Nitrate and Nitrite. Bara River is one of the tributary of Kabul River system. Its water is used for irrigation, recreation, washing and bathing purposes. The study showed that the water was not fit for drinking because of heavy suspended load and nitrates. For which embankment, a forestation, proper use of fertilizer and proper sewerage system were recommended to safeguard Bara River.
- Pervez, (1993). Worked on Kabul River for flood plains vegetation in Dauba-Daudzai area (Area from Warsak dam to Jaba, (Akbarpura). He classified the branches of Kabul River on the basis of pollutants they carried as A clean water (Adezai River) (B) Contaminated water (Naguman River) and (C) very high polluted water (Shalam River). Shalam River was found very much polluted because of municipal effluents and effluents from Khazana Sugar Mills and Toti tanneries entering in it. He also found that the flood plains of Dauba-Daudzai were in lush-green tree forests, grasslands and some parts

were pastures. As a whole the vegetation was much disturbed; and the area was degraded further by increasing sewage and industrial effluents being discharge untreated in Shalam River.

- Janbaz, (1995). Worked on Kabul River for its Socio-economic impacts on Peshawar valley for the period during 1960-1995. Where substantial socio-economic development and changes took place in Peshawar valley after the construction of Warsak Dam. The impacts were associated with irrigation and availability of electricity, considerable uplift in the living standards of the people occurred by providing roads, transport, communication facilities, education and health services. However, some negative impacts were also identified including water logging, flood, erosion, pollution etc, which was associated with fast-growing population and industrialization. The negative impacts were supposed to further accelerate if proper monitoring and pollution abetment, preventive as well as curative measures were not adopted. It was recommended for pollution control measure cause by industrial effluents.
- Amjad, (1996). Investigated river water of NWFP for suspended load quantitatively and qualitatively. In Kabul River system, Chitral and Bara River were found most turbid with 1112 ppm and 1152 ppm, respectively followed by Kabul (684 ppm) Punjkora (443 ppm) Swat (57 ppm). Other parameters studied included pH, Total Dissolved Solids (TDS), Conductivity, Sodium, Potassium, Lithium, Sulfate and Phosphate, which were found within the permissible level for drinking water. The problem of Suspended Solids was associated with barren and steep mountain slopes upstream, a forestation. Reforestation and other watershed management practices were recommended for to decrease pollution loads in these rivers.

- Ijaz et.al (2002). Studied the correlation of sediment load with catchment area and annual runoff volume of Kabul River Basin in Afghanistan. Rivers that were analyzed included the Kabul, Lugar, Gurband and Punjshir. The Kabul River was found turbid for which watershed management was recommended, with the emphasis on a forestation and reforestation activities to reduce the sediment load.

3.6 Concluding Remarks

The literature survey presented in preceding portion of this chapter described various aspects of water pollution associated with industrial effluent and waste water of Hayatabad Industrial Estate which ultimately joining with Kabul River and adversely affect the water quality. In this connection, the examination of pollution caused by effluent and waste water of Hayatabad Industrial Estate (HIE) sewage drain nullah and receiving water body was desirable. It was quite difficult to cover the whole area of HIE due to limited resources and time constraint. Therefore, only forty (40) sites were selected for sampling. The sampling sites included effluent of individual industries; combined industries (cluster) sub-drain (branches) sewage drain, nullah and the receiving water bodies, Shah Alam River and Kabul River. The present study was conducted to know the current status and to determine the pollution load caused by industrial effluent discharged untreated in the nearby natural stream (Khawar) getting the shape of effluent drain joining with Shah Alam River ,which finally finds its way into Kabul River.

3.7 References

- Ahmad, N. and Khan, F. (1983). "Dissolved Oxygen and Biochemical Oxygen Demand of Kabul River and the Industrial wastes of the Nowshera Industrial Area". Journal of National Center of Excellence in Physical Chemistry, University of Peshawar. Pp-87-95.
- Ahmad, N. and Saleem, M. (1982). "Determination of Chemical Pollutants in River, Drinking and Industrial Waste Water of NWFP" Journal of National Center of Excellence in Physical Chemistry, University of Peshawar, Vol. Nm.
- Ahmad, N., Noor, S., Saleem, M. and Fazalullah. (1986). "Water Pollution of the Urban and Industrial Areas of NWFP, Pakistan" Journal of National Centre of Excellence in Physical Chemistry, University of Peshawar, Vol. nm.
- Ali, I. (1993). "Pollution Strength of Bara River" M.Sc. Thesis, Department of Environmental Planning and Management (DEPM), University of Peshawar, pp1-4 and 22-48.
- Amjad, M. (1996). "Quantitative and Qualitative Analysis of the Suspended Sediment from River of North West Frontier Province (NWFP)" M. Phil. Thesis, National Center of Excellence in Geology, University of Peshawar, pp 35-56.
- Amjad, M. (2002). "Evaluation of Surface Water Resources and Sediment Load in Indus and Swat Kohistan North Pakistan" PhD Thesis, Department of Geology, University of Peshawar, pp 164-169.
- Asif, M. K. and Noor, M. (2000). "Investigation of Pollutants Load in Wastewater of Hayatabad Industrial Estate Peshawar". M.Sc. Thesis Department of Environmental Planning and Management, University of

Peshawar.

- Bahadar, K. and Zahidullah. (1991). "Aquatic Pollution Due To Industries in River Kabul at Amangrah Nowshera NWFP (Pakistan)". M.Sc. Thesis Department of Environmental Planning and Management (DEPM) University of Peshawar.
- Bahadur, K. R. (1994). "Environmental Examination of Industrial Estate Hyatabad Peshawar with Special Reference to Vegetable Ghee and Oil Mill". M.Sc Thesis, Department of Environmental Planning and Management Peshawar University.
- Banaras, M. (1994). "Environmental Monitoring of Industrial Estate Hayatabad Peshawar" MSc. Thesis, Department of Environmental Planning and Management, University of Peshawar, pp-11-22.
- Canadian Govt. (1954). "Colombo Plant Report on Indus Basin" Central Engineering Authority, Govt. of Pakistan.
- Fozia and Nargis. (1999). "Environmental Profile of University of Peshawar", M.Sc. Thesis, Department of Environmental Sciences, University of Peshawar.
- Govt. of Pakistan. (1999), "Analysis of Shakeel Marble Factory, Olympia Paper Mill and Mohsin Match Factory, Hayatabad" Environmental Protection Agency (EPA), NWFP Peshawar.
- Haider, L. (2001). "Assessment of Drinking Water Quality in Peshawar", M.Sc. Thesis, Department of Environmental Sciences, University of Peshawar.
- Hamid, S. (1999). "Introduction of an Integrated Approach for Sustainable Industrial Development in Hayatabad Industrial Estate" M.Sc. Thesis,

Department of Environmental Planning and Management (DEPM), University of Peshawar.

- Ijaz, M. Sadia, B. Taiab, M. and Sardar, A. (2002). "Total sediment load: Analysis and results from Kabul River Basin, Afghanistan" Peshawar University Teacher Association Journal, Vol 7 and 8 pp 125-132,
- Imran, K. and Sayyar, K. (2006). "Water Quality Monitoring of Budhni Nullah (Peshawar) and its Effects on Ground Water", M.Sc. Thesis, Department of Environmental Sciences, University of Peshawar.
- Iqrar, M. (1995). "Survey of Khazana Sugar Mill Peshawar and Case Study of Nasir Killy Village Program". M.Sc. Thesis Department of Environmental Planning and Management, University of Peshawar, pp 6-21.
- IUCN-DEPM (1994) "Pollution and the Kabul River, an Analysis and Action Planning". Publication of IUCN and Department of Environmental Planning and Management, University of Peshawar (UOP), published by Environment and Development Department Civil Secretariat Peshawar.
- Jadoon, H, S. (1996). "Chemical investigation of the selected atmospheric and hydrospheric environments of NWFP". Ph.D. Thesis Department of Chemistry, University of Peshawar. pp 216-17.
- Janbaz, K. (1995). "Impact of Kabul River on the Socio-Economic Development of Peshawar Valley" PhD Thesis, Area Study center (Central Asia) University of Peshawar.
- Javed, A. (1989). "Study of Physical, Chemical and Biological Parameters of Kabul River at Nowshera" MSc. Thesis, Department of Zoology, University of Peshawar.
- Kamala-Kannan S., Prabhur B.D.B., Lee K.J., kannan N., Krishnamoorthy R.,

- Shanthi K., and Jayaprakash M. (2008). Assessment of Heavy Metals (Cd, Cr and Pb) in water, sediment and seaweed (*Ulva lactuca*) in the Pulicat Lake, South East India". *Chemosphere* 71:1233-1240.
- Kamin, K., Arif, M., Khattak, M.A, and Shah, R.A. (1985) "Chemical Characteristics of Kabul River and Kheski Lake of NWFP Part 1". Pakistan Council for Scientific and Industrial Research (PCSIR) Laboratories, Peshawar.
 - Kanwal, T. (2003). "Assessment of Drinking Water Quality of Hayatabad Phase 1-6", M.Sc. Thesis Department of Environmental Sciences, University of Peshawar.
 - Kayani, A.M. (1999). "Pollution Control Equipment". Report, Industry Sector Analysis (ISA). Karachi, Pakistan.
 - Khalid, K. (1989). "Primary Productivity, Dissolved Oxygen and Biological Oxygen Demand in Kabul-Indus drainage System at Michni, Nowshehra and Mandori NWFP, Pakistan" M.Sc. Thesis, Department of Zoology University of Peshawar, pp-20-34.
 - Khattak, R.A and Rehman, A. (1992). "Effect of disposal of industrial wastes on the quality of Kabul River Water and Soil at Pirsabaq" A final project report, NWFP Agriculture University, Tipan Project Peshawar, pp 15-45,
 - Larry, J. K. (1977). "Control of pollution of Kabul River and needed legislation". United Nation industrial development organization acting as Executing Agency for the United Nation development program.
 - Masood, (2000). "Socio Economic and Environmental Impacts of Warsak Dam on Surrounding Areas". M.Sc. Thesis Department of Environmental Planning and Management, University of Peshawar, pp 32-65.

- Nafees, M. and Ghulam, K. (1992). "Environmental Impact Assessment (Monitoring) of Amangarh Industrial Estate Nowshera". M.Sc. thesis Department of Environmental Planning and Management University of Peshawar.
- Nafees, M., Ghulam, K. And Sardar, M. (2002). "Investigation of Chemical and Ecological Evaluation of Adezai River" Peshawar University Teachers Association (PUTAJ) Vol. 9, pp 77-82.
- Nawab, B. (1992). "Evaluation of Sewage Water Pollution in Peshawar City" M.Sc. Thesis, Department of Environmental Planning and Management (DEPM), University of Peshawar.
- Nazneen, S. and Begum, F. (1988). "Environmental Study of Lyari River. Pakistan Journal of PCSIR Karachi, 21:16.
- Pervez, M. (1993). "The flood plain vegetation of Kabul River and its tributaries in Duaba-Daudzai area Near Peshawar, Pakistan" M.Phil. Thesis, Area Study Center (Central Asia) University of Peshawar.
- Rafiullah, K. (1994). "Environmental Examination of Industrial Estate Hayatabad Peshawar with Special Reference to Paper and Board Mill". M.Sc. Thesis Department of Environmental Planning and Management, University of Peshawar.
- Rehman, S., Amjad, M., and Jehanzaib, K. (1997). "Discharge Characteristics and Suspended Load from River of Northern Indus Basin, Pakistan" Geological Bulletin, University of Peshawar Vol. 30, pp 325-336.
- Sardar, K. (1998). "On site Waste Reduction in Gadoon Amazai Industrial Estate" M.Sc. Thesis Department of Environmental Planning and Management (DEPM), University of Peshawar.

- Shah, J. (1991). "Survey and Environmental Pollution Abatement Measures for Saleem Tanneries (Pvt.) Jehangira (NWFP)" M.Sc. Thesis, Department of Environmental Planning and Management, University of Peshawar, pp 27-34.
- Shaheen, F. (1998). "Monitoring of Ground Water Quality in Gadoon Amazai Industrial Estate NWFP", M.Sc. Thesis, Department of Environmental Sciences, University of Peshawar.
- Shahina, T. (2001). "Environmental Geochemistry of Surface and Sub-Surface Water and Soil in Peshawar Basin, NWFP, Pakistan" PhD. Thesis, National Centre of Excellence in Geology University of Peshawar, NWFP, Pakistan., pp 80-128, 173-176.
- Sial, R.A., Chaudhary, M.F. Abbas, S.T. Latif, M.I and Khan, A.G. (2006). "Quality of Effluents from Hatar Industrial Estate". On line journal of Zhejiang University Science. 7(12):974-980.
<http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1661672>
- Suhail, A. (1989). "Bottom Fauna and Organic Matter in the Bottom Mud of Kabul-Indus Drainage System, NWFP, Pakistan". Department of Zoology University of Peshawar. pp 14-34.
- Wasim, M.A. (1995). "Inorganic Chemicals in Water Toxic or Useful", M.Sc. Thesis, Department of Chemistry, University of Peshawar.
- Zahidullah, Ashraf, M. and Ayaz, M. (1991). "Internship Report on Environmental Impact Assessment (EIA), Initial Environmental Examination (IEE) and Industrial Surveys". Environmental Protection Agency (EPA), NWFP Peshawar, Pakistan.
- Zhou, C.Y, Wong, M.K. Koh, L.L. and Wee, Y.C. (1997). "Soil, Lead and other metals level in industrial, residential and nature reserve areas in

Singapore". Environmental Monitoring and Assessment, Kluwer Academic Publishers, the Netherlands. 44: 605-615.

- Zubair, P.M. (1993). "The state of Pollution in Kalpani Nullah Mardan" M.Sc. Thesis, Department of Environmental Planning and Management, University of Peshawar, pp 28-36.

Chapter 4

Materials &

Methods

Chapter 4

Materials & Methods

Materials & Methods

CHAPTER- 4

Material and Methods

4.1 Background

The present study was designed to evaluate "Hayatabad Industrial Estate", Peshawar and NWFP for its effluents/wastes, uses, nature, magnitude and pollution load. These aspects vary, along the entire stretch of main effluent drain. The climatic and manmade interferences with the increase in industrialization and urbanization were also considered. This chapter includes the procedures adopted for the study and its various aspects. Two types of areas were identified i.e. Field work and Laboratory Work. Field-work was related to a comprehensive survey and to identify sample sites for sample collection and the analysis of the situation of "Hayatabad Industrial Estate" and its effluent drain. Laboratory work included the analysis and characterization of various industrial effluents and sewage drains for determining the pollution load.

To evaluate pollution and its possible impacts, forty (40) samples were analyzed for nineteen (19) parameters. To identify and evaluate burden of pollution industrial and field survey was conducted.

Sampling and analysis of industrial wastewaters were carried out to identify the types and quantities of pollutants discharged by industries and municipal areas and evaluating their impacts on the receiving surface waters. To get a representative sample, grab sample techniques were used for effluents drains, sewage drains, nullahs and receiving water bodies during low and high flow. For low flow samples were collected during month of January and February while the analysis of high flow was conducted during July and August. Sampling was carried out during 9.00 to 15.00 hours Pakistan Standard time.

4.2. Effluent Sampling

Chemical analysis and their validity depend upon the sample procedure. An ideal sample is the one which truly represents the water bodies from which the sample has been taken. Sampling program, size of sample, site of sample collection and frequency are relevant factors for any sampling. All the samples were collected in

clean dry polyethylene bottles rinsed with 8 molar HNO_3 , followed by rinsing with deionized distilled water. Before sampling, these sample bottles were rinsed thrice with sample water.

4.3 Collection and Description of Sample

To obtain information about the degree of contamination caused by industrial effluents with respect to concentration of pollutants, samples were collected from forty sites. Before sample collection, a comprehensive industrial and field survey was conducted for the selection of appropriate sample sites. The selected forty sample sites include samples from the drains of individual industries in "Hayatabad Industrial Estate", combined drains of cluster industries, sub-drain (branch), main effluent drains at various location, sewage drain joining main effluent drain, (confluence point) nullah (*Khawar*) and the receiving water bodies i.e. Shalam River at Nakoba village and ultimately main Kabul River at camp Korona. A detail description of individual sample is given in the following tables.

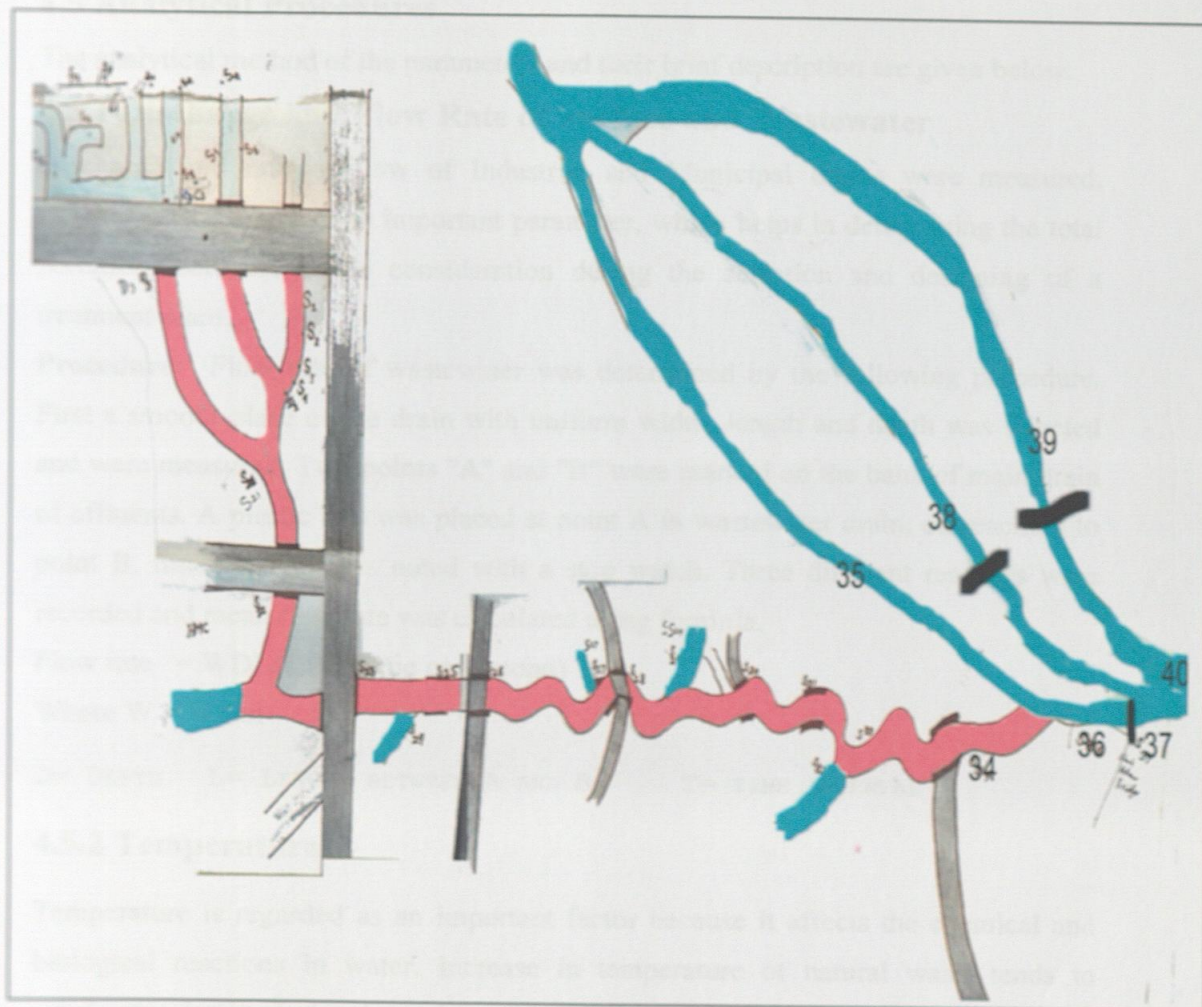
Table 4.1 Description of Sample Sites / location

Sr.N	Sample No	Location Description	GPS Readings		
			Latitude (N)	Longitude (E)	Elevation Above Sea Level (M)
1.	S1	Effluent drain of Mohsin Match Factory	3359.932	7125.653	410
2.	S2	Effluent drain of Premier Formica industry	3359.852	7125.980	409
3.	S3	Effluent drain of Shalman Marble	3359.902	7125.459	395
4.	S4	Effluent drain of AGE Cable Pvt. Ltd.	3359.934	7125.829	409
5.	S5	Effluent drain of Khyber Match Factory	3359.704	7125.357	395
6.	S6	Effluent drain of Pepsi Cola.	3359.850	7125.360	395
7.	S7	Effluent drain of Unique Marble Factory	3359.577	7125.082	411
8.	S8	Effluent drain of Olympia Paper/Board Mills.	3359.588	7125.577	404
9.	S9	Effluent drain of Sarhad Board and Chemical Industries.	3359.505	7125.601	408
10.	S10	Effluent drain of Bryon Pharmaceutical Ltd	3359.306	7125.378	416

11.	S11	Effluent drain of Bilour Match Factory	3359.110	7125.514	415
12.	S12	Effluent drain of Gulab Banaspati Ghee Mills	3359.068	7125.534	416
13.	S13	Effluent drain of Libra Pharmaceutical Pvt. Ltd	3359.044	7125.667	411
14.	S14	Effluent drain of Saydon Pharmaceutical Ltd.	3359.044	7125.667	411
15	S15 (C1)	Combined effluent drain of Bilour Match and Gulab Banaspati Ghee Mills (S11+S12)) Cluster Industries	3359.110	7125.514	416
16.	S16 (C2)	Combined effluent drain of Libra and Saydon pharmaceutical (S13+S14) cluster industries	3359.052	7125.700	420
17.	S17 (C3)	Combined effluent drain of Olympia Paper and Sarhad Paper and Board Mills (S8+S9) cluster industries	3359.437	7125.661	407
18.	S18 (D1)	Sub drain 1 receiving effluents of sample (S1 to S4) Match, Formica , Marble and AGE Cable waste	3359.923	7125.007	399
19.	S19 (D2)	Sub drain 2 receiving effluents of samples (S5 to S7) Match, Pepsi and Marble waste	3359.304	7125.520	410
20.	S20 (D3)	Sub drain 3 receiving effluent of sample no (S8 to S14) 2 paper mills, 1 Match, 1Ghee and 3 pharmaceutical industries waste	3359.434	7125.682	409
21.	S21	Main effluent drain (HIE) the confluence point of the three sub drains D1, D2 and D3 near Rehman Medical Institute (RMI) Peshawar.	3359.899	7126.225	386
22.	S22	Main effluent drain near Hayatabad Medical Complex (HMC) Hospital	3359.820	7126.713	393
23.	S23	Main effluent drain near Board Bridge where a dry, rain stream Bagh-I-Naran "Khawar" meet with it.	3359.884	7127.577	377
24.	S24 (SD)	Sewage drain before mixing with main drain at Canal Town Peshawar.	3400.405	7123.114	353
25.	S25	Main effluent drain after mixing sewage drain near Nasir Bagh Road Peshawar.	3400.405	7123.114	353
26.	S26	Main drain near Prof. Colony Agricultural	3401.318	7128.708	343

