

2- WATER CYCLE

2-1 Rainfall

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

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

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

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

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

FIGURE-3

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

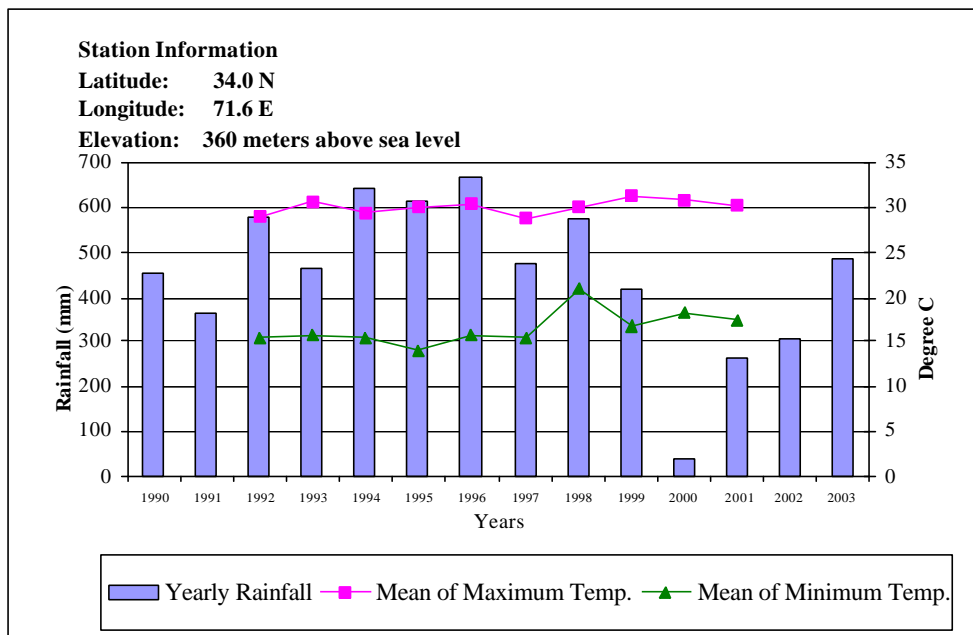


TABLE-16

MONTHLY TOTAL RAINFALL (mm) DATA for PESHAWAR

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

Source: Pakistan Meteorological Department

TABLE-17

MEAN of MAXIMUM and MINIMUM TEMPERATURE °C at PESHAWAR

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

Source: Pakistan Statistical Year Book, 2003

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

TABLE-18

DAILY RAINFALL DATA from 1st to 31st JANUARY, 2004

	Date	Rainfall (mm)
	01-01-2004	Trace
	02-01-2004	4.0
	03-01-2004	Nil
	04-01-2004	Nil
	05-01-2004	Nil
	06-01-2004	Trace
	07-01-2004	Nil
	08-01-2004	Nil
	09-01-2004	Nil
	10-01-2004	Nil
	11-01-2004	Nil
Water Quality Study Period	12-01-2004	Nil
	13-01-2004	Nil
Solid Waste Quality Study Period	14-01-2004	Nil
	15-01-2004	Nil
	16-01-2004	Nil
	17-01-2004	21.2
	18-01-2004	1.0
	19-01-2004	Nil
	20-01-2004	Nil
	21-01-2004	5.0
	22-01-2004	14.2
	23-01-2004	10.8
	24-01-2004	7.8
	25-01-2004	Nil
	26-01-2004	Nil
	27-01-2004	Nil
	28-01-2004	Nil
	29-01-2004	Trace
	30-01-2004	3.7
	31-01-2004	0.3
TOTAL RAINFALL		68.0

Source: Meteorological Office, Peshawar

2-2 Field Survey on Water Quality

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

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

TABLE-19

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

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

**Standard Method for the Examination of water and wastewater, 18th Edition, 1992.*

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

- The water sampling and spot testing team was given complete instructions on the importance and significance of correct sampling procedures.
- Standard Sampling Procedures (SOP) was followed for the water sampling.
- Samples were collected at locations where water was well mixed, homogenized and flowing samples were taken at the middle of the channels.
- Samples were preserved in an ice box at or near 4°C immediately after collection.
- Nitric acid (HNO₃) was added to the sampling bottles in quantities sufficient to lower the pH of the samples to just below 2 to stabilize the concentration of dissolved metals.
- Sampling bottles were given identification numbers immediately after the samples were collected
- For E-Coli sampling, sterilized glass container was used and the sample was shifted immediately under control temperature to National Institute of Health (NIH) for bacteriological analysis.

2-2-1 Testing Methods and Procedures

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

Temperature:

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

pH:

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

Dissolved Oxygen:

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

Conductivity:

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

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

Color:

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

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

TABLE-20

STANDARD SOLUTION for COLOR MEASUREMENT

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

Odor:

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

Turbidity:

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

Flow:

Digital current meter of Tamaya UC-204, Japan was used to measure the flow of the stream. Besides measuring the velocity of water, depth and width of the stream was also measured for the determination of water flow in m³/sec (cubic meter per second).

2-2-2 Laboratory Test Methods and Procedures

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

Biological Oxygen Demand (BOD)

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

Chemical Oxygen Demand (COD)

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

Suspended Solids:

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

Oil and Grease:

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

Total Nitrogen:

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

Heavy Metals Analysis:

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

2-2-3 Analytical Results and Discussion

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

TABLE-21

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

Unit: (mg/l, otherwise mentioned)

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

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

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

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

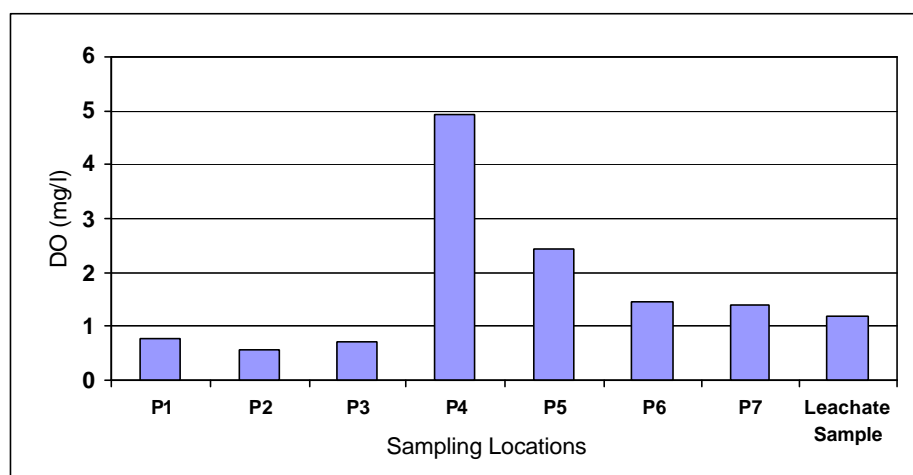
pH basically the buffering capacity of the $\text{CO}_3\text{-HCO}_3$ system in water. The pH rises when the carbonates in the water are utilized by the microorganisms, while the decomposition of organic pollutants causes pH to drop to the acidic range. pH in this study ranges from 7.34 to 8.89, while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

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

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

FIGURE-4

COMPARISON OF DISSOLVED OXYGEN AT SAMPLING POINTS IN HAYATABAD