		University before mixing marble effluent drain			
27.	S27 (ME)	Marble effluent drain at Pir Bala Before mixing with main effluent drain	3404.33	7130.564	320
28.	S28	Main effluent drain after mixing with Marble effluents drain at Pir Bala.	3404.036	7130.567	315
29.	S29 (BN)	Budni Nullah before mixing with main drain near Pir Bala.	3404.263	7130.923	312
30.	S30	Main effluent drain after mixing with Budni Nullah at Dagband Darmangi and Hasan Garhi Peshawar.	3403.955	7131.211	309
31.	S31	Main drain, merged with Budni Nullah at Charsadda Road Near Nishat Mill "Tor Bridge"	3402.340	7134.833	301
32.	S32 (SD)	Sewage drain from Peshawar at Sardar Ahmad Khan colony near Budni Bridge (Tor Bridge).	3402.340	7134.833	303
33.	S33	Main effluent drain including Budni after mixing the sewage drain from Peshawar	3402.523	7134.944	298
34.	S34	Main effluent drain + budni before mixing with shah Alam River at Nakoba (Daman Hindki)	3402.521	7134.942	297
35.	S35 SR	Shah Alam River before mixing with main drain at Nakoba village daman Hindki.	3404.433	7138.815	304
36.	S36 SR	Shah Alam River after mixing with Main drain at Nakoba village Daman Hindki	3404.346	7138.841	287
37.	S37 SRB	Shah Alam River near Shah Alam Bridge (Tributary of Kabul River)	3405.788	7136.721	306
38.	S38 NRB	Naguman River near Naguman Bridge (Tributary of Kabul River)	3407.426	7136.553	292
39.	S39 ARB	Adezai River near Sardaryab Bridge (Tributary /Branch of Kabul River)	3407.998	7141.389	296
40.	S40 MKR	Main Kabul River near Camp Koroona, (Akbarpura).	3405.775	7144.382	275

Figure 4.1 Diagram Showing Samples Sites of the Study Area



Study Area showing Sample Sites

4.4 Samples Analysis

To find out Pollution load samples were analyzed for nineteen (19) parameters (seven physical, six chemical, one biological and five heavy metals), for which reliable and standard analytical methods of waste water and water were used. Parameters including, flow rate of wastewater, pH, Conductivity, Temperature and Dissolved Oxygen (DO) were detected on the spot. Further analytical work was carried out in the laboratory after the proper storage of samples in the refrigerator below 4°C. Parameters including total solids, total dissolved solids, total suspended solids, Nitrate, Sulfate, Chloride, Chloride, Alkalinity, Chemical oxygen demand and biological oxygen demand were tested immediately in the laboratory.

4.5 Analytical Procedures

The analytical method of the parameters and their brief description are given below.

4.5.1 Discharge and Flow Rate of Surface and Wastewater

Discharge and rate of flow of Industrial and Municipal drains were measured. Discharged flow rate is an important parameter, which helps in determining the total pollution load and needs consideration during the selection and designing of a treatment plant.

Procedure: Flow rate of wastewater was determined by the following procedure. First a smooth place of the drain with uniform width, length and depth was selected and were measured. Two points "A" and "B" were marked on the bank of main drain of effluents. A plastic ball was placed at point A in wastewater drain, on reaching to point B, time interval was noted with a stop watch. Three different readings were recorded and mean flow rate was calculated using formula.

Flow rate = WDL/T (Volume per second)

Where W = Width

D= DEPTH L= LENGTH BETWEEN A AND B T= TIME INTERVAL

4.5.2 Temperature

Temperature is regarded as an important factor because it affects the chemical and biological reactions in water. Increase in temperature of natural water tends to accelerate chemical reactions, lowers solubility of gases, change taste, odor and increase metabolic activities of the living organisms. Temperature is one of the most important factors for aquatic environment because; most of the physical, chemical and biological properties are governed by it, (*Trivedi and Raj, (1992)*).

Procedure

It was measured by using a Mercury Thermometer of 0°C to 50°C range and with 0.2°C least count. The temperature of water samples were measured on the spot.

4.5.3 pH Measurement

The pH of water samples was measured according to (Arnold et al. 1996)

Model 7020 pH meter, Japan for field work

InoLab pH level-1, WTW, Germany for Laboratory use

Procedure:

The pH value was determined in the field as well as in the laboratory in quickest possible time. First, the sample was treated with methyl orange and phenaphtaline indicator to find out pH range of sample. Then pH meter was calibrated with required buffer accordingly. Three types of buffer solutions (pH 4, 6 and 8), prepared from standards tablets (BDH, BH151TD, England) were used. Then pH values of samples were measured.

4.5.4 Determination of Conductivity

The conductivity of water samples was determined according to Kumar, (1987). In field, the conductivity was measured using conductivity meter (AGB1000, Japan), while InoLab conductivity meter (WTW, Germany) was used for laboratory determination.

Procedure: Conductivity was measured in the field as well as in the laboratories in quickest possible time. The instrument was calibrated with de-ionized distilled water and standard KCl (0.01 M) prepared by dissolving 745.6 mg of anhydrous KCl in de-ionized distilled water). Then conductivity of the samples was measured in micro-semons per centimeter (uS/cm).

4.5.5 Turbidity

Turbidity is Phenomenon of light absorption or scattering due to suspending substances in water is called turbidity. Turbidity is the optical property of water affecting/causing light penetration. Turbidity disturbs and deviate the transmission of light by scattering and absorbing it instead of its penetration and passing straightly in water. Usually clay, silt, minute and fine inorganic and organic matter, plankton and microscopic organism are responsible for the property of water to be termed as turbid. (Greenberg et al. 2005)

Turbidity of the samples was measured in Nephelometric Turbidity Units. (Peavy, *et al.* 1985)

4.5.6 Total Suspended Solids (TSS)

Suspended solids include organic or inorganic particles or of immiscible liquids. Inorganic solids consist of clay, silt and other soil constituents. Organic solids include plant fibers and biological solids i.e. algal cells and bacteria etc. Suspended materials may be objectionable in water for several reasons. Such material is aesthetically displeasing and provides absorption sites for chemical and biological agents, (Peavy, *et al.* 1985).

Procedure

Pre dried filter paper was taken and weighed it by using electronic balance. 20ml water sample was filtered through it. The non filterable materials were retained on the filter paper. This filter was placed in oven at 104°C overnight for dryness. After drying it was cooled in desiccators and again weighed the filter paper. The difference between initial and final weights of filter paper gives suspended solids. The results were obtained in mg/L using following formula.

$$\text{TSS} = \frac{\text{filter paper weight with residues} - \text{filter paper weight without residues} \times 1000}{\text{ml of water sample used}}$$
 (Peavy, *et al.* 1985, Trivedi and Raj 1992)

4.5.7 Total Dissolved Solids (TDS)

TDS were measured according to Arnold *et al.* (1996).

100 ml of filtrate sample was dried in a crucible. In order to evaporate, the crucibles were kept for an hour in the oven in a range of 103 to 105°C temperature. When it completely evaporated, the crucible cooled in desiccators and weighed. The change in weight corresponded to the weight of dissolved solids. For cross checking conductivity meters were used.

Calculation

Total Dissolve Solid mg/L = $A - B$ (1000/ml of sample)

A= weight of dissolved solids + dish

B= weight of empty dishes

4.5.8 Total Solids (TS)

Total Solids were calculated following (Arnold et al. (1996), using gravimetric method. For a period of one hour, the dried and clean china dishes were kept in oven at 103 to 105°C. The dishes were cooled in desiccators for about 45 minutes and then weighed. After weighing known volume (100 ml for surface water and 50 ml for waste water) of each sample was taken in dishes and put in drying oven at a temperature of 103-105°C for an hour in case of surface water while for waste water the sample was evaporated using water-bath. The dishes were then cooled at room temperature and reweighed. Total Solids were calculated as:

Calculation:

Total Solid mg/L = $A - B$ (1000/ml of sample)

A = weight of china dish + dried residues

B = weight of empty dishes

4.5.9 Alkalinity

Alkalinity: The number and type of ions present in the water which causing neutralization of the Hydrogen ions (H^+) is termed as alkalinity. Thus it is the property of water which neutralizes acids. Bicarbonates, carbonates and hydroxides are the common agents of alkalinity. When these constituents' present in large quantities, they change taste of water. High alkalinity cause pungent and unpleasant taste in water. (Peavy, et al. 1985)

Reagents

- Standard sulfuric acid (H_2SO_4) solution (0.02N)
- Methyl orange indicator (0.5%)
- Phenolphthalein indicator (0.5%)
- Standard sodium carbonate (Na_2CO_3) solution (1N), (Gupta, 2004).
- Preparation of reagents:
- Standard H_2SO_4 solution (0.02 N)

Took in 1 liter flask 27 ml of concentrated H_2SO_4 and make the solution up to (1) liter with the addition of water. Then 20ml from this 1N solution and again diluted it with distilled water up to 1L (liter) in a volumetric flask.

- Methyl Orange Indicator (0.5%)

Dissolved 0.5 grams of methyl orange powder in 100 ml of 95% alcohol (Methanol)

- Phenolphthalein indicator (0.5%)

Dissolved (0.5) gram phenolphthalein powder in 100 ml of 60% ethanol.

- Standard Na_2CO_3 solution (1N)

53gram of Na_2CO_3 was dissolved it in small volume of distilled water and volume was made 1L, (Gupta, 2004).

Procedure

- Carbonate alkalinity

A few drops of phenolphthalein were added to the 20 ml water sample for checking the carbonate alkalinity. With the addition of Phenolphthalein, if the color didn't change into pink, it means absence of carbonate alkalinity.

- Bicarbonate alkalinity

Took 0.02 N sulfuric acid in burette and 20 ml water sample in a titration flask and few drops of methyl orange were added as indicator. The known volume of titrant, 0.02 N H_2SO_4 , was used in the titration. Titration continued till the color changed to orange red from orange yellow. The quantity or volume of titrant utilized was noted. Alkalinity was calculated by using the following formula.

Formula for Alkalinity as CaCO_3

$$= \frac{\text{Volume of } \text{H}_2\text{SO}_4 \text{ used} \times \text{Normality of } \text{H}_2\text{SO}_4 \times \text{Equivalent weight of } \text{CaCO}_3 \times 1000}{\text{ml of water sample used}}$$

(Gupta, 2004)

4.5.10 Dissolved Oxygen (DO)

a. Field Work: For fieldwork electrode method was used (Arnold et al. 1996)

In the field Dissolved Oxygen was measured with electrode method by using DO meter Genway Model No. 9070. DO meter was first calibrated with sample of known concentration and a sample with zero DO (by mixing sodium sulfite in an excess and cobalt chloride in traces gave zero DO). For fresh water where interference was not expected, water sample being tested was used while for polluted water such as industrial or domestic effluents; distilled water was used for calibration purpose. After calibration, Dissolved Oxygen was measured. The observed readings were also checked with stream temperature.

b. In laboratory the BOD of waste water samples was determined according to (Arnold et al. 1996)

Dissolved Oxygen was measured using Iodometric method. The following were required:

Apparatus

1. BOD/Incubation bottles 300ml
2. Incubator

Solutions

1. Manganese Sulfate (MnSO_4) Standard Solution:

Dissolve 480 g of $\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$ in a little distilled water and made it then up to one liter.

2. Sulfuric Acid (H_2SO_4) concentrated
3. Reagent Alkali Iodide Azide

Dissolved (500 g) NaOH and NaI (135 g) first dissolved in little distilled water and added 10 g NaN_3 dissolved in distilled water and was. This was tested with starch solution when diluted and acidified. No coloration indicates absence of dissolved oxygen.

4. Starch Indicator

For preservation purposes, starch specified for laboratory usage (2g) and salicylic acid (0.2g) dissolved in 100 ml warm distilled water.

5. Standard $\text{Na}_2\text{S}_2\text{O}_3$ (0.025N) Solution: (Standard Sodium Thiosulfate Solution)

Dissolve 6.205 g $\text{Na}_2\text{S}_2\text{O}_3$ in distilled water. Then added 6 N NaOH 1.5 ml and made it to one liter with addition of distilled water. The reagent kept standardizing each time with the standard KMnO_4 solution before the DO test.

6. Standard Potassium dichromate solution 0.025N for standardization:

Dissolved 12.29 g of $\text{K}_2\text{Cr}_2\text{O}_7$ of primary grade dried at 103°C for 2 hours in distilled water and was diluted to 1000 ml.

7. Potassium Iodide (KI) 5% Dissolved 5 g of KI in distilled water and diluted to 100 ml.

Procedure

Sodium thiosulfate solution ($\text{Na}_2\text{S}_2\text{O}_3$) was standardized against standard Potassium dichromate solution where starch was used as indicator. Normality of ($\text{Na}_2\text{S}_2\text{O}_3$) was calculated by using formula " $N_1V_1 = N_2V_2$ ".

For Dissolved Oxygen, 1ml each of Manganese Sulfate Solution, Alkali Iodide Azide, concentrated. H_2SO_4 and starch indicator were added to 250 ml of sample in a sequence with five minutes interval. Then titrated against (0.025 N) ($\text{Na}_2\text{S}_2\text{O}_3$) solutions.

Calculation

$\text{DO mg/L} = A (N (8000/\text{ml of sample}))$

$A = \text{ml of } (\text{Na}_2\text{S}_2\text{O}_3)$

$N = \text{Normality of } (\text{Na}_2\text{S}_2\text{O}_3)$

4.5.11 Biological Oxygen Demand (BOD5) (Arnold et al. 1996)

BOD_5 was determined through calculations due to difference between initial DO and final DO after 5 days incubation at 20°C by using the following formula:

BOD_5 of fresh water was calculated as = DO initial - DO final (after five days incubation).

BOD_5 of waste water was calculated as = DO initial - DO final/P

Where "P" is Dilution factor

4.5.12 Chemical Oxygen Demand (COD)

Samples with a known access of potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$) in strongly acidic solution were refluxed. Used amount of potassium dichromate during refluxing was determined by titrating it with the ferrous ammonium sulfate. The oxidized organic matter was considered as the amount equivalent to oxygen.

4.5.13 Nitrate (Arnold et al. 1996)

Nitrate was measured with spectrophotometer Hitachi UV-Vis, 1100, Japan. The following reagents were used.

Solutions

1. Phenol Diasulphonic acid Concentrated
2. Potassium Hydroxide (12N):

Solution of Potassium Hydroxide prepared through dissolving 67.2 g of KOH in distilled water and then made it 100 ml.

3. Standard Nitrate Solution (100 ppm). Dissolved 137 mg of (NaNO_3) in 1000ml of distilled water

Procedure

Took 50 ml in a china dish and placed in an incubator at a temperature 105°C till its complete dryness.

One ml of Phenol-disulphonic acid was added; equilibrated for a few minutes. Added one ml of KOH and diluted up to 50 ml. Measured the yellow color at 410 nanometer (nm) wavelengths.

4.5.14 Sulfate (Arnold et al. 1996)

Sulfate was measured with turbid metric Method by using spectrophotometer Hitachi UV-Vis, 1100, Japan. Barium Chloride (BaCl_2) was used to produce Barium Sulfate BaSO_4 suspension (if sulfate was present) and was measured with spectrophotometer at 420 nanometer (nm) wavelength.

Solutions

1. Barium Chloride (BaCl_2)

2. Buffer Solution: dissolved 30 g Magnesium Chloride, ($\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$), 5 g Sodium Acetate ($\text{CH}_3\text{COONa} \cdot 3\text{H}_2\text{O}$),

KNO_3 1g and 20 ml of 99% CH_3COOH were first dissolved in little distilled water and made it 1 liter

3. Standard Sulfate Solution (100 ppm as SO_4): Dissolved 0.1479 g anhydrous Na_2SO_4 in distilled water and final volume was made 1000 ml. by dilution.

Procedure

100ml sample was transferred to a 250 ml flask. 20 ml buffer solution was added and mixed for few minutes. During stirring spoonful of BaCl_2 was added to it. The turbidity was measured at 420 nm. Concentration as SO_4 was calculated by comparing the sample with sulfate solution of various known concentrations, prepared from the standard solution of 100 ppm.

4.5.15 Chlorides

Chlorides were measured by Argent metric method, following the method of (Arnold et al. 1996). The following reagents were used.

Solutions

1. Standard AgNO_3 Solution (0.0141 N)

AgNO_3 (2.395g) dissolved and made it 1 liter with the distilled water.

2. Standard Sodium Chloride (0.0141 N)

Dissolved 824 mg NaCl (dried at 140°C) in distilled water and diluted to one liter.

3. Potassium chromate indicator:

Dissolve 50 g K_2CrO_4 in small volume of distilled water. Added AgNO_3 solution till a definite red ppt. was formed. Equilibrated for 12 hours, filtered and diluted to one liter (1L) with distilled water.

4. Hydrogen per oxide H_2O_2 30%

5. Aluminum Hydroxide $\text{Al}(\text{OH})_3$

Procedure

Silver Nitrate solution was standardized against standard Sodium Chloride solution. 100 ml of sample was taken in a conical flask. For colored effluent sample, 1 ml $\text{Al}(\text{OH})_3$ was added, while for sulfide, 1 ml of H_2O_2 and in case of both color and sulfide, both, H_2O_2 and $\text{Al}(\text{OH})_3$ were added. The content was stirred for few minute. Then added 1 ml of K_2CrO_4 to the sample and titrated with AgNO_3 until the pinkish point.

$$\text{Chloride mg/L} = (A - B) (N (35450)/\text{ml of sample})$$

A= ml of titrant used

B= ml of titrant for blank

N= normality of AgNO_3

4.5.16 Detection of Heavy Metals in Effluent Samples by Atomic Absorption Spectrometry

Atomic Absorption Spectrophotometer usage for heavy metals in the samples: For assessing the heavy metals in the collected water samples, the AAS method was used.

Apparatus: Phillips Flame Atomic Absorption Spectrometer PUI900x, corning 240 digital pH meters and porcelain evaporating dish.

Chemicals: All the chemicals used in analysis were pure, of analytical grade and utilized as such that no additional purification step were followed.

The chemicals used were concentrated HCl , Concentrated HNO_3 and standard stock solution (1000 ppm) of each metal to be determined.

Preparation of Solution

Standard solution of the metals: Prepared 100 ml solution of each of 1, 2, 5, 10, 20, and 50 ppm of the metals solution from the stock solutions of the metals to be determined. Dilution was made using deionized distilled water. Each solution was 10% in hydrochloric acid concentration.

The sample solutions were then aspirated into Atomic Solution of the metal to be determined

Unfiltered well shaken sample took in beaker. Taken sample was 100 ml. 10 ml of Concentrated HNO_3 and concentrated HCl mixture in ration of (1:3) was added to it.

This mixture was evaporated to reduce the volume to 100 ml.

Absorption Spectrometer and the metal concentration read directly form the display.

Table 4.2: Instrumental parameters for the studied metals

Metal	Wavelength (nm)	Spectral Band pass (nm)	Fuel/Support	Lamp Current (m amperes)
Cr	357.9	0.2	Acetylene /Air	12
Cu	324.8	0.5	Acetylene /Air	05
Fe	248.3	0.2	Acetylene /Air	15
Ni	323	0.2	Acetylene /Air	15
Pb	217	0.5	Acetylene /Air	10

(Jadoon, 1996)

Procedure

100 cm^3 of the unfiltered well mixed sample was taken in a beaker. 10 ml of Concentrated HNO_3 and HCl mixtures (1:3) were added in it.

To determine the metals in the samples, the mixture kept on evaporation till it

Reducing to 100 ml and then subjected to Philips Atomic Absorption Spectrometer

For Detection of metals given in table 4.2

4.6 References

- Arnold, G.E., Lenore, S.C. and Andrew, O.E. (1996). "Standard Methods for the Examination of Water and Waste Water" 19th edition, American Public Health Association, 1015 Fifteenth Street, Washington, DC, 20005.
- Greenberg A.E., Andrew, O.E and Lenore, S.C, (2005), "Standard Methods for the Examination of Water and Waste Water." 21st edition jointly published by American Water Work Association (AWWA), Water Pollution Control Federation (WPCF) and American Public Health Association (APHA) USA.

- Gupta, PK. (2004). "Methods in Environmental Analysis Water, Soil and Air", 1st edition, Updesh Purohit for Agrobios, Agro House Jodhpur India. pp 47-48.
- Jadoon, H. S. (1996). "Chemical Investigation of the Selected Atmospheric and Hydrospheric Environments of NWFP". Ph.D. Thesis Department of Chemistry, University of Peshawar. pp 96-97, 141-43.
- Kumar, A.D. (1987). "Environmental Chemistry" Wiley Eastern Limited, New Delhi, India.
- Peavy, H. Rowe, D. and Tchobanoglous, G. (1985). "Environmental Engineering", Mc Graw-Hill Inc London. pp 15-45.
- Trivedi, P.R. Raj, G. (1992), "Environmental Water and Soil Analysis", 1st edition, Akashdeep Publishing House, New Delhi India. pp 59-161.

Chapter 5

Result & Discussion

CHAPTER-5

Result and Discussion

5.1 Physico Chemical Properties of Effluent/Waste Water of Hayatabad Industrial Estate, Peshawar

The composition of water and waste water depends upon many factors; the most important ones are geology, topography, land use, discharge characteristics and other human activities including industrial effluents and sewage etc. In order to understand the variations and potential discharges samples were collected from individual industrial units and entire stretch of main effluent drains from forty different sites. To evaluate the impact of joining tributaries, sewage drains, Budni nullah and the receiving water bodies were also considered. To know the overall impact of the main effluent drains, the joining sewage drain, tributaries and the receiving water bodies the selected sites were sampled in both winter and summer conditions. Analytical results of Physico chemical parameters are given in (Table 5.1 to 5.8) and that of the heavy metals are listed in (Table 5.9 to 5.12.) Description of each parameter is as under.

5.1.1 Flow Rate of Water and Waste Water

Flow rate of waste water varies during various seasons of the year and even in a single day. Fluctuation in discharge during various working hours with change in flow rate (as a consequence of) effluent, the amount of pollutant being discharge in effluent drain also changes. The dilution of pollutants depends on the volume of water in the receiving water bodies itself changing the concentration of pollutants. Flow rates and discharge data of the important drains of Hayatabad Industrial effluent drain, sewage drains and nullah are depicted in (Table 5.13). Seasonal low and high flow rates are also fruitful in judging the carrying capacity for future work, which is given in table as well.

5.1.2 Temperature

Temperature is an important factor which affects aquatic organisms. Although it is not used to directly evaluate the water quality but it affects a number of other parameters. It changes the solubility of essential gases like oxygen in water. Changes in temperature also influence the metabolic rate. Temperature has bearing on most of the chemical reaction that occur in aquatic eco system (peavey, et al. 1985). Temperature at the 40 sampling sites in Hayatabad Industrial Estate was in the range of 17.1°C to 38.2°C (Table 5.1 to 5.2).

The maximum temperature 38.2°C was found in the effluent drain of Olympia Paper and Board Mill (Table 5.2). Such high temperature may be caused by industrial discharge in the drain. Although temperature of most of the effluent in both low and high flow season of the year remained within the permissible limits (40°C) of National Environmental Quality Standards (NEQS) evident form (Table 5.1 to 5.4). In some cases the temperature reached near to the maximum permissible limits, due to hot season and heating process within the industry (Table 5.2 and 5.4). The addition of these hot waste waters discharge by "Hayatabad Industrial Estate" (HIE) reduced the ability of receiving water body to hold oxygen for self purification thus creating anaerobic conditions which came affect the survival of aquatic life.

5.1.3 pH

The pH value of waste water indicates the strength of acid or alkali present in it. pH is a measure of Hydrogen ion concentration. It shows a scale of intensity of alkalinity or acidity. Technically the Negative (-ve) logarithmic value of Hydrogen ion concentration is regarded as pH. Since the pH scale is based on logarithm to the base of 10, each unit change in pH actually represents a tenfold change in degree of acidity or alkalinity. For example a solution with pH=5 is 10 time more acidic than a solution with pH=6. Similarly a solution with pH =4 is 100 time more acidic than the solution having pH=6 (Nathanson, 2004).

The pH value is relatively stable without any effect of outside, however it may change sharply by interference caused by rain fall, domestic waste and contamination of industrial effluents. Industrial waste with very low pH when discharged into stream badly damage aquatic life and crops if used for irrigation. Similarly, high pH of waste water causes serious damage to soil as well as to aquatic life. According to USPH standards, pH should range from 6.0 to 8.5 in drinking water, while WHO specify a range of 6.5 to 8.5. According to Indian Standards, the pH of water should be 6.0 to 9.0 and Pakistan National Environmental Quality Standards.

(Pak-NEQS) it should be 6 to 10 for the waste water (liquid and Industrial effluents, appendix 1). The pH in the present study ranged from 7.01 to 8.58 (Table 5.1.) the minimum pH values was of sample No. S39, (Table 5.1) and the maximum pH value were found in the paper mill effluent drain. The reason for highest pH values 8.58 might be industrial discharges of "Hayatabad Industrial Estate" (HIE).

5.1.4 Conductivity

Conductivity bases on the type and quantity of ionic material dissolved in water. Ions dissolved in the water are responsible of for the electrical conductance, which can be easily determined by a conductivity meter. Conductivity is a non-specific parameter used to establish pollution zone. Measuring electrical conductivity is the easiest way for calculating the strength of dissolved electrolytes in water. In other words, in this way it is easy to know about the dissolved substances present in water. The safe range defined by USPH is 300 $\mu\text{S}/\text{cm}$ (Kumar, 1989). Very high conductivity values were observed in most of industrial and sewage drain samples (Tables 5.1 to 5.4.) Conductivity value in all the samples investigated showed a range from 320 to 1370 $\mu\text{S}/\text{cm}$. during low flow (Table 5.1 and 5.3.) The maximum conductivity value was found in sample No S12 (Table 5.3). Since in most of the samples conductivity values were exceeded the safe limits. The industries observed to be responsible for these highest values were Gulab Banaspati, Paper and Board, Marble and Match factories in HIE.

5.1.5 Turbidity

Turbidity of water is used for light penetration in the water. The light penetration in water is usually affected by either scattering or absorbing the suspended materials, which mainly includes organic compounds, clay, and silt and micro organisms. Measuring turbidity has two functions: 1) it helps in knowing the general quality and the extent of treatment to be required in the treatment plant; 2) it gives an idea of the unsolved substances. According to WHO guidelines the maximum turbidity level for water quality is 5 NTU. According to the Pakistan Standard Institution standards for drinking water, turbidity ranges between 5 to 25 (Appendix 1). In present study it was found that turbidity value in the entire sample was very high (Tables 5.1 to 5.4.). In most of the samples including industrial, sewage, drain and receiving water bodies, the turbidity values exceeded the permissible limits. The highest value was found to be 226.5 NTU (Table 5.2) of sub drain D3 of HIE. The reason for such high turbidity was the industrial discharges of paper mill, match, ghee and pharmaceutical industries.

5.1.6 Total Suspended Solids (TSS)

One of the very important parameters included in the present study used for pollution strength assessment of waste water was suspended solids concentration. The suspended solids tend to settled to the bottom or wash up on the bank and decomposed causing odors and depletion of oxygen. The greater are Total Suspended Solids in water, the higher its turbidity and the lower its transparency (clarity). The NEQS value for TSS is 150 mg/L and that of WHO standards for suspended solids is 5 mg/L (Appendix1). The TSS range observed was 300 to 960 mg/L (Table 5.1 to 5.4) in all the sample sites. Most of the industrial effluents, sewage drain and receiving water bodies investigated showed very high TSS concentration (Table 5.2) which was; mainly due to effluents of marble, match, and paper discharges being released untreated in the main effluent drain of HIE. One of the other reasons was the addition of other sewage drains in Canal Town and on Charsada road near Budni Bridge entering into the main effluent drain, further increasing the TSS load of the drain and the receiving water bodies.

5.1.7 Total dissolved Solids

Pollution strength in water is caused by dissolved solids. Inorganic salts with small concentration of organic matter in dissolved material constitute Total Dissolved Solids (TDS). TDS are comprised of carbonates, bi-carbonates, chlorides, sulfate, nitrates, sodium, potassium, calcium and magnesium. Dissolved solids may reduce the penetration of light in water thus reducing photosynthesis. According to WHO and USPH, the maximum permissible limit of TDS is 1000 mg/L and 500 mg/L respectively; and that of Pak NEQS is 3500 mg/L for municipal and industrial effluents (Appendix 1).

The TDS content was found in range of 300 to 2860 mg/L (Table 5.1). TDS values remained within the permissible limits of NEQS (table 5.1 to 5.4). Some of the industrial effluents showed exceeding values of TDS than (WHO) permissible limits (Table 5.2 & 5.3). This was mainly found in industrial effluent of marble, paper and board and ghee mill industries. Many of the industrial effluents (Table 5.1 and 5.4) were found to have TDS values exceeding the USPH standards. The industries observed to be responsible for these higher values were Mohsin Match, Pharmaceutical and Marble industries.

5.2 Chemical Characteristics

5.2.1 Alkalinity

Alkalinity of water can be described as the quality to neutralize acids. It usually reflects the strength and type of ions that react with hydrogen ions.

The most common constituents of alkalinity are carbonates, bi-carbonates and hydroxide ion. In large quantities, alkalinity causes a bitter taste in water (Peavey, et al. 1985).

Alkalinity is an important parameter as it measures the ability of water to resist acidification, for instance, to acid rain. Alkalinity in water is related to pH, Hardness, Calcium, Magnesium, Sodium, Potassium, Sulfate and TDS parameters usually are examined in water analysis. For use as potable water, alkalinity is not a significant parameter. When alkalinity is greater than hardness, basic salts such as sodium, potassium etc., may be present in addition to calcium and magnesium salts. If alkalinity is less than hardness the presence of calcium and magnesium salts are more likely to be sulfates instead of carbonates. The annoying feature of the alkaline water is due to the reaction of alkalinity with cations present in the water. This reaction causes a precipitation, which damaged pipes and other water system appliances. The IS: 10500-1991 Standard for Alkalinity is 200-600 mg/L, while US-EPA standard for Alkalinity is 500 mg/L (Bilal and Asim 2006). Alkalinity of water is its acid neutralizing capacity. The measured value may vary significantly with the end point pH use.

Primarily alkalinity is a function of carbonate, bi-carbonate and hydroxide content. The measured value may also include contribution from borate, phosphate, silicate, and other bases if present.

Acid neutralizing capacity is termed as water alkalinity. Its value significantly changes with the pH. Usually carbonates, bi-carbonates, hydroxide, borate, silicates, phosphates, and other bases may also affect the value of water alkalinity. Measuring alkalinity of water is usually done for the treatments of water. The allowable water supply has usually alkalinity not in the pattern of raw water, (GOP, 2005). Alkalinity range in the present study was from 84 to 395 mg/L (Table 5.7). The highest value was found in the effluent discharge by Olympia Paper Mill of HIE, Peshawar sample no. S8 (Table No. 5.7). The reason of high alkalinity value was the presence or release of strongly alkaline industrial waste.

5.2.2 Dissolved Oxygen

Dissolved oxygen is significant parameters in water quality, pollution control and several treatment processes. Biological decomposition of organic matter utilizes dissolved oxygen DO concentrations significantly below saturation values often occur in polluted waters. Since fishes and most of aquatic life deplete due to dissolved oxygen, therefore, dissolved oxygen determination is a principal measurement of polluted water in pollution survey. At least 4 mg/L of DO is required for fish; even some aquatic species may require more (Peavy, et al. 1985). Oxygen in water bodies may be depleted by bacterial oxidation of suspended and dissolved organic matter. The organic matter is discharged into water bodies from both natural and human activities. The DO level in water and waste water depends upon the physical, chemical and biological activities taking place in the aquatic environment. DO determine whether or not biological changes are brought about by aerobic or an-aerobic micro organisms. According to USPH, the standard of water quality (domestic water supply) for dissolved oxygen is 4.0 to 6.0 mg/L (Kumar, 1989). In the present study all industrial effluents investigated showed zero or nil DO Sample No. S1 to S14, (Table 5.5 to 5.8).

The sewage drain sample sites were also deficient in DO contents. Most of the sewage drains and nullah having less DO content when joint with main drain had changed to negligible DO concentration. Industrial effluents and sewage waste water discharges are the major causes of low DO throughout the entire stretch of the main effluent drain. The main drain lacking DO when enter in the receiving water body (Shalam River) it also adversely affects in lowering the DO level of the receiving water body as can be seen in sample No. S 35. (Table 5.6) The DO level of Shalam River before mixing with effluent drain was 5 mg/L but at the confluence point after mixing with the effluent drain sample No. 36, the DO level dropped to 3.5 mg/L (Table 5.6.) Thus the industrial effluent has direct impact on the water quality of the receiving water body (Shalam River) and ultimately on Kabul River system. As these industrial effluents of HIE along with other sewage drain of Peshawar through the open main effluent drain being entering untreated in the receiving water body (Shalam River) at Naqoba village, whose downstream becomes part of Kabul River. Thus Kabul River was adversely affected receiving pollution load caused by "Hayatabad Industrial Estate" (HIE) effluent getting through Shalam River appears. In low season Shalam River appear as nullah itself with low DO level 3.0 mg/L sample No. 35 (Table 5.7).

5.2.3 Biological Oxygen Demand (BOD)

Dissolve oxygen content (amount) consume during the microbial neutralization of organic matter is called BOD. BOD of water is equivalent to the amount of organic matter which consumed oxygen present in water during its stabilization by micro organism. The BOD is one of the most important parameter to determine the strength and amount of organic matter. DO is used by micro organism to decompose the organic matter. BOD in general provides a quantitative index of organic matter which is easily bio-degradable in short period of time. It has been used as an index of organic pollution in water (Gautam, 1990). BOD is a very valuable test in the analysis of sewage, polluted water and industrial effluents for assessing organic pollution. It is considered as the major characteristics used in stream pollution control. BOD provides information regarding the purification capacity of stream and serves as a guideline for the regulatory authority to check the effluent quality, discharge into water bodies (Dara, 2004). Biological Oxygen Demand normally represents the presence of biodegradable materials in water. Biodegradable material consists of organics that can be utilized for food by naturally occurring microorganisms within reasonable length of time. In dissolved form, these materials usually consist of starches, fats, proteins, alcohols, acids and esters. They may be the end products of the initial microbial decomposition of plants and animal tissue, or they may be the result of domestic or industrial waste water discharges. Some of these matters can cause color, taste or odor problems. This parameter is highly important for designing waste water treatment plant facilities and is also help in checking the efficiency of treatments plants for treating the sewage and industrial effluents, US EPA fixed 5 mg/L of BOD₅ as standard for safe drinking water.

The BOD standard for municipal and liquid industrial effluent of Pakistan (NEQS) is 80 mg/L. The result of BOD at different sampling locations in HIE varied from 85 to 395 mg/L, sample No. S19 and Sample No. S8, respectively (Table 5.7), where as the BOD of sewage drains ranged 140 to 330 mg/L sample NO.S21 to sample No S29. BOD value of 140 mg/L was found in Budni Nullah, Sample S.29 and 330 mg/L was found in the main industrial drain at the confluence point of three sub-drains (D1, D2 and D3) at Hayatabad near Rehman Medical Institute, sample No S21 (Table 5.5). The highest concentration 400 mg/L at sampling site sample No S8 i.e. effluent of Olympia Paper and Board Mill of HIE (Table 5.6.) that was due to highest concentration of industrial waste waster being discharge untreated in the effluent drain.

This high concentration of BOD released by industrial effluent caused deterioration in the down stream receiving water body. The main effluent drain down ward receive other drain of Hayatabad near Board Bridge and sewage drain of Peshawar city on Charsada road near Budni Bridge, which further contribute BOD load along the entire stretch of the drain. Both industrial effluents and sewage drain are merging in the main effluent drain downstream caused pollution in the receiving water body.

5.2.4 Chemical Oxygen Demand (COD)

COD is a measure of the amount of dissolve oxygen required for the oxidation of organic matter chemically. COD is an important parameter allowing a quick measure of the pollution load of a stream, sewage and industrial waste water samples. COD test shows that waste water measurement in terms of total amount of dissolved oxygen required for oxidation to carbon dioxide and water (GOP, 2001). COD tells us about the oxygen used in the oxidation of all present organic matter chemically. COD usually happened to be greater from BOD values in the same nature of water samples. There exists a certain correlation between COD and BOD of a waste water/effluent. By taking repeated observation this correlation can easily be established. Thus COD values can replaced by BOD and thus indicate with fair accuracy of pollution strength of the waste water. COD test require only two hours for completion where as BOD determination requires 5 days for determination. Hence significant time is saved if COD test, is conducted instead of BOD. The ratio between COD and BOD of waste water also indicates its biological treatability. A waste with BOD: COD ratio of 0.6:1 or more is considered biological treatable (Anon, 1983).

The COD standard of Pak. NEQS for municipal and industrial effluent is 150 mg/L while according to USPH standard the maximum limit of COD in drinking water is 4.0 mg/L . Pakistan Standard Institution also drafted standard of drinking water quality for COD the maximum acceptable concentration of 10 mg/L (Appendix 1). Industrial effluents checked so far revealed the COD values. These are ranging from 400 mg/L to 1200 mg/L from sample S1 to sample No S20 (table 5.5). In sewage drain and nullah samples the COD concentration was also high which ranged from 260 mg/L to 1700 mg/L sample No S34 and sample No S21 (Table 5.6). The highest concentration of COD investigated was found 2000 mg/L in the main HIE effluent drain sample No.S21 (Table 5.5). The reason for this high value of COD is that, here at this location all the three sub-drains (branches) of industrial effluent combined and form one main drain which receives all types of untreated effluents discharged by HIE.

These untreated industrial effluents were responsible for polluting downstream receiving water bodies.

5.2.5 Nitrate

Aerobic decomposition of organic matter in water caused oxidation of nitrogen into nitrate. Its major sources in water are agriculture runoff (Fertilizers), drainage from dairy farms, domestic and industrial effluents. Besides, decayed vegetable and animal matter, sewage, leachate from landfills refused, atmospheric wash out and industrial discharges contribute nitrates in waste waters. Excessive quantities (Amounts) above the safe permissible limits in water are harmful, especially to children.

At higher concentration nitrate reduce the oxygen carrying capacity of blood and they may cause a disease called Methaemoglobinaemia (GOP, 2005).

Nitrate is important for plants, animals and human, but its excessive presence in drinking water is injurious to health. Infants and pregnant women are at risk when it present in water above the permissible limit. Nitrate is present or release from all sorts of emissions. Animal waste, fertilizers, natural deposits, septic tanks and sewage waste waters are other sources of nitrates in drinking water. So if these sources are in contact with water supply system by some means, the drinking water will most likely be contaminated with nitrates.

According to WHO the permissible limit for nitrate is 45 mg/L. When it is present in excess it causes eutrophication i.e. abnormal growth of Algae, often present in blooms.

Nitrate above 10 ppm badly impact the oxygen carrying capacity of the red blood cells and result in blue baby disease. Therefore it is considered as potential threat to the children between 6 months to one year. It is also a major threat to adults. Nitrate concentrations in the tested samples are given in (Table 5.5).

While its concentration from Sample No. S21 to Sample No. S32 was found in range of 4.4 to 29.1 mg/L (Table 5.5). The highest value of nitrate was found 30 mg/L in sample No. S29 (Table 5.7) In all the investigated samples of this study nitrate values were found within the permissible limits (Appendix 1), but some sampling sites like sewage drain and Budni nullah showed slight increase in nitrate contents. The reason may be agriculture run off and domestic sewage being discharged in the downstream area. This slight increase in nitrate contents associated with agricultural activities and domestic sewage along with decomposition of organic matter. The chances of conversion from Nitrate to Nitrite may

occur. As Nitrite is more harmful than Nitrate, therefore, there is a need to check and regulate agricultural activities in the context of fertilizer usage along with curative and preventive measures for domestic sewage.

5.2.6 Sulfate

Sulfate is abundantly present in the lithosphere and it may occur in water due to weathering of gypsum, sodium sulfate and shale. Mine drainages and pyrite oxidation also cause high concentration of sulfate. Organic compounds and industrial effluents are other contributors of sulphate in water. WHO has defined two types of standards: desirable level and permissible level. The desirable level is 200 mg/L and permissible level is 400 mg/L (GOP, 2005). The oxidation of sulfides to sulfate under anaerobic conditions can contribute to high sulfate content of waste water.

Sulfates occur naturally in the groundwater because the water dissolves them out of rocks. Natural levels can be increased by the decay of plants and animals, contamination from mines, mills, landfills, sewage and other artificial sources. Wastes seepage through the soil having sulfates cause contamination of ground water. Dehydration can be a serious result of diarrhea following ingestion of large amounts high concentrations of sulfate. Consuming drinks having more than 500 ppm sulfates caused following symptoms are responsible for diarrhea and stomach acidity.

Sulfate itself is not a great problem but during anaerobic condition it is converted into sulfide which is toxic to aquatic life. Waste discharges into the water bodies add sulphate in its concentration. Among these, households wastes (mainly detergents) and industrial effluents mainly tanneries, steel mill and textile mills are the important ones. Ordinary conventional procedures are not helpful in removing sulphate from water. Below 500 mg/L no apparent negative impact has been observed. However above 1000 mg/, it cause some physiological effect (diarrhoea), (GOP, 2004). Pak NEQS for municipal and industrial effluent for sulfate is 600 mg/L (Appendix 1). Compared with NEQS standards all the investigated samples were found within the permissible limits (Table 5.5 to 5.8). But results in some location were found slightly high like in sample No. S1 sulfate value was observed 430 mg/L (Table 5.5) Likewise in sample No. S5 (Table 5.7) sulfate concentration was found 440 mg/L; which was the highest values of all results. The rest of the results were also varied (Table 5.5 to 5.8). The higher value of sulfate was found in the effluents of marble and match factories. These industries may contribute in increasing the concentration of sulfate contents in HIE effluent

drain. However sulfate content in most of the industrial effluents sewage drains and receiving water bodies in different season (winter and summer) remained within the safe limit of 600 mg/L.

5.2.7 Chloride

Chloride is widely available in the form of salts of sodium, potassium and calcium. Industrial effluents, oil-wells, domestic sewage and agriculture runoff are the major sources of chloride presence in water bodies. Content in drinking water is often associated with high total dissolved solids content.

Chloride itself is not harmful but at concentration, when it is associated with sodium in drinking water, it is a major concern for people suffering from heart and kidney diseases. It is medically reported that taking more than 4000 mg/L of chloride ion is harmful for heart and kidney disease patients (GOP 2004).

Drinking water with chloride may impart a salty taste at concentrations as low as 100 mg/L, however, the limit of 250 mg/L is considered as taste threshold for the average individual.

Chloride is the most prominent inorganic anion water. Its taste in drinking water is based on its associate with other elements. For example water having 250 mg/L chloride is considered of salty taste if it is attached with the sodium. And when it is attached with calcium and magnesium, the salty taste may be absent even up to the concentration of 1000 mg/L. Waste water contain high chloride than raw water. Industrial effluents are one of the sources of chloride in the water bodies. Negative impacts of high concentration of chloride include harming metallic pipes, structures and plants, (GOP 2005). Chloride in excess may cause health problems and if the water remains in a place for longer time (stagnant) in cretin place it may cause localized salinity. The Pakistan NEQS for chloride is 1000 mg/L for municipal and industrial effluents. Chloride was found within the permissible limits by comparing with national and international standard (Appendix 1). Analytical findings of industrial effluents, sewage drains and water bodies varied that were within the range of 20-400 mg/L, (Table. 5.5). A slight increase occurred in Chloride contents varied from 390 to 410 mg/L in sampling site (S12), mentioned in (Table 5.5 to 5.7). Such results were associated with the industrial effluent/waste water being discharged untreated directly into the effluent drain of "Hayatabad Industrial Estate".

5.3 Heavy Metals

5.3.1 Chromium (Cr)

Natural water has usually friction or very small quantity of chromium. Mining and industrial are usually the contributing agents of Cr in water. Besides, other sources of chromium include waste water from chrome plating operations, lather, tanning and fossil fuel combustion. Presence of reducible organics affects the valance state of chromium. Chromium especially in hexavalent state is highly toxic to man, as it produces lungs tumor when inhaled. It also induces skin sensitization (Anon, 1983).

For drinking water, WHO recommends 0.05 mg/L. Pakistan NEQS for chromium (Cr) is 1.0 mg/L for the municipal and industrial waste effluents (Appendix 1).

In most of the investigated samples of the present study, the Cr concentration was found higher (Table 5.9 to 5.12), than the permissible limit prescribed by national and international standards (Appendix 1). The Cr contents varied in the analyzed samples ranging from 0.645 mg/L to 1.632 mg/L (Table 5.9). Similarly it is within the range of 0.243 – 1.101 mg/L, (Table 5.10). A .maximum value of Cr was found as 1.787 mg/L in sample No S5 (in the effluent discharged by Khyber Match Factory Table 5.11). The higher concentrations of (Cr) were mostly observed in the effluent of Khyber and Mohsin Match factory (1.787 mg/L and 1.654mg/L respectively) as can be seen in sample no. S5 and sample No S1 in the (Table 5.11.) These higher concentrations of Cr were found in the industrial effluents in general and the effluents of match factories in particular were probably due to use of glass powder as raw material during the synthesis of which, Cr_2O_3 was used as coloring agent.

5.3.2 Copper (Cu)

Copper is an essential dietary trace element. It is supposed to be present in all body cells, being particularly concentrated in the liver, which is the main Cu storage site of the body. Copper is widely distributed in food. Under normal conditions the diet of farm animals is likely to contain adequate amount of Cu. Seeds and their bi- products are usually rich in Cu (Donald et al. 1981). The most important Cu ors are sulfides, oxides and Carbonates. Since copper performs many functions in the animal's body, there are a variety of Cu deficiency symptoms. These include anemia, poor growth, bone disorder, infertility and discoloration of hair and wool (Donald et al. 1981). Copper salts given in access to animals are toxic. Continuous ingestion of Cu in access of nutritional requirement leads to its accumulation in

the body tissue, especially in the liver. Besides, addition of copper salts to aquatic environment results in serious ecological changes. Copper in excess of 1 mg/L may impart certain taste to water (Donald, et al. 1981). Copper is commonly found in drinking water. The principal source of Cu contamination of water supply is corrosion of brass and copper pipes. Some industrial effluents also contain copper contamination. In all the samples analyzed Cu concentration was found in a range of 0.001 mg/L to 0.373 mg/L (Table 5.9 to 5.12); which were well below the permissible limits of national and international water quality standards specified for copper (Appendix 1). Since most of industrial effluents, sewage drains and the receiving water bodies have negligible or very less copper contents therefore, copper, effluent drains has no effects on the receiving water bodies and were found in safe range. The water can even be used for irrigation if only Copper is considered.

5.3.3 Iron (Fe)

Iron usually exists in ferric state and is the key dietary constituent of human being. Being widely available in the lithosphere, it is available in minor quantities in the water. However its presence in the water systems is due to rocks weathering, acid mines and industries. In water it is precipitated as ferric hydroxide, which is insoluble. Presence of more iron in water adds unpleasant and inedible taste and an orange color. Thus the coloration and taste make the water unfit for domestic use. World Health Organization (WHO) suggests 0.3 ppm as standard for drinking water. While (NEQS) for Iron of municipal and industrial effluents is 2.0mg/L. In most of the industrial effluent samples analyzed iron concentration was high than the permissible limits sample No.S6, 8, 10 & S12 (Table 5.9). The receiving water body and sewage drain had comparatively low value of iron ranging from 0.001 to 0.942 mg/L in sample No S39 and sample No S23 respectively (Table 5.10). The highest values found as 6.288, 5.413 and 5.145 mg/L respectively in the samples, (Table No. 5.9, 5.10, 5.11 and 5.12). These highest values were found in the industrial effluents of Gulab Banaspati (Ghee mill), Olympia Paper and Board Mill and effluent drain of Pepsi Cola and Bryon Pharmaceutical factories. These high concentrations might be contributed/ imparted either by the (Fe) pigment polished on machinery or (Fe) alloys present in the raw material.

5.3.4 Nickel (Ni)

Nickel is a silver-white, metallic element. It plays an important role in nucleic acid metabolism. It is thought to be non-toxic and non-nutritive. Ni may result as leachate from the Ni bearing ores as nickel salts. Nickel is poorly absorbed in the digestive track and does not normally cause a serious health hazard. The toxicity of Ni to aquatic life as reported by (McKee and Wolf, 1963.) indicated that tolerance varies in various living species According to (Vanselow, A.P. 1966). Ni has adverse impacts on plants. He practically demonstrated that 0.5 to 1 mg/L is harmful to number of plants. Exhibiting less susceptibility to Ni, Plant were oats with toxic effect at 2.5 mg/L and tobacco with no toxic affect at 3.0 mg/L (Saone and Saunders, 1959). The NEQS standard for Ni present in municipal and industrial effluents is 1.0 mg/L while that of WHO specified 0.02 mg/L Ni for drinking water quality. Nearly all of the effluents samples from sewage drain and even receiving water bodies were found to have higher Ni, concentration (Table 5.9 to 5.12) than the permissible limit as specified by WHO (Appendix 1) and ranged from 0.032 to 1.745 mg/L in sample No. S37 (Table 5.10) and sample No S12 (Table 5.11.) respectively. Some of the samples investigated showed Ni contents below the permissible limit of Pakistan NEQS for Ni specified for Municipal and Industrial Effluents; (Table 5.9 to 5.12) except sample No.S12 (Table 5.11) which showed the higher concentration of Ni than NEQS in all the analyzed samples. Such higher Ni concentration was found in the effluent of Gulab Banaspati (Ghee Mill) where (Ni) was used as catalyst during hydrogenation of oil. It showed that the nickel contents are added in the effluent drain of HIE due to the discharge of waste water of ghee mill.

5.3.5 Lead (Pb)

Lead is naturally found in all environmental media in small concentrations. Lead (Pb) is transferred from the atmosphere to soil water and vegetation through dry and wet deposition. Industries, mines, smelter discharges, dissolution of old lead and vehicular emissions are the major sources of (Pb) concentration in the water. Atmospheric deposits are the largest source of (Pb) present in surface water (GOP 2001). Leaded gasoline, industries making batteries, paints and lead pipes are also the sources of (Pb) in the environment, especially water. Lead has no desirable nutritional effects and is toxic metal that tends to accumulate in the tissues of man and other animals. Negative impacts of Lead (Pb) include central nervous system in children, distortedness in fertility, liver and kidney failure, loss of appetite, renal impairment and mental retardation, (GOP, 2004). Lead (Pb) also enters the aquatic environment through precipitation, lead dust fall out, erosion and leaching of soil, municipal and industrial waste

discharge. World Health Organization (WHO) has suggested 0.01 mg/L for drinking water, while PCRWR and PSI prescribed the limit of 0.05 mg/L for drinking water. The NEQS specified 0.5 mg/L of lead for municipal and industrial effluents. Lead concentration in most of the samples investigated varied in range of 0.724 to 1.438 mg/L (Table 5.9) which was well the prescribed permissible limit of NEQS (Appendix 1). Likewise, nearly in all samples the value of lead was exceeding the maximum limit (Table 5.9 to 5.12). The highest value of lead 1.921 mg/L was found in sample No. S21 (Table 5.11.) in the main effluent drain near Rehman Medical Institute Hayatabad, Peshawar, where the three sub effluent drain D1, D2, and D3 of HIE combined and fell in the main drain. The 2nd highest value of lead content 1.438 mg/L in all the investigated samples was observed in sample No S9 table 5.9 in the effluent drain of Sarhad Board and Chemical Industry. These industrial effluents are discharged untreated in the main effluent drain due to which the entire stretch of the main drain up to the receiving water body had high lead content. Hence, the receiving water body, Shah Alam River ultimately joins with Kabul River, which is adversely affected by the pollution load of industrial effluent of "Hayatabad Industrial Estate".

5.4 Possible Pollution Control and Preventive Measures

The term low waste-no-waste, clean technology and Clean Processing (CP) have emerged in recent past for pollution prevention. Some preventive measures at the end of pipe were also mentioned in the recent past for the pollution control. There may be two types of approaches for pollution control, prevention and clean processing. One is Site Specific Analysis (SSA) in which the pollution produced from the raw material stage, processes and up to getting of the final products. Still the another approach is Life Time Analysis (LTA) which starts from the input or raw material up to life time of a product usages and its impacts on the environment later on. Usually Site Specific Analysis (SSA) is suggested at the initial stage for pollution prevention. It includes the minimization or reduction of the pollution at the input or raw material stage like use of sulfur free coal i.e. pre-process removal of the pollution causing agents, then at the processing stage and finally at the out put stage in the form of product and by-product. Examples of pre-process are "use of lead free gasoline and sulfur free coal". During the process of marble cutting and polishing dust is emitted, that could be controlled by shower of water. Thus dust could be controlled but water usage may be increased. The same water could be stored/ stopped in a septic or sedimentation tank and could be re-used. The example of post processing is that when CaCO_3 in marble factory after cutting remained in the insoluble form, settled down in the sedimentation tank. That calcium carbonate could be utilized for the manufacturing of insulation bricks, vim powder, and cement provided that these alternatives might be feasible quality wise and economically. The waste or by-products could be recovered, recycled or reused further in the process as raw material for further minimization/reduction of waste and protect the environment from its adverse effects. Such kind of approaches leads us toward clean processing or clean technology.

This study was an attempt to examine the extent/magnitude of pollution load caused by waste water of "Hayatabad Industrial Estate" and its impacts on the receiving water bodies through Shalam River on Kabul River. The beneficial uses of Kabul River include fresh water fisheries, agriculture, irrigation, live stock, and Khashki reservoir supplied by water from Kabul River is used for recreational and boating purposes.

All the beneficial uses of Kabul River are potentially threatened through industrial waste discharges. The effluent/waste water from HIE are being discharged untreated in the seasonal streams (Gandow Khawar) getting the shape of effluent drain. This drain downward receives other sewage drain at Canal Town from Hayatabad, Charsada road near Nishat Mill from Peshawar city and marble effluent drain at Pir Bala village. Besides this main effluent drain it

combines with Budni nullah down-stream, and then it joins with Shah Alam River at Nakoba village (Daman Hindki) which ultimately joins Kabul River. The adverse impact of the industrial effluent of HIE in the form of pollution load had observed in the present study.

Therefore, it is high time now to prevent and control the wastewater pollution caused by industries in HIE. In this direction various strategies and initiative can be taken for the abatement of waste water pollution of HIE. Industries can control their pollution through following manifold steps. However it is more good keep control pollution at source. Never the less, equalization (neutralization, sedimentation) of different waste component may be beneficial to reduce treatment cost in some cases. To keep control of waste water pollution, it is essential to reduce the quantity and strength of waste water produced by the industrial units. Keeping this control can only be possible through treating and reuse of waste water produced. It is an established fact that being little careful many industries can conserve water in their normal manufacturing process.

In the study area, water in the industries is mainly used for cooling. Such as Formica industry, marble industry, AGE Cable Industry and Ghee industry. These industries could reuse their used water to reduce water consumption. The strength of wastes can be reducing through bringing changes in processes, machinery, neutralization and recovery of by product, (Anon., 1983). Sedimentation, filtration, by-product recovery, removal of bi-mass, trapping of nutrients, aeration, recycling and re-utilization of waste products may also assessed in the abatement of waste water pollution. The industries should incorporate certain fundamental concepts like recovery of materials as part of manufacturing process and training of industrial personnel towards consequences of industrial pollution and to teach the ways which are most appropriate to control the pollution. Pollution prevention can generally be categorized (ETPI, 2000) in the following major groups namely, water conservation, reduction/ minimization of pollutants load, saving of energy and prevention of pollution.

Water Conservation

Changes in process include shifting from batch process to continuous processes to reduce cleaning frequency through automatic cleaning-in-practice system. It controls and optimizes water usage; flow of water for manual cleaning can be controlled by putting fixtures in place; for cleaning surfaces high pressure is preferred than high volume of water; reuse of a little bit clean waste water for other cleaning steps; calculation of water used in non-critical steps; installation of meters for checking water consumption; before cleaning, the floors and

equipments should be soaked in order to lose the dirt; compressed air should be preferred instead of water if it is workable; reporting and correcting the leakages immediately.

Reduction/Minimization of pollutant load

- 1 To remove the product residues before cleaning, it needs to be ensured that through using pigs and plugs, the pipes drained completely. Pigs and plugs are devices to stop wastage of products and could retain the product's residues.
- 2 Controlling spills from vessels and tankers can be avoided by installing automatic shut-off and level control.
- 3 Solid substances and material used as stock feed should be collected.
- 4 Entrance of solid material into the drains should be stopped through fixing screens at the drains to avoid the blockage.
- 5 To minimize loses of both product and water sensors should be installed for differentiating between water and product. It will help in reducing the wastage of both.
- 6 For avoiding overfilling from the tanks, it should be done through installing and maintaining the automatic shut-offs.
- 7 Where it is possible, dry cleaning methods such as cleaning with air gun before cleaning should be adopted.

Saving of Energy

1. Encourage installing of automatic and sensors programs for automatic turn off the equipment when not in use.
2. Insulation on cooling/heating systems and pipe work should be properly ensured Preference should be given to energy efficient equipment. Optimizing equipment energy efficiency could be achieved through adopting proper maintenance. Because improved level of maintenance of devices and equipments can help in energy conservation. For steam and water boilers optimal combustion should be kept; strictly control and repaired properly and immediately the leakages; in operation low grade energy should be used.

The aforementioned are some of the steps through which energy could be saved.

Prevention of Pollution

Pollution prevention and end of pipe treatment can be possibly summarized, prioritize as below.

1. Recycle process solutions and chemicals
2. Re-use waste for secondary uses
3. Recovery for sale or exchange
4. Reduction through waste concentration
5. Waste segregation
6. Increase purity of raw materials
7. End of pipe treatment
8. Land disposal

Such efforts may be extremely helpful in the future planning of the industries in solving specific environmental problems.

5.5 Institutional Role in Pollution Abatement

To make a successful abatement program there is a great need of collaboration, coordination and information sharing system among various research, academic, scientific and regulatory institutions. These institutions include Pakistan Council for Scientific and Industrial Research (PCSIR), Public Sector Universities, Mineral Testing Laboratories (MTL), Public Health Engineering Department, Industry Department, and Federal and Provincial Environmental Protection Agencies (EPAs). The above mentioned institutions can collaborate for the control industrial discharges and can work on various aspects of pollution abatement. For example Agriculture University can access pesticides and work on all those aspect which have direct or indirect relation to agriculture sector including crops, soil, and water quality for irrigation. Similarly Peshawar University; environmental science department and faculty of sciences, may work on pollution status and other environmental problem associated with industrial waste water pollution. Likewise, public health engineering department and industry department can effectively work in their own areas of specialization. MTL and PCSIR may effectively contribute their expertise in analytical and research work for abatement of pollution. The industry department/Industries and EPA must have a record regarding the specific pollution problems faced by a particular industry. Besides, self

monitoring, there must be a comprehensive monitoring and checking mechanism involving high level professional experts to assess the existing situation and to impart training to the personnel involved for the prevention of pollution at the source.

Another responsibility on part of these institutions to introduce a system of data collection and information exchange on the matters of environmental protection and to indicate the performance of control measures adopted by various industries. Information exchange and data collection may be carried out by regulatory agency like Environmental Protection Agency (EPA). Research institutions can act as the technical information centers to help the industries in pollution control and environmental protection problems.

These research institutions should also look into the possibilities for establishing indigenous measures for the abatement of water pollution. There are many research areas which require proper attention with regard to environmental pollution control. For the smooth conduction of such research based programs, these institutions must have sufficient fund at their disposal.

It is also expected from these research institutions having qualified and technically experienced staff to offer such consultancies and advise industries for the installation of proper pollution control equipments. Thus, these institutions can play an effective role in pollution prevention/reduction associated with industrial effluents.

To conclude, the discussion on the pollution control strategy, collective efforts should be put forth by relevant organizations, people, and government, industry and research organizations. The pollution abatement may be achieved for ecological balance and better living environment.

5.6 References

- Anon. (1983). "Industrial Waste Pollution Report Pakistan". Associated Consulting Engineers (ACE) Ltd (Environment Division,) Published by Govt. of Pakistan, Environment and Urban Affair Division, Ministry of Housing and work Islamabad. Pp 2-6 to 2-9 and 4-20 to 4.21.
- Bilal, A.S. and Asim, M., (2006). "Analysis of Drinking Water Quality of Hayatabad Peshawar". M.Sc. unpublished Thesis, Department of Environmental Sciences, pp-116.
- Dara, S.S. (2004). "A text book of Environmental Chemistry for Pollution Control". 7th edition S. chant and Co. Ltd. Ram Nagar, New Delhi 110055. Pp 65-69 and 71-72.
- Donald, Mc., Edward, R.A., and Greenhalgh, J.F.D. (1981). "Animal Nutrition". Longman London. Pp-66-67, 74-75, 86-87.
- ETPI (2000). "Environmental Report of Diary Sector". Environmental Technology Program for Industry: (A joint project of Federation of Pak. Chamber of Commerce and Industry FPCCI and Govt. of the Netherland), Federation House, Main Clifton, Karachi Pakistan.
- Gautam, A. (1990). "Ecology and Pollution of Mountain Waters", Asheesh Publishing House, New Delhi. pp 33-34.
- GOP. (2001). "Investigation of Air and water quality (Rawalpindi and Islamabad)". JICA and PAK-EPA, Islamabad, pp-96, 99.
- GOP. (2004). "Water Quality Status in Pakistan. 2nd Report Pakistan Council of Research in Water Resources (PCRWR)". Ministry of Science and Technology Islamabad. Pp- 62, 67, 72-73.
- GOP. (2005). "Water Quality Status. 3rd Report Pakistan Council of Research in Water Resources (PCRWR)". Ministry of Science and Technology Islamabad. Pp-43, 49, 50, 54, 55.
- Kumar, A. D. (1989). "Environmental Chemistry" Delhi: Wiley Eastern Ltd, pp-157-159.
- McKee, J.E. and Wolf, H.W., (1963). "Water Quality Criteria". California state water resources control board, publication No. 3-A, pp-163.
- Nathanson, J.A. (2004). "Basic Environmental Technology water supply waste management and pollution control". 4th edition A Soke K, Printice- Hall of India Pvt. Ltd, M 97 Connaught Circus, New Delhi-110001 pp. 58-59, 123- 125.

- Peavy, H, Rowe, D. and Tchobanoglous G., (1985.) "Environmental Engineering. McGraw Hill Book Co; Singapore" pp 11-14, 18-20, 83.
- Saone, B.K and Saunders, D.H. (1959). "Nickel and Chromium Toxicity of Serpentine Soil in Ruothern Rhodesia. Soil Sciences, 88:322.
- Vanselow, A.P., (1966). "Diagnostic criteria for plants and soils". University of California Division of Agro-sci. Berkley, California, pp-142-156.

Chapter 6

Conclusions and

Recommendations

Chapter 6

Conclusions and Recommendations

CHAPTER-6

Conclusions and Recommendations

6.1 Conclusion

To evaluate the extent and magnitude of pollutants in the industrial waste water of "Hayatabad Industrial Estate" (HIE) Peshawar, effluent of individual industries, cluster industries (combine effluent drain) and main effluent drain along with other sewage drains at selected locations were analyzed for various physico-chemical and heavy metals parameters.

Among the physical parameters, temperature ranged from 17.1°C to 38.2°C and pH values ranged from 7.10 to 8.58 and were within the permissible limits of 40°C and 6.00 to 10.00 respectively.

Suspended Solids and Turbidity were the major/common pollutants contributed by the Industrial Estate of Hayatabad Peshawar. The values of all the analyzed samples exceeded the permissible limit of national and international standards. The results of the investigation of the effluent samples of the industries indicated that most of the industries were the source of pollution in the context of suspended solids and turbidity.

Conductivity was higher in all the samples analyzed except one sampling point of receiving water body. Due to high amount of solids the water had high electric conductivity values. However, the level of dissolved solids were observed in safe range due to high permissible limit of 3500 mg/L for municipal and industrial effluents specified by National Environmental Quality Standards (NEQS). By comparing with the drinking water standards of WHO 1000 mg/L, the value of total dissolved solids were found high which has given rise to high electric conductivity values.

Analytical work revealed that Nitrate, Sulfate and Chloride parameters were in the safe range, while dissolved oxygen, biological oxygen demand and chemical oxygen demands parameters for all the samples in both the industrial effluents and domestic sewage were above the prescribed permissible levels.

In all the industrial effluents Dissolved Oxygen values were nil (zero) and its values were also observed negligible (very less) through out the entire stretch of the main drain up to the confluence point of Shalam River, which consequently lowering the Dissolved Oxygen content of the receiving water body. The low DO content with high organic load (BOD and COD) had adversely affected the water quality of Shah Alam River and ultimately of Kabul River.

Throughout the study area, among the heavy metals concentration of Cu was found in safe range, while fluctuation was observed in Nickel. As the NEQS prescribed limit for Ni is 1 mg/L, so Gulab Banaspati ghee mill sample No S12 exceeded this limit because it was in range of 1.271 to 1.489 mg/L (Table. 5.10 and 5.9 respectively).

In most of the effluent and sewage drain samples chromium concentrations were found high than the permissible limit. Similarly lead concentrations in most of the samples exceeded the safe limit of NEQS (0.5mg/L). Lead (Pb) content was almost high in all of the samples investigated.

A significant fluctuation was observed in iron concentration. In most of the samples iron (Fe) concentrations were found below the limit and were in safe range of the NEQS standard of 2.00 mg/L, while in some sampling sites the "Fe" concentrations exceeded than the permissible limits since it ranged from 4.021 to 6.288 mg/L. The higher concentrations of "Fe" were found in the industrial effluents drain of Pepsi Cola, Paper and Board Mill, Bryon Pharmaceutical and Gulab Banaspati (Ghee Mill) of "Hayatabad Industrial Estate" (HIE) Peshawar.

In addition to industrial waste water, there were other important sewage drain (pollution sources) combining with effluent drain which particularly deteriorating the environmental conditions in the project area.

6.2 Recommendations

Recommendations have been divided into two parts, general recommendation and specific recommendation. The specific recommendations are given for particular problem identified in the study area. General recommendations are given regarding sustainability in surface water quality and these recommendations could be apply where ever there is industrial/ waste water and surface water quality problems.

6.2.1 General Recommendations

- An integrated hydrological information system may be established in the entire Hayatabad Peshawar. Such kind of information would be very helpful. It should provide information about the quality and quantity of industrial wastewater as well as surface water to decision maker in particular and public in general to plan and make better use of the available water resources.
- Environmental theme specifically industrial waste water pollution theme may be included in the curriculum at school and college level.
- Health education, water quality, safety and associated hazards should also include as a subject in the curriculum at school level.
- There is a need to create awareness in public on water quality problems affecting public health and to educate the general public to utilize water resources judiciously, as these resources are not enough compared to current and future demands.
- Specific research on water resources, its status and the factors which are responsible for its quality deterioration may be considered.
- Appropriate scientific and technological methodologies may be introduced for efficient water resource management.
- A well coordinated and systematic technical assessment and situation analysis mapping showing the relationship between health and water quality may be done. Besides, linkage between water resources and health sector at all level may be strengthened.
- Project assessment may not be based only on economic criteria. Environmental and social factors should also be included in the cost benefit analysis of all the proposed projects.
- Environmental Impact Assessment (EIA) of all projects may be done. At least three alternatives may be given. In case the principal proposal was unsuitable

for implementation, option will be there to save time, money, environment and energy.

- Water quality monitoring capacity, in terms of field, laboratory equipments and trained staff may be developed.
- To identify the characteristics and magnitude of water pollution problem, reference laboratories which should be well equipped and have trained staff for analysis of waste water, may be established.
- The water management agencies should be made responsible to maintain water quality up to the consumer level.
- Wastage of water at all levels may be controlled through awareness campaigns using mass media.
- It is need of the hour to reduce unnecessary use of water in various activities. These include using tap water for car washing or over-irrigating lawns and gardens. Attitudinal change should be bringing among the people that optimal utilization of water would result in producing least waste water.
- For adopting corrective plans and framework designs, regular monitoring is required to check the problem areas and causes of contamination. For creating awareness, educational institutions, mosques and media would play critical role in inculcating the importance of water among the public. Water quality monitoring results could be regularly shared with all the relevant stakeholders through workshops, seminars and lectures.

6.2.2 Specific Recommendations

- To increase the availability and conservation of water, the water used in industries of HIE for cooling and other purposes may be reused.
- Recycling of waste and bi-product recovery practices should be encouraged to save the resources.
- Equipments, machineries, various sections and pipes may be cleaned periodically and any leaked or damaged pipes may be replaced on regular basis.
- Pollution control measures may be immediately adopted in Industrial Estate Hayatabad Peshawar e.g. wastewater treatment facilities may be installed in the industrial area. Each industry should have primary treatment including

screening, sedimentation and neutralization on the premises of the factory to decrease the load of suspended materials and minimize the extent of pollution load and reduce biological oxygen demand, prior to their discharge into the receiving water bodies.

- There is a great need for enforcement and implementation of our own water quality standards based on periodic monitoring results.
- Agricultural runoff, use of pesticides and fertilizer should be controlled through awareness and education in the down stream project area.
- All the industrial activities must be evaluated periodically to know their short terms and long terms impacts on the eco-system so that remedial measures could be taken to meet/face un-foreseen impacts.
- Periodic monitoring of the project area for pollution assessment purposes may be undertaken and the effects of pollutant on health of the inhabitants in the area should also be recorded regularly. This exercise can apprise the industrialist for pollution abatement.
- Research organizations like Pakistan Council for Scientific and Industrial Research (PCSIR), Department of Environmental Science, University of Peshawar, Industry Department and EPA may work in collaboration for the abatement of industrial/waste water pollution in HIE.
- All kind of plants and animals of the study area (fauna and flora) need to be preserved according to the convention of the Biological Diversity of which Pakistan is also a signatory. To save the flora and fauna of the study area from Hayatabad up to the receiving water body should be included in these programs.
- In compliance of environmental legislation, all industrial and domestic waste should be treated properly prior to the discharge into any water body.
- In HIE industries may be categorized/grouped in term of wastewater disposal. The wastewater of these industries may be collected and treated/disposed at one place to help in abatement of pollution. For example marble factories waste water/effluents could be collected at one place and separate treatment could be carries out.

- Likewise match factory effluent can be segregated and collected at one place for treatment. This could also be an alternative for the abatement of pollution in HIE Peshawar.
- The possibility of joint treatment of cluster (combine) industrial unit located in HIE to conserve expenses may be explored.
- The possibilities of having a common industrial waste treatment plant at the industrial estate may also be explored. This will have to be looked into thoroughly to save the treatment cost. It should be studied so as to make the effluent fit for discharging into water channel or river according to the imposed standards.
- Any indigenous knowledge used for the water treatment and conservation should be collected and recorded for the development of widely accepted technologies to treat the industrial, agricultural and domestic waste and make it fit for the reuse.
- For making effective comparisons of water quality, it is essential to establish baselines of all the water sources at the national level.
- Sewage system of the project area HIE may be cleaned and improved to safeguard ground water and river water from getting contaminated.
- Government and regulatory authority should guide and provide treatment facilities at low cost to industrialists for reducing pollution and risks of using effluents.
- Integrated approach for effective solid waste management needs to be adopted to stop pollutants entrance into surface and ground water sources present in the project area. It should be obligation of all the relevant agencies to regularly test the industrial effluents either through their own or other certified well-known laboratories of repute in the country.
- It should be mandatory on the agencies responsible to assess the quality of industrial waste water through analysis at their own laboratory or other accredited laboratories of repute.
- In HIE a comprehensive environmental monitoring program for the existing industries may be conducted for abatement of pollution while for new industries yet to be constructed will need a detail EIA so that the unforeseen

possible adverse impacts of new industries could be minimized/reduce up to a greater extent.

- The municipal waste water of Peshawar city should also be treated before discharging into HIE effluent drain and natural tributary of Kabul River.
 - The national water quality standards promulgated by Pakistan Standard Quality Control Authority and NEQS for municipal and industrial effluents should be enforced immediately and made applicable to both private and public bodies and entrepreneurs in the water sector.
 - Nearly all of the industries in HIE are indiscriminately discharging harmful waste water into open "Khawar" (seasonal streams). The EPA should become more active and strictly enforce rules and regulations preventing industrial entrepreneurs from discharging their effluents directly in to open water bodies.
 - Incentives in terms of tax rebate may be given to those industries that employ and effectively operate pollution control measures.
 - It is also recommended that government should provide soft loan to industrialist to adopt advance technology to ensure environmental protections.
 - Aerated lagoons for removal of pollution load and BOD for the effluents of Ghee and Paper Mill were recommended.
 - All the machinery in industries of "Hayatabad Industrial Estate" should be provided with protective guard.
 - The industry should be helped in controlling pollution through advisory and consulting services for design and installation of pollution control facilities by research institutions.
 - Trees can also play an important role in cleaning the environment. Trees not only consume CO₂ but also act as filter to absorb dust and control soil erosion.
- It is strongly recommended that plantation in and around "Hayatabad Industrial Estate" (HIE) be made at the earliest to protect environmental degradation of the project area.

Tables

(5.1 to 5.16)

Table No 5.1
Investigation of Industrial Effluent of (HIE) Sewage Drain, Nullah and the Receiving Water Bodies for Physio-Chemical Properties
During Low Flow 2005

S.No	Sample	Temp °C	pH	E.Cond (µs/cm)	Turbidity	TSS	TDS	TS
1	S 1	19.12	7.92	1150	142.4	388	1600	1988
2	S 2	20.26	8.13	1168	142.2	409	1560	1969
3	S 3	19.35	8.26	1198	142	415	1580	1995
4	S 4	20.14	8.44	1200	141.2	421	1600	2021
5	S 5	20.12	8.35	1148	141.8	400	300	700
6	S 6	19.81	7.96	1168	142.2	314	1800	2114
7	S 7	20.22	8.37	1170	144.6	720	1700	2420
8	S 8	21.17	8.58	1200	146.2	850	2000	2850
9	S 9	20.80	8.29	1210	142.5	810	1400	2210
10	S 10	19.10	8.41	1215	144.6	615	1800	2415
11	S 11	19.20	8.14	1250	141.8	480	2860	3340
12	S 12	19.20	8.46	1350	142.6	618	1700	2318
13	S 13	19.10	8.01	1240	141.2	612	1600	2212
14	S 14	20.20	8.01	1210	140.1	614	1800	2414
15	S 15 (C1)	20.40	8.24	1180	133.5	670	1700	2370
16	S 16 (C2)	19.10	8.32	1190	132.8	640	1720	2360
17	S 17 (C3)	19.40	8.10	1170	131.6	710	1680	2390
18	S 18 (D1)	19.61	8.40	1160	128.5	540	1610	2150
19	S19 (D2)	19.71	8.20	1167	126.6	570	1580	2150
20	S20 (D3)	19.65	8.02	1158	127	520	1490	2010
21	S21	18.65	8.04	966	124.4	510	1410	1920
22	S22	19.01	7.95	917	122.8	490	1300	1790
23	S23	19.21	7.80	995	123.4	440	1200	1640
24	S24	18.20	7.70	1300	129.2	500	860	1360
25	S25	17.61	7.91	1240	128.1	490	740	1230
26	S26	17.82	7.69	1148	119.4	450	650	1100
27	S27	17.02	7.71	950	117.2	610	615	1225
28	S28	17.54	7.65	910	119.6	540	590	1130
29	S29	17.54	7.84	858	118.2	650	560	1210
30	S30	17.98	7.51	810	118.4	620	670	1290
31	S31	17.85	7.63	780	117.6	610	610	1220
32	S32	17.65	7.52	740	116	600	890	1490
33	S33	17.51	7.65	710	116.9	790	750	1540
34	S34	17.61	7.44	700	117.6	900	800	1700
35	S35	17.54	7.53	480	76.5	600	790	1390
36	S36	17.21	7.46	585	98.9	850	830	1680
37	S37	18.11	7.56	585	18.9	840	820	1660
38	S38	17.02	7.65	480	5.8	320	480	800
39	S39	17.01	7.01	430	5.6	300	350	650
40	S40	17.45	7.60	560	6.8	380	600	980
	Min	17.01	7.01	430	5.6	300	300	650
	Max	21.17	8.58	1350	146.2	900	2860	3340

Table No.5.2

Investigation of Industrial Effluents of (HIE) Sewage Drain, Nullah and the Receiving Water Bodies for Physico-Chemical Properties during High Flow 2005

S.No	Sample	Temp °C	pH	E.Cond (µs/cm)	Turbidity	TSS	TDS	TS
1	S 1	29.2	7.1	1240	140	370	1650	2020
2	S 2	28.4	8	1220	149	400	1620	2020
3	S 3	28.6	8.1	1210	146	450	1600	2050
4	S 4	27.5	8	1205	139.6	417	1640	2057
5	S 5	27.3	8.1	1190	139.8	405	2200	2605
6	S 6	28.6	7.6	1200	140.1	425	1840	2265
7	S 7	31.8	8	1180	142.4	725	1850	2575
8	S 8	38.2	8.2	1250	143.8	830	1900	2730
9	S 9	29.6	8	1190	141.6	805	1750	2555
10	S 10	30.4	8.1	1200	143.5	610	1760	2370
11	S 11	29.6	7.9	1250	140.6	476	1810	2286
12	S 12	29.8	7.9	1330	140.8	610	1600	2210
13	S 13	29.4	8	1246	141.1	600	1500	2100
14	S 14	30.2	8.1	1220	140	590	1810	2400
15	S 15 (C1)	30.4	8.1	1200	132.2	630	1690	2320
16	S 16 (C2)	29.2	8.2	1195	132	620	1700	2320
17	S 17 (C3)	29.4	8	1150	131.8	700	1670	2370
18	S 18 (D1)	29.6	8.2	1140	127.5	520	1600	2120
19	S 19 (D2)	29.8	8	1150	126.2	530	1560	2090
20	S 20 (D3)	29.4	7.9	1130	226.5	510	1470	1980
21	S 21	28.5	8.1	890	123.6	505	1400	1905
22	S 22	29.4	7.4	885	122.6	450	1300	1750
23	S 23	29.8	7.6	900	122.1	400	1190	1590
24	S 24	28.4	7.6	1200	127.6	380	760	1140
25	S 25	27.2	7.5	1220	24.8	400	700	1100
26	S 26	27.4	7.4	1100	17.8	480	620	1100
27	S 27	27.1	7.5	900	116.2	630	605	1235
28	S 28	27.3	7.4	870	117.2	560	580	1140
29	S 29	27.3	7.7	840	116.8	710	510	1220
30	S 30	28.1	7.6	790	116.9	640	610	1250
31	S 31	27.6	7.4	700	117.6	630	605	1235
32	S 32	27.6	7.3	710	115.2	640	800	1440
33	S 33	22.4	7.4	640	115.4	840	710	1550
34	S 34	26.3	7.2	610	114.5	960	750	1710
35	S 35	25.1	7.6	440	65.8	710	755	1465
36	S 36	24.1	7.3	510	86.2	890	810	1700
37	S 37	26.2	7.4	495	15.4	880	790	1670
38	S 38	22.4	7.3	425	4.6	530	430	960
39	S 39	20.2	7.4	400	4.2	510	240	750
40	S 40	20.6	7.7	470	5.4	570	400	970
	Min	20.2	7.1	400	4.2	370	240	750
	Max	38.2	8.2	1330	226.5	960	2200	2730

Table No 5.3
Investigation of Industrial Effluents of (HIE), Sewage Drain, Nullah and the Receiving Water Bodies for Physico-Chemical Properties During Low Flow 2006

S.No	Sample	Temp °C	p ^H	E.Cond (µs/cm)	Turbidity	TSS	TDS	TS
1	S 1	20.2	8.1	1160	142.6	400	1680	2080
2	S 2	21.4	8	1170	142.4	410	1600	2010
3	S 3	21.6	8.2	1200	142.2	420	1690	2110
4	S 4	20.2	8.1	1210	141.4	425	1640	2065
5	S 5	21.4	8.2	1160	141.2	405	1690	2095
6	S 6	21	8	1170	142.4	435	1610	2045
7	S 7	22.1	8.1	1180	144.8	725	1710	2435
8	S 8	22.4	8.2	1210	146.4	860	2010	2870
9	S 9	22.6	8.1	1220	142.7	815	1460	2275
10	S 10	23.6	8	1230	144.8	620	1820	2440
11	S 11	24.2	7.9	1260	141.6	485	2880	3365
12	S 12	23.8	8.1	1370	142.8	625	1720	2345
13	S 13	23.4	8	1260	142	618	1650	2268
14	S 14	22.8	8.1	1220	141.1	614	1820	2434
15	S 15 (C1)	23	8	1200	133.8	680	1710	2390
16	S 16 (C2)	23.2	7.9	1210	132.6	650	1730	2380
17	S 17 (C3)	23.4	8	1190	131.8	720	1690	2410
18	S 18 (D1)	23.6	8.2	1170	129.5	550	162	712
19	S 19 (D2)	22.8	8.1	1177	127.5	570	1590	2160
20	S 20 (D3)	23.6	8.2	1170	127.8	525	1510	2035
21	S 21	23.8	8.1	980	125.6	520	1320	1840
22	S 22	23	8	927	122.8	495	1210	1705
23	S 23	22	7.7	1005	123.4	455	890	1345
24	S 24	21	7.8	1310	129.4	510	750	1260
25	S 25	20.8	7.6	1250	128	500	670	1170
26	S 26	20.6	7.7	1159	119.2	460	630	1090
27	S 27	20.8	7.5	960	119.4	620	595	1215
28	S 28	20.4	7.4	930	119.8	545	580	1125
29	S 29	20.4	7.8	868	118.5	655	690	1345
30	S 30	21.2	7.4	805	118.6	630	620	1250
31	S 31	21.4	7.5	790	117.8	620	900	1520
32	S 32	21.6	7.6	750	116.5	610	780	1390
33	S 33	21.8	7.5	720	116.9	800	810	1610
34	S 34	20.4	7.8	710	117.8	910	820	1730
35	S 35	19.2	7.2	460	67.5	620	840	1460
36	S 36	18.1	7.3	590	88.8	865	850	1715
37	S 37	18.4	7.4	600	28.6	854	500	1354
38	S 38	18.8	7.3	500	6.5	330	350	680
39	S 39	18.1	7.2	320	6.3	310	360	670
40	S 40	18.7	7.5	565	7.5	395	650	1045
	Min	18.1	7.2	320	6.3	310	162	670
	Max	24.2	8.2	1370	146.4	910	2880	3365

Table No. 5.4

Investigation of Industrial Effluents of (HIE), Sewage Drain, Nullah and the Receiving Water Bodies for Physico-Chemical Properties During High Flow 2006

S.No	Sample No	Temp °C	pH	E.Cond (µs/cm)	Turbidity	TSS	TDS	TS
1	S 1	29.6	8.3	1250	142.4	405	1875	2280
2	S 2	29.4	8.1	1230	142.2	415	1805	2220
3	S 3	29.5	8.2	1200	141	418	1880	2298
4	S 4	29.3	8	1210	141.2	430	1835	2265
5	S 5	29.4	8.2	1205	141.4	410	1880	2290
6	S 6	29.5	8.1	1160	141.6	440	1805	2245
7	S 7	28.9	7.9	1170	142.8	730	1800	2530
8	S 8	28.8	7.8	1200	144.2	865	2000	2865
9	S 9	27.5	7.9	1205	145.2	820	1440	2260
10	S 10	27.4	7.9	1210	142.2	622	1810	2432
11	S 11	27.3	7.8	1220	144.2	488	2840	3328
12	S 12	28.1	8	1330	141	629	1900	2529
13	S 13	27.6	8.1	1240	142.4	625	2700	3325
14	S 14	27.9	8	1200	141.8	619	2600	3219
15	S 15 (C1)	28.6	7.9	1190	141	685	1900	2585
16	S 16 (C2)	28.4	7.8	1200	132.6	653	1700	2353
17	S 17 (C3)	28.2	7.7	1140	132	724	1695	2419
18	S 18 (D1)	27.8	7.6	1130	131.2	560	1600	2160
19	S 19 (D2)	27.6	7.9	1135	129	580	1500	2080
20	S 20 (D3)	26.5	8	1140	127.1	531	1490	2021
21	S 21	25.4	7.9	960	127.2	540	1300	1840
22	S 22	24.8	7.8	920	124.1	510	1200	1710
23	S 23	24.6	7.6	990	121.4	495	890	1385
24	S 24	24.4	8.1	1300	122.2	550	1100	1650
25	S 25	24.2	8	1230	127.2	560	600	1160
26	S 26	24	7.9	1130	126.1	510	610	1120
27	S 27	23.8	7.8	850	118.1	650	570	1220
28	S 28	23.6	7.7	810	118.2	595	680	1275
29	S 29	23.8	7.8	820	118.4	659	600	1259
30	S 30	23.6	7.6	780	117.8	645	820	1465
31	S 31	23.6	7.7	750	118	649	710	1359
32	S 32	22.8	7.6	730	116.6	630	800	1430
33	S 33	22.6	7.5	710	115.2	890	800	1690
34	S 34	22.8	7.9	430	76.1	930	810	1740
35	S 35	21	7.4	500	95.8	630	830	1460
36	S 36	22.4	7.6	510	17.4	870	500	1370
37	S 37	22.2	7.5	560	8.4	860	380	1240
38	S 38	22	7.4	310	6.6	380	350	730
39	S 39	20.4	7.3	405	5.1	320	320	640
40	S 40	21.0	7.6	500	6.2	405	325	730
	Min	20.4	7.3	310	5.1	320	320	640
	Max	29.6	8.3	1330	145.2	930	2840	3328

Table No.5.5

Chemical Characteristics of Industrial Effluents, Sewage Drain, Nullah, and Receiving Water Bodies During Low Flow 2005

S. No	Sample	Alkalinity	D.O	BOD	COD	Nitrate	Sulfate	Chloride
1	S1	112	0.0	170	430	18.2	430	82
2	S2	210	0.0	185	490	9.6	160	94
3	S3	160	0.0	176	445	17.2	230	45
4	S4	152	0.0	196	485	8.6	210	65
5	S5	140	0.0	178	435	9.5	310	90
6	S6	195	0.0	240	400	10.1	325	30
7	S7	178	0.0	240	450	6.5	300	48
8	S8	380	0.0	390	680	12.4	210	160
9	S9	168	0.0	280	1200	18.2	190	140
10	S10	140	0.0	190	430	5	210	48
11	S11	160	0.0	180	425	10.2	250	66
12	S12	385	0.0	310	1050	9.6	185	400
13	S13	210	0.0	215	430	4.8	285	78
14	S14	240	0.0	220	400	5	290	84
15	S15 (C1)	310	1.2	195	560	10.2	215	230
16	S16 (C2)	320	0.8	320	665	5.6	286	80
17	S17 (C3)	340	1.0	240	610	18.6	230	110
18	S18 (D1)	250	0.6	300	770	19.4	210	85
19	S19 (D2)	120	0.0	180	390	7.8	320	74
20	S20 (D3)	245	0.0	250	1200	15.6	218	246
21	S21	220	0.0	330	2000	8	195	195
22	S22	210	0.0	300	600	16.6	249	260
23	S23	205	2.0	240	900	23.8	415	272
24	S24	188	0.0	160	600	26.8	12	20
25	S25	160	0.0	200	630	13.6	410	265
26	S26	190	2.2	180	720	4.4	315	378
27	S27	121	0.0	300	325	10.2	40	310
28	S28	260	2.1	175	520	7.8	290	240
29	S29	185	3.4	140	270	29.1	220	168
30	S30	195	3.2	160	210	6.5	250	180
31	S31	175	2.8	190	320	7	185	174
32	S32	180	0.0	380	1270	28.4	15	190
33	S33	160	1.7	215	230	6.8	205	260
34	S34	170	2.8	200	305	12.6	210	280
35	S35	170	4.0	100	168	9.5	210	280
36	S36	140	3.0	160	282	13.2	135	270
37	S37	100	3.2	155	270	11.4	100	210
38	S38	180	5.5	15	40	9.2	82	180
39	S39	175	7.6	4	12	5.6	70	170
40	S40	195	7.0	4.8	14	6	170	190
	Min	100	0	4	12	4.4	12	20
	Max	385	7.6	390	2000	29.1	430	400

Table No. 5.6
Chemical Characteristics of Industrial Effluents, Sewage Drain, Nullah, and Receiving Water Bodies During High Flow 2005

S. No	Sample	Alkalinity	D.O	BOD	COD	Nitrate	Sulfate	Chloride
1	S1	250	0	165	435	17.2	370	80
2	S2	200	0	190	485	9.8	161	90
3	S3	255	0	180	450	16.4	228	40
4	S4	150	0	200	490	10.8	205	61
5	S5	145	0	170	440	11.2	308	85
6	S6	115	0	200	410	9.8	330	35
7	S7	180	0	260	325	6.1	280	50
8	S8	360	0	400	670	25.6	215	150
9	S9	160	0	270	1100	24.4	205	135
10	S10	145	0	195	210	4.2	215	42
11	S11	165	0	190	230	8.2	255	61
12	S12	380	0	350	1010	7.4	195	390
13	S13	200	0	200	310	4	260	70
14	S14	230	0	230	410	4.5	280	79
15	S15 C1	300	1.4	180	510	10.1	200	210
16	S16 C2	310	1	290	550	5.1	270	70
17	S17 C3	345	1.8	160	570	16.5	220	100
18	S18 D1	265	1.8	185	560	19.2	200	70
19	S19 D2	125	0	100	285	7.2	300	69
20	S20 D3	250	0	240	1100	13.2	200	210
21	S21	215	0	280	1700	7.1	170	160
22	S22	200	2.4	209	500	14.2	210	210
23	S23	190	2.6	190	700	25.6	290	240
24	S24	170	0	280	500	25.8	10	160
25	S25	150	0	210	520	12.4	360	215
26	S26	180	2.8	180	600	3.2	305	310
27	S27	200	0	280	330	6.2	35	290
28	S28	220	2.6	195	480	5.8	250	210
29	S29	160	3.8	130	240	25.8	200	160
30	S30	150	3.6	160	250	6.3	210	140
31	S31	165	3	170	300	5.2	164	150
32	S32	170	0	390	1280	24.2	12	155
33	S33	140	1.7	200	240	4.8	145	215
34	S34	130	2.9	190	260	8.5	190	240
35	S35	180	5	90	160	6.2	140	160
36	S36	100	3.5	140	190	7.4	110	200
37	S37	195	3.8	130	265	7.2	80	180
38	S38	160	5.8	10	30	5.1	60	130
39	S39	150	7.8	3	10	4	40	120
40	S40	155	7.5	4	12	5.5	70	140
	Min	100	0	3	10	3.2	10	35
	Max	380	7.8	400	1700	25.8	370	390

Table No. 5.7
Chemical Characteristics of Industrial Effluents, Sewage Drain, Nullah, and Receiving Water Bodies During Low Flow
2006

S. No	Sample	Alkalinity	D.O	BOD	COD	Nitrate	Sulfate	Chloride
1	S1	278	0	175	425	18.6	410	84
2	S2	215	0	192	495	10.2	170	97
3	S3	175	0	182	450	11.8	235	52
4	S4	164	0	200	490	9.2	215	68
5	S5	160	0	199	440	10	440	95
6	S6	105	0	250	405	10.5	330	35
7	S7	84	0	255	355	6.8	316	55
8	S8	395	0	395	685	13	220	168
9	S9	162	0	290	1210	12.4	210	155
10	S10	160	0	199	235	6.2	220	55
11	S11	170	0	189	422	10.4	260	71
12	S12	300	0	320	1040	10.5	205	410
13	S13	240	0	220	435	5.3	200	81
14	S14	250	0	200	410	5.5	300	88
15	S15 (C1)	320	1.1	205	550	11.6	235	240
16	S16 (C2)	325	0.7	325	670	6.2	305	90
17	S17 (C3)	345	0.9	250	600	19.1	240	120
18	S18 (D1)	255	0.5	305	565	13.2	250	90
19	S19 (D2)	135	0	185	395	8.2	330	76
20	S20 (D3)	250	0	255	1230	16.2	220	256
21	S21	230	0	340	1900	9.8	200	210
22	S22	214	0	310	610	17.2	250	270
23	S23	210	1.8	249	840	7.1	250	292
24	S24	177	0	190	610	23.4	14	212
25	S25	150	0	210	640	4.8	415	275
26	S26	180	2	190	740	5.6	320	388
27	S27	200	0	320	330	11.2	45	313
28	S28	250	2	182	530	8.2	295	244
29	S29	165	3	148	290	30.4	225	170
30	S30	190	2.6	168	240	17.5	255	184
31	S31	182	2	210	340	8.2	190	170
32	S32	185	1.5	340	1290	26.2	18	200
33	S33	165	2	200	250	7.2	210	265
34	S34	177	1.8	215	255	18.8	220	285
35	S35	196	3	120	175	10.2	100	190
36	S36	145	2.8	165	286	15.2	150	280
37	S37	110	3	160	275	13.6	180	215
38	S38	185	5	30	50	10.2	90	185
39	S39	176	7	5	14	6.5	75	172
40	S40	198	6.5	5.5	16	7.6	160	195
	Min	84	0	5	14	4.8	14	35
	Max	395	7	395	1900	30.4	440	410

Table No. 5.8.

Chemical Characteristics of Industrial Effluents, Sewage Drain, Nullah, and Receiving Water Bodies During High Flow 2006

S. No	Sample	Alkalinity	D.O	BOD	COD	Nitrate	Sulfate	Chloride
1	S1	270	0	170	412	15.1	350	80
2	S2	218	0	190	490	9.5	161	90
3	S3	180	0	180	446	11.2	230	51
4	S4	168	0	198	485	8.8	211	61
5	S5	168	0	195	435	9.1	390	89
6	S6	110	0	248	401	10	325	30
7	S7	190	0	251	300	5.8	291	51
8	S8	393	0	391	681	10.2	213	159
9	S9	174	0	288	1200	12.5	205	151
10	S10	165	0	190	230	5.6	211	49
11	S11	178	0	180	310	10	245	69
12	S12	310	0	325	1010	9.6	200	405
13	S13	252	0	210	311	4.8	198	70
14	S14	254	0	195	400	5.1	291	73
15	S15 (C1)	321	1.4	190	530	9.7	215	211
16	S16 (C2)	328	1	305	560	5.2	290	81
17	S17 (C3)	348	1.2	241	580	15.4	235	110
18	S18 (D1)	260	1.3	150	360	16.8	240	71
19	S19 (D2)	145	0	150	290	7.6	300	66
20	S20 (D3)	240	0	250	1200	14.6	205	246
21	S21	245	0	335	1800	8.2	190	194
22	S22	210	0	305	600	14.8	210	216
23	S23	205	2.5	239	820	12.5	215	236
24	S24	165	0	180	600	19.2	11	197
25	S25	145	0	200	610	12.8	200	211
26	S26	175	3	178	712	4.8	300	317
27	S27	180	0	310	320	9.1	35	297
28	S28	240	3	170	510	7.6	235	247
29	S29	155	3.5	142	240	26.2	211	150
30	S30	182	2.8	158	210	16.6	215	144
31	S31	171	2.5	195	310	7.2	135	140
32	S32	176	2.4	305	1240	15.8	14	160
33	S33	159	2.4	190	230	7.2	200	245
34	S34	175	2.1	200	240	14.2	205	250
35	S35	90	3.6	100	160	8.3	90	150
36	S36	140	3.4	120	178	11.8	130	215
37	S37	195	3.5	115	268	9.8	128	195
38	S38	170	5.6	25	46	7.4	80	170
39	S39	158	7.8	4	11	5.8	60	155
40	S40	175	7.2	5	13	6.6	110	175
	Min	90	0	4	11	4.8	11	30
	Max	393	7.8	391	1800	26.2	390	405

Table 5.9: Analytical Results of Industrial Effluents of Hayatabad Industrial Estate, Sewage Drains, Nullah and the Receiving Water Bodies for Heavy Metals, During Low Flow 2005

S.No.	Sample No.	Cr	Cu	Fe	Ni	Pb
1	S1	1.548	0.063	0.898	0.403	0.809
2	S2	0.645	0.012	0.635	0.405	0.827
3	S3	0.698	0.014	0.179	0.404	0.724
4	S4	0.717	0.04	1.268	0.455	0.889
5	S5	1.632	0.014	0.204	0.427	0.968
6	S6	0.834	0.012	4.628	0.435	1.004
7	S7	0.838	0.014	0.22	0.432	1.015
8	S8	0.907	0.011	5.288	0.48	1.012
9	S9	0.968	0.012	1.45	0.472	1.438
10	S10	0.952	0.009	2.862	0.47	0.943
11	S11	1.048	0.005	1.083	0.47	1.12
12	S12	1.066	0.006	6.288	1.489	1.052
13	S13	1.087	0.005	0.368	0.468	1.042
14	S14	1.128	0.004	0.35	0.468	1.3
15	S15 (C1)	1.155	0.004	0.29	0.486	1.162
16	S16 (C2)	1.191	0.006	0.425	0.145	1.259
17	S17 (C3)	1.2	0.007	0.513	0.152	1.259
18	S18 (D1)	1.251	0.007	0.26	0.156	1.213
19	S19 (D2)	1.288	0.003	4.067	0.15	1.256
20	S20 (D3)	1.236	0.006	0.487	0.158	1.162
21	S21	1.422	0.018	0.713	0.178	1.311
22	S22	1.519	0.052	1.12	0.19	1.267
23	S23	1.581	0.025	1.268	0.205	1.325
24	S24	1.428	0.02	0.573	0.168	1.365
25	S25	1.152	0.03	1.354	0.191	1.12
26	S26	1.157	0.001	0.394	0.85	1.16
27	S27	1.489	0.003	0.223	0.181	1.192
28	S28	1.539	0.009	0.327	0.197	1.246
29	S29	1.577	0.004	0.227	0.189	1.12
30	S30	1.517	0.003	0.205	0.221	1.232
31	S31	1.615	0.002	0.226	0.187	1.369
32	S32	1.457	0.007	0.25	0.197	1.257
33	S33	1.294	0.003	0.334	0.19	1.319
34	S34	1.451	0.042	0.278	0.183	1.35
35	S35	1.632	0.333	0.216	0.181	1.24
36	S36	1.308	0.037	0.279	0.163	1.227
37	S37	1.347	0.003	0.189	0.153	1.365
38	S38	1.396	0.002	0.232	0.162	1.303
39	S39	1.416	0.003	0.201	0.178	1.132
40	S40	1.4	0.005	0.195	0.205	1.214
	Min	0.645	0.001	0.179	0.145	0.724
	Max	1.632	0.333	6.288	1.489	1.438

Table 5.10: Analytical Results of Industrial Effluents of Hayatabad Industrial Estate, Sewage Drains, Nullah and the Receiving Water Bodies for Heavy Metals, During High Flow 2005

S.No.	Sample No.	Cr(ppm)	Cu (ppm)	Fe	Ni	Pb
1	S1	1.101	0.002	0.687	0.312	0.671
2	S2	0.243	0.002	0.543	0.321	0.660
3	S3	0.697	0.011	0.098	0.320	0.613
4	S4	0.716	0.002	0.987	0.782	0.764
5	S5	1.001	0.001	0.201	0.314	0.854
6	S6	0.831	0.010	4.023	0.324	0.975
7	S7	0.788	0.012	0.145	0.311	0.964
8	S8	0.895	0.010	4.928	0.371	0.923
9	S9	0.891	0.009	1.012	0.345	1.248
10	S10	0.890	0.004	2.045	0.341	0.815
11	S11	1.048	0.005	0.935	0.342	0.601
12	S12	1.006	0.006	5.413	1.271	0.951
13	S13	1.001	0.005	0.254	0.356	0.942
14	S14	1.002	0.004	0.215	0.367	1.043
15	S15 (C1)	1.001	0.004	0.157	0.364	1.004
16	S16 (C2)	1.002	0.006	0.343	0.045	1.054
17	S17 (C3)	0.812	0.007	0.427	0.051	1.062
18	S18 (D1)	0.912	0.007	0.145	0.053	1.043
19	S19 (D2)	0.980	0.003	3.143	0.052	1.031
20	S20 (D3)	0.936	0.006	0.378	0.056	1.004
21	S21	0.929	0.002	0.521	0.064	1.051
22	S22	0.981	0.020	0.923	0.074	1.004
23	S23	0.995	0.010	0.942	0.114	1.125
24	S24	0.992	0.008	0.357	0.046	0.971
25	S25	1.002	0.012	0.943	0.081	0.955
26	S26	1.001	0.001	0.115	0.065	0.961
27	S27	1.010	0.001	0.146	0.074	0.975
28	S28	0.953	0.004	0.115	0.072	0.986
29	S29	0.987	0.002	0.104	0.086	0.943
30	S30	0.975	0.001	0.146	0.121	0.951
31	S31	1.025	0.001	0.151	0.075	1.004
32	S32	1.070	0.003	0.213	0.078	0.945
33	S33	1.081	0.001	0.154	0.076	0.956
34	S34	1.032	0.020	0.103	0.084	0.945
35	S35	1.071	0.213	0.126	0.064	0.961
36	S36	0.958	0.016	0.054	0.046	0.975
37	S37	0.947	0.001	0.046	0.032	1.121
38	S38	0.927	0.001	0.011	0.051	0.921
39	S39	0.972	0.001	0.001	0.062	1.002
40	S40	0.954	0.002	0.196	0.404	1.011
	Min	0.243	0.001	0.001	0.032	0.601
	Max	1.081	0.213	5.413	1.271	1.248

Table 5.11 Analytical Results of Industrial Effluents of Hayatabad Industrial Estate, Sewage Drains, Nullah and the Receiving Water Bodies for Heavy Metals, During Low Flow 2006

S.No.	Sample No.	Cr	Cu	Fe	Ni	Pb
1	S1	1.654	0.082	1.154	0.712	1.156
2	S2	0.754	0.031	0.934	0.754	1.043
3	S3	0.715	0.024	0.478	0.765	1.023
4	S4	0.851	0.051	1.518	0.965	1.102
5	S5	1.787	0.026	0.503	0.765	1.254
6	S6	0.976	0.026	4.884	0.758	1.304
7	S7	1.102	0.031	0.52	0.743	1.345
8	S8	1.231	0.028	5.675	0.765	1.354
9	S9	1.454	0.032	1.784	0.743	1.542
10	S10	1.405	0.036	2.965	0.776	1.254
11	S11	1.365	0.025	1.986	0.765	1.465
12	S12	1.287	0.027	5.512	1.745	1.354
13	S13	1.565	0.0102	0.765	0.764	1.381
14	S14	1.646	0.052	0.654	0.754	1.523
15	S15 (C1)	1.532	0.064	0.574	0.752	1.342
16	S16 (C2)	1.643	0.071	0.742	0.453	1.521
17	S17 (C3)	1.687	0.052	0.827	0.465	1.554
18	S18 (D1)	1.747	0.066	0.645	0.475	1.561
19	S19 (D2)	1.653	0.052	4.864	0.468	1.571
20	S20 (D3)	1.543	0.064	0.854	0.454	1.426
21	S21	1.687	0.027	1.075	0.496	1.921
22	S22	0.983	0.072	2.012	0.487	1.561
23	S23	1.745	0.045	1.867	0.512	1.562
24	S24	1.653	0.038	0.865	0.456	1.584
25	S25	1.345	0.056	1.654	0.467	1.847
26	S26	1.251	0.007	0.945	0.457	1.501
27	S27	1.642	0.005	0.624	0.467	1.474
28	S28	1.785	0.011	0.562	0.456	1.554
29	S29	1.754	0.006	0.626	0.457	1.423
30	S30	1.732	0.005	0.562	0.547	1.523
31	S31	1.654	0.004	0.625	0.478	1.564
32	S32	1.293	0.009	0.645	0.487	1.643
33	S33	1.432	0.005	0.754	0.476	1.651
34	S34	1.723	0.043	0.431	0.478	1.652
35	S35	1.432	0.001	0.421	0.492	1.573
36	S36	1.465	0.373	0.527	0.421	1.543
37	S37	1.474	0.265	0.381	0.542	1.845
38	S38	1.561	0.003	0.534	0.421	1.521
39	S39	1.543	0.002	0.521	0.412	1.123
40	S40	1.651	0.004	0.954	0.575	1.338
	Min	0.715	0.001	0.381	0.412	1.023
	Max	1.787	0.373	5.675	1.745	1.921

Table 5.12: Analytical Results of Industrial Effluents of Hayatabad Industrial Estate, Sewage Drains, Nullah and the Receiving Water Bodies for Heavy Metals, During High Flow 2006

S.No.	Sample No.	Cr	Cu	Fe	Ni	Pb
1	S1	1.561	0.071	1.126	0.641	1.045
2	S2	0.687	0.022	0.845	0.654	1.021
3	S3	0.645	0.014	0.365	0.641	1.002
4	S4	0.746	0.042	1.154	1.049	1.001
5	S5	0.854	0.021	0.443	0.645	1.023
6	S6	0.845	0.061	4.021	0.657	1.125
7	S7	1.054	0.024	0.432	0.647	1.124
8	S8	1.087	0.017	5.145	0.656	1.145
9	S9	1.245	0.023	1.478	0.647	1.123
10	S10	1.268	0.027	2.145	0.658	1.045
11	S11	1.065	0.016	1.865	0.678	1.145
12	S12	1.051	0.018	5.087	1.375	1.045
13	S13	1.165	0.051	0.615	0.645	1.056
14	S14	1.611	0.042	0.541	0.645	1.165
15	S15 (C1)	1.321	0.054	0.476	0.674	1.321
16	S16 (C2)	1.554	0.062	0.624	0.325	1.261
17	S17 (C3)	1.564	0.043	0.725	0.356	1.265
18	S18 (D1)	1.472	0.054	0.542	0.374	1.345
19	S19 (D2)	1.542	0.042	3.367	0.346	1.345
20	S20 (D3)	1.423	0.056	0.745	0.376	1.246
21	S21	1.674	0.005	0.975	0.367	1.421
22	S22	0.845	0.054	1.767	0.247	1.421
23	S23	1.654	0.026	1.261	0.412	1.213
24	S24	1.423	0.017	0.654	0.361	1.041
25	S25	1.123	0.032	1.432	0.343	0.976
26	S26	1.045	0.005	0.754	0.345	0.978
27	S27	1.426	0.003	0.442	0.356	0.965
28	S28	1.574	0.001	0.346	0.354	0.967
29	S29	1.545	0.003	0.462	0.254	0.965
30	S30	1.671	0.002	0.354	0.246	0.951
31	S31	1.454	0.002	0.267	0.274	0.961
32	S32	1.071	0.007	0.461	0.247	0.976
33	S33	1.231	0.003	0.561	0.242	0.942
34	S34	1.567	0.002	0.231	0.251	0.942
35	S35	1.145	0.001	0.343	0.246	0.954
36	S36	1.456	0.176	0.432	0.262	0.948
37	S37	1.321	0.078	0.287	0.342	0.949
38	S38	1.001	0.002	0.214	0.201	0.947
39	S39	1.012	0.001	0.145	0.241	0.912
40	S40	1.445	0.002	0.721	0.254	0.965
	Min	0.645	0.001	0.145	0.201	0.912
	Max	1.674	0.176	5.145	1.375	1.421

Table 5.13: Discharge of Effluent Drain, Swage Drians, Nullah and Main Drain Joining Shah Alam River Directly

S No	Effluent Drain	Season	Width (M)	Depth (M)	Length (M)	Time (Second)	volume (M ³ /Sec)
1	Sub Drain (D1) in Hayatabad Industrial Estate, Peshawar	Low	0.60	0.10	4.50	15.0	0.0180
		High	0.70	0.14	4.50	15.0	0.0294
		Avg.	0.65	0.12	4.50	15.00	0.02
2	Sub Drain (D2) Hayatabad Industrial Estate, Peshawar	Low	0.40	0.09	4.50	15.0	0.0108
		High	0.60	0.10	4.50	14.0	0.0193
		Avg.	0.50	0.10	4.50	14.50	0.02
3	Sub Drain (D3) Hayatabad Industrial Estate, Peshawar	Low	0.40	0.09	4.50	16.0	0.0101
		High	0.70	0.10	4.50	14.0	0.0225
		Avg.	0.55	0.10	4.50	15.00	0.02
4	Main Effluent Drain Near Board Bridge	Low	1.20	0.15	4.50	18.0	0.0450
		High	1.30	0.16	4.50	17.0	0.0551
		Avg.	1.25	0.16	4.50	17.50	0.05
5	Swege Drain at Canal Town Peshawar.	Low	0.90	0.48	4.50	15.0	0.1296
		High	1.00	0.50	4.50	14.0	0.1607
		Avg.	0.95	0.49	4.50	14.50	0.15
6	Marble Effluent Drain at Pir Bala Peshawar	Low	1.20	0.90	6.00	11.0	0.5891
		High	1.30	1.00	6.00	10.0	0.7800
		Avg.	1.25	0.95	6.00	10.50	0.68
7	Budni Nullah Near Pir Bala Village.	Low	9.00	0.90	9.00	20.0	3.6450
		High	9.20	1.10	9.00	18.0	5.0600
		Avg.	9.10	1.00	9.00	19.00	4.35
8	Sewage Drain from Peshawar Near Sardar Ahmad Khan Colony, "Tor Bridge" or Budni Bridge.	Low	3.60	0.30	12.00	17.0	0.7624
		High	3.80	0.40	12.00	15.0	1.2160
		Avg.	3.70	0.35	12.00	16.00	0.99
9	Main Effluent Drain Including Budni befor Mixing with Shah Alam River at Nakoba Village (Daman Hindki)	Low	15.00	0.90	12.00	28.0	5.7857
		High	18.00	1.00	12.00	25.0	8.6400
		Avg.	16.50	0.95	12.00	26.50	7.21

Table No. 5.14
Physico-Chemical Characteristics of Water and Leachate Samples of Hayatabad
Peshawar

Sample Points Parameters	PI	PII	PIII	PIV	PV	PVI	PVII	Leachate Sample
Ambient Air Temp (⁰ 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 (⁰ 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	2.956	1.053	1.193	20.8
Turbidity (NTU)	241	114	307	316	54.5	153	131	296
Flow (m ³ /sec)	0.22	0.24	0.10	0.007	0.002	0.36	0.07	-
BODs days	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
Total viable count	-	-	-	-	-	-	-	7.6 x10 ⁴
Coli form organisms	-	-	-	-	-	-	-	2 x 10 ⁴
Faecal coli form organisms	-	-	-	-	-	-	-	Negative
Salmonella	-	-	-	-	-	-	-	6 x 10 ³
Staphylococcus	-	-	-	-	-	-	-	6 x 10 ⁴
Fungus	-	-	-	-	-	-	-	-

Table 5.14 continue

Table 5.14 continue

Oil & Grease	600	80	260	50	40	80	120	820
Lead (Pb)	0.395	0.374	0.514	0.629	0.494	0.297	0.198	0.593
Chromium (Cr)	1.62	0.83	1.21	0.82	0.4	0.79	0.75	2.82
Zinc (Zn)	0.145	0.285	0.073	0.251	N.D	0.318	0.313	1.062
Arsenic (As)	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Cadmium (Cd)	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Copper (Cu)	0.070	0.075	0.080	0.149	0.087	0.045	0.090	0.381

(N.D. stands for not detected or below detection limit)

Sample Points Description for Table 5.14

Sample Points	Location
PI	Gandoa khawar after leaving Hayatabad area before mixing with Narai khawar
PII	On Narai Khawar after leaving Hayatabad area
PIII	Industrial waste water coming through north nullah before joining main stream
PIV	North nallah before entering industrial estate
PV	Mid stream point on Gandao Khawar
PVI	Domestic/Municipal waste water coming from sewage
PVII	Next to solid waste dumping site on Gandao khawar

(Source: Pakistan Environmental Protection Agency (EPA) and Overseas Environmental Cooperation Center (OECC), Japan, 2004.)

Table 5.15 Physico Chemical Analysis of Paper and Boar Mill Hayatabad Peshawar

Location	pH	EC	TSS	Alkalinity	Nitrate	TDS	BOD
At Source	8.4	4780	60	480	18.90	1950	440
	8.4	7856	1160	650	5.15	3950	514
	8.2	9260	1720	448	20.60	4130	381
150 meter down stream	8.3	4690	40	475	19.10	1970	390
	8.7	6840	640	640	5.15	1370	480
	8.4	9230	1680	430	18.70	3870	360

(Source: (Rafiullah Khan Department of Environmental Sciences UOP, 1993.)

Table 5.16. Physical Characteristics of Major Effluent Drains Joining Kabul River in NWFP

Sample Sites/Location	Temp	pH	DO	Cond.	SS	DS
During Low Flow >	L Flow	L Flow	L Flow	L Flow	L Flow	L Flow
Khazan Sugar Mill	3.68	0.12	0.00	59.20	48.99	77.57
Ganda Erab	0.47	0.24	0.00	36.74	2.45	20.41
S.C.T. M and PM Mixed	2.05	0.02	0.00	44.91	72.67	10.61
Associated Ghee Mill	2.05	0.06	0.00	8.16	46.43	25.72
Nowshera Sewage Drain	3.40	0.04	0.00	12.25	7.79	2.05
Fuji Corn Complex	2.87	0.12	0.00	43.68	4.08	110.23
Sample Sites/Location	Temp	pH	DO	Cond.	SS	DS
During High Flow >	H Flow	H Flow	H Flow	H Flow	H Flow	H Flow
Khazan Sugar Mill	2.05	0.21	0.00	338.85	48.99	106.14
Ganda Erab	3.68	0.09	0.00	73.48	8.58	4.08
S.C.T. M and PM Mixed	2.05	0.07	0.00	2.05	3.68	50.63
Associated Ghee Mill	1.63	0.19	0.00	32.66	44.97	38.00
Nowshera Sewage Drain	2.05	0.19	0.00	8.16	8.16	2.87
Fuji Corn Complex	4.08	0.13	0.00	73.08	8.16	20.41

Chemical Characteristics of Major Effluent Drains Joining Kabul River in NWFP

Sample Sites/Location	Hardness	Nitrate	Sulfate	Chloride.	BOD	Coliform
During Low Flow >	L Flow	L Flow	L Flow	L Flow	L Flow	L Flow
Khazan Sugar Mill	22.86	0.00	19.19	2.87	2.87	8.16
Ganda Erab	8.16	0.12	4.08	4.08	2.45	81.65
S.C.T. M and PM Mixed	13.47	0.00	1.25	2.05	4.08	24.49
Associated Ghee Mill	6.13	0.00	12.25	4.99	13.47	9.39
Nowshera Sewage Drain	7.59	0.00	3.68	2.05	12.25	16.33
Fuji Corn Complex	6.94	0.00	2.05	5.31	3.27	8.16
Sample Sites/Location	Hardness	Nitrate	Sulfate	Chloride.	BOD	Coliform
During High Flow >	H Flow	H Flow	H Flow	H Flow	H Flow	H Flow
Khazan Sugar Mill	36.33	0.00	13.49	8.16	2.05	16.33
Ganda Erab	8.16	0.08	2.45	4.08	4.08	81.65
S.C.T. M and PM Mixed	4.08	0.00	2.87	4.08	8.16	40.82
Associated Ghee Mill	2.87	0.00	4.08	5.31	3.68	2.05
Nowshera Sewage Drain	8.16	0.00	6.94	1.25	3.68	24.49
Fuji Corn Complex	4.50	0.00	3.86	4.90	2.36	16.33

Source: M. Nafees 2002, Department of Environmental Sciences, UOP

Appendix 1

Water Quality

Standards

Appendix-1

1.0 Water Quality Standards:

The basic purpose of making guidelines or standards is to provide safe drinking water to the citizens. The World Health Organization (WHO) has provided guidelines for drinking water, which are advisory in nature, and are based on scientific research and epidemiological findings. The values of various water quality parameters recommended by WHO are the general guidelines. That is why; different countries have established their own water quality standards to meet their national priorities taking into account their economic, technical, social, cultural and political requirements. The PCRWR and Pakistan Standard Institution (PSI) have already drafted drinking water quality standards; however, the enforcement of these standards is still pending. This matter needs to be addressed on top priority basis. The WHO guidelines and standards proposed by national agencies like PCRWR, Pakistan Standard Institution (PSI), International Bottled Water Association (IBWA), Food Development Authority (FDA), Environmental Protection Agency (EPA) and other countries are presented in this section.

1.1 WHO. GUIDELINES:

A: Bacteriological Qualities:

Source/Organisms	Guideline value
a. all water intended for drinking (E. coli or thermo tolerant coli form bacteria)	Must not be detectable in any 100 ml sample
b. Treated water entering the distribution system (E. coli of thermo tolerant coli form and total coli form bacteria)	Must not be detectable in any 100 ml sample
c. treated eater in the distribution system (E. coli or thermo tolerant coli form and total coli form bacteria)	Must not be detectable in any 100 ml sample in the case of large supplies where sufficient 95% of samples taken throughout any 12-month period.

B. Chemicals of Health Significance:

Inorganic	mg/L	Inorganic	mg/L	Inorganic	mg/L
Antimony	0.005	Copper	2.000	Molybdenum	0.070
Arsenic	0.010	Cyanide	0.070	Nickel	0.020
Barium	.0700	Fluoride	1.500	Nitrate(NO3)	50.00
Boron	0.300	Lead	0.010	Nitrate(NO2)	03.00
Cadmium	0.003	Manganese	0.500	Selenium	0.010
Chromium	0.050	mercury	0.001		

C. Other parameters:

Inorganic	mg/L	Inorganic	mg/L	Inorganic	mg/L
Color	15 TUC	1.2 dichlorobenzene	1-10	Hardness, pH, DO	-
Taste, dour.	-	1.4Dichlorobenzene	0.3-30	Hydrogen sulfide	0.05
Turbidity	5NTU	Dichlorobenzene	5-50	Iron	0.3
Toluene	24-170	Synthetic detergents	-	Manganese	0.1
Xylenes	20-1800	Aluminum	0.2	Sodium	200
Ethyl benzene	2.4-200	Ammonia	1.5	Sulfate	250
Styrene	4-2600	Chloride	250	TDS	1000
Monochlorobenzene	10-120	Copper	1	Zinc	3

D. Disinfectants and Disinfectant by Products:

Name	Value	Name	Value
Chlorine chlorophenol	600-1000	2,4,6 trichlorophenol	2-300
2,4-dichlorophenol	0.3-40	2-chlorophenol	0.1-10

1.2 Standards Drafted By Pakistan Council for Research in Water Resources PCRWR:

A. Bacteriological Standards (Urban and Rural water supplies):

Categories	Standards
<i>A. Piped Water Supplies</i>	
A-1 Treated water Entering the distribution system	
• Fecal Coli form	0/100 ml
• Coli form organisms	0/100 ml
A-2 Un-treated water entering the distribution system	
• Fecal Coli form	0/100 ml
• Coli form organisms	0/100 ml
• Coli form Organism	3/100 ml
A-3 Water in the distribution system	
• Fecal Coli form	0/100 ml
• Coli form organisms	0/100 ml
• Coli form organism	3/100 ml
<i>B. Un-piped Water Supplies</i>	
• Faecal Coli form	0/100 ml
• Coli form Organism	10/100 ml

B. Standards for Inorganic Health Related Constituents:

Constituent	Unit	HDL*	MPL**	Toxic Effects
Fluoride	mg/L	1.00	1.500	Dental fluorosis in children, excessive concentrative may cause crippling skeletal fluorosis
Nitrate (NO ₃)	mg/L	45.000	45.000	Infantile Methaemoglobinaemia
Lead	mg/L	0.050	0.050	Children particularly susceptible to effects of lead on central nervous system
Mercury	mg/L	0.001	0.001	Neurological effects

*Highest Desirable level

** Maximum Permissible level

C. Other Parameters:

Constituent	Unit	HDL*	MPL**	Undesirable Effects
Turbidity	NTU	2.5	5	Un-aesthetic, decreases in efficiency of disinfections
Color	PCU	5	15	Un-aesthetic
Taste & Odour	-	Unobjectionable		Taste & Odor
TDS	mg/L	500	1500	Fault or salty taste, corrosion or instruction
Iron	mg/L	0.1	1.0	Taste, Discoloration
Manganese	mg/L	0.05	0.5	Taste, discoloration
Copper	mg/L	0.05	1.5	Taste, corrosion of pipes and utensils taste
Zinc	mg/L	5	15.0	Taste
Sulfate	mg/L	200	400	Corrosion, Laxative effective
Chloride	mg/L	200	600	Taste, Corrosion
pH	-	7.0-8.5	6.5-9.2	Taste, Corrosion
Hardness	mg/L	200	500	Corrosion or scale formation
Phenolic substances	mg/L	0.001	0.002	Taste

*Highest Desirable level

** Maximum Permissible level

1.3 Pakistan Standard Institution :(Drinking Water Quality Standards)

A. Physical Requirements:

S.#	Characteristics	Unit	MAC*	MAC**
1.	Turbidity	NTU	5	25
2.	Color	TCU	5	50
3.	Taste & Odour	-	Unobjectionable	
4.	pH	-	7.0-8.5	>6.5-<9.2

B. Chemical Requirements:

1.	Total Dissolved Solids	mg/L	1000	1500
2.	Chloride (Cl)	mg/L	200	600
3.	Sulfate (SO ₄)	mg/L	200	400
4.	Nitrate (NO ₃)	mg/L	-	45
5.	Total Hardness (CaCO ₃)	mg/L	20	500
6.	Nitrate (NO ₂)	mg/L	Nil	Nil
7.	Magnesium (Mg)	mg/L	500	1000
8.	Total Ammonia	mg/L	0.1	0.5
9.	Hydrogen Sulfide	mg/L	Undetectable Odour	
10.	Fluoride (F)	mg/L	-	15
11.	Iron (Fe)	mg/L	0.3	1.0
12.	Zinc (Zn)	mg/L	5.0	15.0
13.	Manganese (Mn)	mg/L	0.1	0.5
14.	Copper (Cu)	mg/L	1.0	1.5
15.	Calcium (Ca)	mg/L	75	200
16.	Magnesium (Mg)	mg/L	50	150
17.	Phenolic Substances	mg/L	0.001	0.002
18.	Alkyl Benzyl Sulfates	mg/L	0.5	1.0
19.	Carbon Chloroform Extract	mg/L	0.2	0.5

C. Limits of Toxic Substances:

1.	Arsenic (As)	mg/L	0.05	-
2.	Cadmium (Cd)	mg/L	0.01	-
3.	Chromium (Cr)	mg/L	0.05	-
4.	Cyanide (Cn)	mg/L	0.20	-
5.	Lead (Pb)	mg/L	0.05	-
6.	Selenium (Se)	mg/L	0.20	-
7.	Radionuclide	Uo/L	1000	-

D. Biological requirements (Chemical Indicators of Pollution):

1.	Chemical Oxygen Demand (COD)	mg/L	10	-
2.	Biochemical Oxygen Demand (BOD)	mg/L	6	-
3.	Ammonia (NH ₃)	mg/L	0.5	-
4.	Grease	mg/L	1	-

E. Limits for Bacteriological Contaminants:

Acceptable bacterial standard for potable water supplies:

i. Standard plate count (SPC)/mls	No more than 100
ii. Presumptive test for Coli form	Negative
iii. Most probable number (MPN)	< 101 subject to the frequency of opportunity for water analysis

* Maximum Acceptable Concentration

** Maximum Allowable Concentration

1.4 International Bottled Water Association (IBWA) Standards:

A. Chemical Quality:

Characteristics	Unit	Standard	Characteristics	Unit	Standard
Arsenic (As)	mg/L	0.05	Mercury (Hg)	mg/L	0.001
Barium (Ba)	mg/L	1	Nitrate (NO ₃)	mg/L	10
Cadmium (Cd)	mg/L	0.005	Nitrate (NO ₂)	mg/L	1
Chromium (Cr)	mg/L	0.05	Selenium (Se)	mg/L	0.01
Chloride (Cl)	mg/L	250	Silver (Ag)	mg/L	0.025
Copper (Cu)	mg/L	1	Sulfate (SO ₄)	mg/L	250
Cyanide (Cn)	mg/L	0.1	Phenolic	mg/L	0.001
Fluoride (F)	mg/L	4	PCB	mg/L	0.0005
Iron (Fe)	mg/L	0.3	TDS	mg/L	500
Lead (Pb)	mg/L	0.005	Zinc (Zn)	mg/L	5
Manganese (Mn)	mg/L	0.05	-	-	-

B. Microbiological Quality:

Total Plate Count/ml	CFU/ml	<200	Escherichia Coli	MPN/100ml	
Coliform (MPN/100ml)	MPN/100ml	<200	Salmonella	CFU/100ml	

1.5 Food Development Authority (FDA) Water Standards:

Characteristics	Unit	Standard	Characteristics	Unit	Standard
Arsenic (As)	mg/L	0.05	Nitrate (NO ₃)	mg/L	10

Barium (Ba)	mg/L	1	Selenium (Se)	mg/L	0.01
Cadmium (Cd)	mg/L	0.01	Silver (Ag)	mg/L	0.05
Chromium (Cr)	mg/L	0.05	Sulfate (SO ₄)	mg/L	250
Chloride (Cl)	mg/L	250	Phenolic	mg/L	0.001
Copper (Cu)	mg/L	1	Ra 226 activity (pCi/l)	mg/L	5
Iron (Fe)	mg/L	0.3	Total Beta Activity (pCi/l)	mg/L	8
Lead (Pb)	mg/L	0.05	TDS	mg/L	500
Manganese (Mn)	mg/L	0.05	Zinc (Zn)	mg/L	5
Mercury (Hg)	mg/L	0.002	Coliform (MPN/100ml)		<2.20

1.6 National Environmental water Quality Standards (NEQS)* (for Municipal and Liquid Industrial Effluents:

Sr.#	Parameter	Standards
1.	Temperature	40 C
2.	pH Value (acidity/ basicity)	6-10 pH
3.	5-Day Biochemical Oxygen Demand (BOD) at 20 ⁰ C	80 mg/L
4.	Chemical Oxygen Demand (COD)	150 mg/L
5.	Total Suspended Solids	150 mg/L
6.	Total Dissolved Solids	3500 mg/L
7.	Grease and oil	10 mg/L
8.	Phenolic Compounds (as phenol)	0.1 mg/L
9.	Chloride (as Cl)	1000 mg/L
10.	Fluoride (as F)	20 mg/L
11.	Cyanide (as Cn)	2 mg/L

12.	An-ionic detergents (as MBAS) ³	20 mg/L
13.	Sulfate (SO ₄)	600 mg/L
14.	Sulfide (S)	1.0 mg/L
15.	Ammonia (NH ₃)	40 mg/L
16.	Pesticides, Herbicides, fungicides and insecticides	6.15 mg/L
17.	Cadmium	0.1 mg/L
18.	Chromium (Trivalent and hexavalent)	1.0 mg/L
19.	Copper	1.0 mg/L
20.	Lead	0.5 mg/L
21.	Mercury	0.01 mg/L
22.	Selenium	0.5 mg/L
23.	Nickel	1.0 mg/L
24.	Silver	1.0 mg/L
25.	Total Toxic Metals	2.0 mg/L
26.	Zinc	5.0 mg/L
27.	Arsenic	1.0 mg/L
28.	Barium	1.5 mg/L
29.	Iron	2.0 mg/L
30.	Manganese	1.5 mg/L
31.	Boron	6.0 mg/L
32.	Chlorine	1.0 mg/L

*Published by Environmental Protection Agency (EPA) in August 10, 2000.

1.7 Indian Water Quality Standards:

A. Physical and Chemical Standards:

Sr. #	Characteristics (mg/L)	Acceptable	Marginal	Sr.#	Characteristics (mg/L)	Acceptable	Marginal
1.	Turbidity (NTU)	2.5	10	6.	Fluoride	1.0	1.5
2.	Colour (TCU)	5	25	7.	Nitrate (N)	45	45
3.	Taste and Odour	Unobjectionable		8.	Calcium	75	200
4.	pH	7-8.5	6.5-9.2	9.	Magnesium	30	150
5.	TDS	500	1500	10.	Iron	0.1	
11.	Hardness	200	600	20.	Manganese	0.05	0.5
12.	Chloride	200	1000	21.	Copper	0.05	1.5
13.	Sulfate	200	400	22.	Zinc	5.0	15
14.	Phenolic Compounds	0.001	0.002	23.	Lead	0.1	0.1
15.	Anionic	0.2	1.0	24.	Selenium	.01	0.001
16.	Arsenic	0.05	0.05	25.	Mercury	0.001	0.2
17.	Cadmium	0.1	0.1	26.	Polynuclear aromatic hydrocarbons (g/L)	0.2	3
18.	Chromium	0.05	0.05	27.	Gross Alpha Activity	3 (pCi/l)	30
19.	Cyanide	0.05	0.05	28.	Gross Beta Activity pico curie/l	30 (pCi/l)	-

The figures indicated under the column "Acceptable" are the limits up to which the water is generally acceptable to the consumers.

Figures in excess of those mentioned under "acceptable" render water not acceptable, but still may be tolerated in absence of alternative and better source but up to the limits indicated under column "Marginal" above which the supply will have to be rejected.

B. Bacteriological Standards:

Water entering the distribution system coliform count in any sample of 100ml should be zero.

Water in the distribution system shall satisfy all the three criteria indicated below.

E.Coli count in 100 ml of any sample should be zero.

Coliform organisms no more than 10 per 10 ml shall be present in any sample, and

Coliform organism should not be detectable in 100 ml of any two consecutive samples or more than 50% of the samples collected for the year.

Individual or small community supplies

E.Coli count should be zero in any sample of 100ml and coliform organisms should not be more than 3 per 100 ml.

C. Virological Aspects:

A level of 0.5 mg/L of free chlorine residual for one hour is sufficient to inactivate virus, even in water that was originally polluted. This free chlorine residual is to be insisted in all disinfected supplies in areas suspected of endemicity of infectious hepatitis to take care of the safety of the supply from virus point of view, which incidentally takes care of the safety from the bacteriological point of view as well. For other areas 0.2 mg/L of free chlorine residual for half an hour should be insisted.

1.8 Water Quality Standards of Indonesia, Singapore, Malaysia, Thailand, Philippines and Brunei:

A. Chemical Quality:

S.#	Substances	Unit	Indonesia	Singapore	Malaysia	Thailand	Philippines	Brunei
1.	Arsenic (As)	mg/L	0.05	0.05	0.05	0.05	0.05	<0.003
2.	Barium (Ba)	mg/L	-	1	-	1	-	<0.02
3.	Borate (BO ₃)	mg/L	-	0.03	30	-	-	0.2
4.	Cadmium (Cd)	mg/L	0.1	0.01	0.01	0.005	0.01	<0.002
5.	Chromium(Cr)	mg/L	-	0.05	0.05	0.05	0.05	<0.01
6.	Chloride (Cl)	mg/L	250	0.05	-	250	-	-
7.	Chlorine (Cl ₂)	mg/L	-	-	1	1	-	-
8.	Copper (Cu)	mg/L	0.5	-	-	0.1	1	<0.01
9.	COD	mg/L	-	-	0.01	1	-	-
10.	Cyanide (CN)	mg/L	0.05	0.01	2	-	0.01	-
11.	Fluoride (F)	mg/L	1	2	-	-	2	0.09
12.	Hardness(CaCO ₃)	mg/L	170	-	-	100	-	-
13.	Iodine (I)	mg/L	-	1	-	0.3	-	-
14.	Iron (FE)	mg/L	0.1	-	-	0.05	1	-
15.	Lead (Pb)	mg/L	0.05	0.05	0.05	0.05	0.05	<0.01
16.	Manganese (Mn)	mg/L	0.05	2	2	0.002	0.1	0.01
17.	Mercury (Hg ⁰)	mg/L	0.001	1	0.001	-	-	-
18.	Mineral Oil	mg/L	-	ND	ND	-	-	-
19.	Nitrate (NO ₂)	mg/L	ND	45	45	4	45	<0.01
20.	Nitrate (NO ₂)	mg/L	ND	0.005	0.005	-	0.01	-
21.	Organic Matter	mg/L	1	0.003	3	-	5	-
22.	Selenium (Se)	mg/L	-	0.01	0.01	0.01	0.01	-

1.8 Water Quality Standards of Indonesia, Singapore, Malaysia, Thailand, Philippines and Brunei:

A. Chemical Quality:

S.#	Substances	Unit	Indonesia	Singapore	Malaysia	Thailand	Philippines	Brunei
1.	Arsenic (As)	mg/L	0.05	0.05	0.05	0.05	0.05	<0.003
2.	Barium (Ba)	mg/L	-	1	-	1	-	<0.02
3.	Borate (BO ₃)	mg/L	-	0.03	30	-	-	0.2
4.	Cadmium (Cd)	mg/L	0.1	0.01	0.01	0.005	0.01	<0.002
5.	Chromium(Cr)	mg/L	-	0.05	0.05	0.05	0.05	<0.01
6.	Chloride (Cl)	mg/L	250	0.05	-	250	-	-
7.	Chlorine (Cl ₂)	mg/L	-	-	1	1	-	-
8.	Copper (Cu)	mg/L	0.5	-	-	0.1	1	<0.01
9.	COD	mg/L	-	-	0.01	1	-	-
10.	Cyanide (CN)	mg/L	0.05	0.01	2	-	0.01	-
11.	Fluoride (F)	mg/L	1	2	-	-	2	0.09
12.	Hardness(CaCO ₃)	mg/L	170	-	-	100	-	-
13.	Iodine (I)	mg/L	-	1	-	0.3	-	-
14.	Iron (FE)	mg/L	0.1	-	-	0.05	1	-
15.	Lead (Pb)	mg/L	0.05	0.05	0.05	0.05	0.05	<0.01
16.	Manganese (Mn)	mg/L	0.05	2	2	0.002	0.1	0.01
17.	Mercury (Hg ⁰)	mg/L	0.001	1	0.001	-	-	-
18.	Mineral Oil	mg/L	-	ND	ND	-	-	-
19.	Nitrate (NO ₂)	mg/L	ND	45	45	4	45	<0.01
20.	Nitrate (NO ₂)	mg/L	ND	0.005	0.005	-	0.01	-
21.	Organic Matter	mg/L	1	0.003	3	-	5	-
22.	Selenium (Se)	mg/L	-	0.01	0.01	0.01	0.01	-

23.	Silver (Ag)	mg/L	-	-	--	-	2	-
24.	Surfactant	mg/L	-	ND	ND	-	2	-
25.	Sulfide (S)	mg/L	ND	-	-	250	-	-
26.	Sulphate (SO ₄)	mg/L	200	-	-	250	-	-
27.	Phenolic	mg/L	-	ND	ND	0.001	0.001	0.001
28.	Ra 226 activity	pCi/l	-	30	-	-	-	-
29.	Total Beta activity	pCi/l	-	1	-	-	-	-
30.	TDS	mg/L	500	-	-	500	-	-
31.	Zinc (Zn)	mg/L	-	-	5	5	5	-

B. Microbiological Quality:

1.	Total Plate Count/ml	CFU/ml	Max 1×10^4	Max. 1×10^5	-	-	-	-
2.	Coliform(MPN/100ml)	MPN/100ml	<2.20	0/250ml	Max.10	<2.20	<2.20	Nil
3.	Escherichia Coli	MPN/100ml	0	0	0	Negative	-	Nil
4.	Salmonella/100ml	CFU/100ml	-	0	-	-	-	-
5.	Staphylococcus Aureus/250 ml	CFU/250ml	-	0	-	-	-	-
6.	Pseudomonas Aeruginosa/250ml	CFU/250ml	0	0	-	-	1/100ml	-
7.	Faecal Streptococci/20ml	MPN/20ml	-	-	-	-	1/100ml	-

1.9 Water Quality Standards of Vietnam, Japan, China, Hong Kong, Korea and Taiwan:

A. Chemical Quality:

S.#	Substances	Unit	Vietnam	Japan	China	H.Kong	Korea	Taiwan
1.	Arsenic (As)	mg/L	0.05	<0.2	0.05	0.01	0.05	0.05
2.	Ammonium (NH ₄)	mg/L	-	<0.5	-	1.5	0.5	-
3.	Barium (Ba)	mg/L	-	-	-	0.7	-	-
4.	Borate (BO ₃)	mg/L	10	-	-	0.3	-	-
5.	Cadmium (Cd)	mg/L	0.01	<0.05	0.01	0.003	0.01	0.01
6.	Chromium (Cr)	mg/L	-	<0.05	0.05	0.05	0.05	0.05
7.	Chloride (Cl)	mg/L	-	<350	250	250	150	250
8.	Chlorine (Cl ₂)	mg/L	-	-	-	-	-	1
9.	Copper (Cu)	mg/L	1	<0.05	1	2	1	0.01
10.	COD	mg/L	-	-	-	-	-	0.8
11.	Cyanide (Cn)	mg/L	0.01	<0.01	0.01	0.07	ND	-
12.	Fluoride (F)	mg/L	2	<1.5	0.8	1.5	1	-
13.	Hardness (CaCO ₂)	mg/L	-	100-500	250	-	300	250
14.	Iodine (I)	mg/L	-	-	-	-	-	0.3
15.	Iron (Fe)	mg/L	-	<0.1	0.3	0.3	0.3	0.05
16.	Lead (Pb)	mg/L	0.05	<0.1	0.05	0.01	0.1	0.05
17.	Manganese (Mn)	mg/L	2	<0.1	0.05	0.5	0.3	0.001

18.	Mercury (Hg)	mg/L	-	-	0.001	0.001	ND	-
19.	Nitrate (NO ₃)	mg/L	45	<5.0	10	50	10	10
20.	Nitrate (NO ₂)	mg/L	-	-	ND	3	-	ND
21.	Organic Matter	mg/L	3	-	0.1	-	-	0.1
22.	Selenium (Se)	mg/L	-	<0.05	0.01	0.01	0.01	0.01
23.	Silver (Ag)	mg/L	0.01	-	0.05	-	-	0.05
24.	Sulphate (SO ₄)	mg/L	-	<250	250	250	200	250
25.	Phenolic	mg/L	-	<0.001	-	-	0.005	-
26.	Total Beta activity	pCi/l	-	-	-	1.0Bq/l	-	-
27.	TDS	mg/L	-	<1000	500	1000	-	500
28.	Zinc (Zn)	mg/L	5	<5	5	3	1	5

B. Microbiological Quality:

1.	Total Plate Count/ml	CFU/ml	<10	-	100	-	<100	-
2.	Coliform (MPN/100ml)	Mpn/100ml	-	<15.100	3	<2.2	0	-
3.	Escherichia Coli	MPN/100ml	2.2	-	-	-	-	0/100ml

1.10 Water Quality Standards of Saudi Arabia, Guam, Australia, Argentina, Mexico and Canada:

A. Chemical Quality:

S. #	Substances	Unit	S.Arabia	Guam	Australia	Argentina	Mexico	Canada
1.	Arsenic (As)	mg/L	0.05	0.05	0.05	0.05	0.05	0.025
2.	Ammonium (NH ₄)	mg/L	-	-	-	0.2	0.5	-
3.	Bartium (Ba)	mg/L	1	1	1	-	0.7	1
4.	Borate (BO ₃)	mg/L	-	-	30	-	-	5
5.	Cadmium (Cd)	mg/L	0.01	0.01	0.005	0.01	0.005	0.005
6.	Chromium (Cr)	mg/L	0.05	0.05	0.05	0.05	-	0.05
7.	Chloride (Cl)	mg/L	250	250	-	350	250	-
8.	Chlorine (Cl ₂)	mg/L	-	-	0.01	0.5	0.1	-
9.	Copper (Cu)	pCi/l	1	1	1	2	1	-
10.	COD	mg/L	-	-	3	-	-	-
11.	Cyanide (Cn)	mg/L	0.05	-	0.1	0.10	-	0.2
12.	Fluoride (F)	mg/L	-	-	1.5	2	2	-
13.	Iron (Fe)	mg/L	0.3	0.3	-	2	0.3	-
14.	Lead (Pb)	mg/L	0.05	0.05	-	0.05	0.02	0.01
15.	Manganese (Mn)	mg/L	0.05	0.05	2	0.1	0.05	-
16.	Mercury (Hg)	mg/L	-	0.002	0.001	0.001	0.001	0.001
17.	Nitrate (NO ₃)	mg/L	-	10	45	45	10	45

18.	Nitrite (NO ₂)	mg/L	-	-	0.041	0.1	-	3.2
19.	Selenium (Se ⁰)	mg/L	-	0.01	0.01	-	0.05	0.01
20.	Silver (Ag)	pCi/l	0.05	0.05	-	0.05	-	-
21.	Surfactant	mg/L	-	-	-	-	0.5	-
22.	Sulfide (S)	mg/L	-	-	0.05	-	-	-
23.	Sulphate (SO ₄)	mg/L	250	250	-	500	250	-
24.	Phenolic	mg/L	0.001	0.001	-	-	0.001	-
25.	Ra activity	226 pCi/l	3	5	1	-	-	-
26.	Total Beta activity	pCi/l	-	8	-	-	-	-
27.	TDS	mg/L	-	500	-	1500	500	-
28.	Zinc (Zn)	mg/L	5	5	5	5	3	-

B. Microbiological Quality:

1.	Total Plate Count/ml	CFU/ml	-	-	<1	500	100	100
2.	Coliform(MPN/100ml)	MPN/100ml	-	<2.20	Max.1'0	3	<2	-
3.	Escherichia Coli	MPN/100ml	-	-	-	Negative	-	0
4.	Pseudomonas Aeruginosa/250ml	CFU/250ml	-	-	-	Negative	-	0

Source: Pakistan Council of Research in Water Resources (2005) "Water Quality Status third report 2003-04" publication no. 131-2005. PCRWR, Ministry of Science and Technology Government of Pakistan Islamabad. pp 25-33.

Drinking Water Quality Standards

Pollution Control Department, Ministry of Natural Resources and
Environment, Bangkok Thailand.

Properties	Parameters	Units	Standards	
			Maximum Acceptable Concentration	Maximum Allowable Concentration
Physical	Color	Pt-Co	5	15
	Taste	-	Non Objectionable	Non Objectionable
	Odor	-	Non Objectionable	Non Objectionable
	Turbidity	SSU	5	20
	PH	-	6.5-8.5	9.2
Chemical	Total Solids	mg/dm ³	500	1,500 ^a
	Iron (Fe)	mg/dm ³	0.5	1.0
	Manganese (Mn)	mg/dm ³	0.3	0.5
	Fe & Mn	mg/dm ³	0.5	1.0
	Copper (cu)	mg/dm ³	1.0	1.5
	Zinc (Zn)	mg/dm ³	5.0	15.0
	Calcium (Ca)	mg/dm ³	75 ^b	200
	Magnesium (Mg)	mg/dm ³	50	150
	Sulphate (SO ₄)	mg/dm ³	200	250 ^c
	Chloride (Cl)	mg/dm ³	250	600
	Fluroride (F)	mg/dm ³	0.7	1.0
	Nitrate (NO ₃)	mg/dm ³	45	45
	Alkylbenzyl Sulfonates (ABS)	mg/dm ³	0.5	1.0
	Phenolic substance (as phenol)	mg/dm ³	0.001	0.002
Toxic elements	Mercury (Hg)	mg/dm ³	0.002	-
	Lead (Pb)	mg/dm ³	0.05	-

	Arsenic (As)	mg/dm ³	0.05	-
	Selenium (Se)	mg/dm ³	0.01	-
	Chromium (Cr hexavalent)	mg/dm ³	0.05	-
	Cyanide (CN)	mg/dm ³	0.2	-
	Cadmium (Cd)	mg/dm ³	0.01	-
	Barium (Ba)	mg/dm ³	1.0	-
Bacterial	Standard plate count	colonies/cm ³	500	-
	Total coliform	MPN/100cm ³	2.2	-
	E.Coli	MPN/100cm ³	None	-

Remarks

Pt-Co: Platinum Cobalt Scale

SSU: Silica Scale Unit, mg/d m³: milligram per cubic decimeter

MPN: Most Probable Number

- These values are allowed for tap water or ground water that is used as temporary drinking water. Such water with a parameter between the maximum acceptable concentration and the maximum allowable concentration cannot be certified as standard drinking water for industrial products and stamped with the standard logo.
- If the calcium concentration is higher than the standard and magnesium concentration is lower than the standard, calcium and magnesium will be identified in terms of total hardness with a standard value of less than 300 mg/dm³ (as CaCO₃).
- If a sulphate concentration of 250 mg/dm³ is reached, magnesium concentration must not be more than 30 mg/dm³.

Source: Notification of the Ministry of Industry, Bangkok, Thailand No. 322, B.E. 2521 issued under the Industrial Products Standards Act B.E. 2511 (1968), published in the Royal Gazette, Vol. 95, Part 68, dated July 4, B.E. 2521 (1978).

Surface Water Quality

Bangkok, Thailand

Classification and Objectives	
Classification	Objectives/Condition and Beneficial Usage
Class 1	Extra clean fresh surface water resources used for : conservation not necessary pass through water treatment process require only ordinary process for pathogenic destruction ecosystem conservation where basic organisms can breed naturally
Class 2	Very clean fresh surface water resources used for : consumption which requires ordinary water treatment process before use aquatic organism of conservation fisheries recreation
Class 3	Medium clean fresh surface water resources used for : consumption, but passing through an ordinary treatment process before using agriculture
Class 4	Fairly clean fresh surface water resources used for : consumption, but requires special water treatment process before using industry
Class 5	The sources which are not classification in class 1-4 and used for navigation

Surface Water Quality Standards:

Sr. No.	Parameter	Units	Statistics	Class 1	Class 2	Class 3	Class 4	Class 5	Methods Examination for
1.	Color, Odor and Taste	-	-	n	n	N	n	-	-
2.	Temperature	Co	-	n'	n'	N'	n'	-	Thermometer

3.	pH	-	-	n	5-9	5-9	5-9	-	Electrometric pH Meter
4.	Dissolved Oxygen	mg/L	P20	n	6	4	2	-	Azide Modification
5.	BOD (5 days, 20oC)	mg/L	P80	n	1.5	2.0	4.0	-	Azide Modification at 20 o C , 5 days
6.	Coliform bacteria								Multiple Fermentation Technique
	- Total coliform	MPN/100 ml	P80	n	5,000	20,000	-	-	
	- Fecal coliform	MPN/100 ml	P80	n	1,000	4,000	-	-	
7.	NO3 -N	mg/L	Max. allowance	n	0.5			-	Cadmium Reduction
8.	NH3-N	mg/L	-	n	0.5			-	Distillation Nesslerization
9.	Phenols	mg/L	-	n	0.005			-	Distillation,4-Amino antipyrine
10.	Copper (Cu)	mg/L	-	n	0.1			-	Atomic Absorption-Direct Aspiration
11.	Nickel (Ni)	mg/L	-	n	0.1			-	Atomic Absorption-Direct Aspiration
12.	Manganese (Mn)	mg/L	-	n	1.0			-	Atomic Absorption-Direct Aspiration
13.	Zinc (Zn)	mg/L	-	n	1.0			-	Atomic Absorption-Direct Aspiration
14.	Cadmium (Cd)	mg/L	-	n	0.005* 0.05**			-	Atomic Absorption-Direct Aspiration
15.	Chromium Hexavalent	mg/L	-	n	0.05			-	Atomic Absorption-Direct Aspiration
16.	Lead (Pb)	mg/L	-	n	0.05			-	Atomic Absorption-Direct Aspiration
17.	Total Mercury	mg/L	-	n	0.002			-	Atomic Absorption-Cold Vapour Technique
18.	Arsenic (As)	mg/L	-	n	0.01			-	Atomic Absorption-Gaseous Hydride
19.	Cyanide (CN)	mg/L	-	n	0.005			-	Pyridine-Barbituric Acid
20.	Radioactivity								Low Background Proportional Counter
	- Alpha	Becqurel /l	-	n	0.1			-	
	-Beta	Becqurel /l	-	n	1.0			-	

21.	Total Organochlorine Pesticides)	mg/L	-	n	0.05	-	Gas-Chromatograp
22.	DDT	µg/L	-	n	1.0	-	Gas-Chromatograp
23.	Alpha-BHC	µg/L	-	n	0.02	-	Gas-Chromatograp
24.	Dieldrin	µg/L	-	n	0.1	-	Gas-Chromatograp
25.	Aldrin	µg/L	-	n	0.1	-	Gas-Chromatograp
26.	Heptachlor & Heptachlorepoxi d e	µg/L	-	n	0.2	-	Gas-Chromatograp
27.	Endrin	µg/L	-	n	none	-	Gas-Chromatograp

Remarks

- P Percentile value
n Naturally
n' Naturally but changing not more than 3 ° C
* when water hardness not more than 100 mg/L as CaCO₃
** when water hardness more than 100 mg/L as CaCO₃

Based on Standard Methods for the Examination of Water and Wastewater recommended by APHA : American Public Health Association, AWWA : American Water Works Association and WPCF : Water Pollution Control Federation

Source:

Notification of the National Environmental Board, Bangkok, Thailand, No. 8, B.E. 2537 (1994), issued under the Enhancement and Conservation of National Environmental Quality Act B.E.2535 (1992), published in the Royal Government Gazette, Vol. 111, Part 16, dated February 24, B.E.2537 (1994).

Drinking Water Standards of Various Countries:

Physical Parameters

Sr. No	Parameter	ELH-BEST	WHO	US EPA	Canada	EEC	S. Africa	Taiwan	China	Czech Rep.
1.	Total Dissolved Solids (mg/L)	100	1000	500	500			500	1000	1000
2.	Taste and Odor (TON)			3						2
3.	Temperature (°C)				15					
4.	Turbidity (NTU)	0.1	5	1	1		0.5	4	<3	5 ZF
5.	pH	0.1	<8.0	6.5 – 8.5	6.5 – 8.5		6-9.5	6.5-8.5	6.5-8.5	6.0-8.0

Inorganic: mg/L (ppm)

Sr. No.	Parameter	ELH-BEST	WHO	EPA	Canada	EEC	S. Africa	Taiwan	China	Czech Rep.
6.	Ammonia	0.3	1.5			0.5	1.5			0.01
7.	Bromate	0.02	25			0.01	0.025			
8.	Bromide	0.02								
9.	Chlorate	0.02	NAD							
10.	Chloride	2	250	250	250	250	250	250		100
11.	Chlorite	0.02	200				0.2			
12.	Fluoride	0.2	1.5	4	1.5	1.5	1	0.8	1	1.5
13.	Hardness	0.2				>60(as Ca)	20-300	300	540	0.9-5mmol/l
14.	Iodine		NAD							
15.	Nitrate(as NO ₃ -)	0.2	50	10	10	50	10	10	20	50
16.	Nitrite (asNO ₂ -)	0.1	3	1	3.2	0.5	1			0.1
17.	Sulfate	0.5	250	250	500	250	200	250		250

Microbial Parameter:

Sr. No.	Parameter	ELH-BEST	WHO	EPA	Canada	EEC	S. Africa	Taiwan	China	Czech Rep.
18.	Total Coliform	1 cfu	ND		10 cfu			>1 cfu	3 N/100	0 cfu

Reference: Environmental Health Laboratories, "Toward Global Environmental Quality Standards" Division of under written Laboratories, Inc, 110 South Street, South Bend, IN 4667, 2000.

Abbreviations and Units:

1. EHL = Environmental Health Laboratories Broad Spectrum Test
2. US EPA = United States Environmental Protection Agency Secondary or Unregulated Analytes July 17, 1996
3. WHO = World Health Organization 1993
4. Canada = Canadian Drinking Water Quality Guidelines April 1996
5. Taiwan, Taipei Drinking Water Regulations June 25, 1996
6. EEC = European Economic Community June 25, 1996
7. UN = United Nations June 1996
8. CCL = US EPA Contaminant Candidate List March 2, 1998
9. South Africa, Umgeni 1998
10. China April, 1999
11. Czech Republic IWSA World Water Congress International Report 1999
1. mg/L = milligram per liter
2. ND =Not Detected in 100 ml
3. NAD= No adequate data to permit recommendation of a health-based guideline value
4. cfu = Colony Forming Unite per 100 ml
5. NTU= Nephelometric Turbidity Unit
6. N/100 ml= Number per 100 milliliter

Field and Laboratory Slides



Effluent drain of Shalman Marble in HIE Peshawar Sample # 3



Effluent drain of AGE Cable HIE Peshawar Sample # 4



Back side view of Pepsi Cola factory HIE sample # 6



Back side view of Pepsi Cola factory HIE sample # 6



Sample taken from Unique Marble factory HIE sample # 7



Drain of Olympia Paper & Board Mill HIE sample #8

Picture while taking sample of Savian Pharmaceuticals Pvt Ltd at HIE sample # 14.



Children playing near Gulab Banaspati (Ghee Mill) HIE near sample # 12



Picture while taking sample of Saydon Pharmaceuticals PVT LTD at HIE sample # 14



Combined effluent drain of Olympia & Sarhad Paper & Board Mills HIE
sample # 17(C-3)



Main effluent drain near RMI Peshawar Sample # 21

Main effluent drain near Prof. Ghalib Agri. University sample # 26



Main effluent drain near board bridge where B.Naran "Khwar" meet with it
sample # 23



Main effluent drain near Prof. Colony Agri. University sample # 26



Main effluent drain before mixing with Budni Nullah at Pir Bala sample #28



Main drain after mixing Marble effluent at Pir Bala



Main drain after mixing with Budni Nullah at Darmangi sample # 30



Sample taken near Nishaat Mill Charsadda road of main drain including Budni sample # 31



Main drain including Budni Nullah after mixing with Pesh. Sewage drain sample # 33



Shah Alam river before mixing with effluent drain sample # 35



Shah Alam River(branch of Kabul river) before mixing with main drain at Naqoba sample # 35





Preparation for collection of sample



Labelling of sample in laboratory.



Putting samples in oven for analysis of TDS in lab



Weighing the china dishes for measuring solids



Measuring pH in lab



Measuring Conductivity and Turbidity in the Lab.



Preparation and labelling of samples for detection of heavy

metals



Sample preparation for lab analysis



Picture taken while conducting COD in lab



Reagent preparation for COD in lab



Picture taken while putting BOD bottles in Incubator at 20 °C



Picking BOD bottles after 5 days incubation for measuring final DO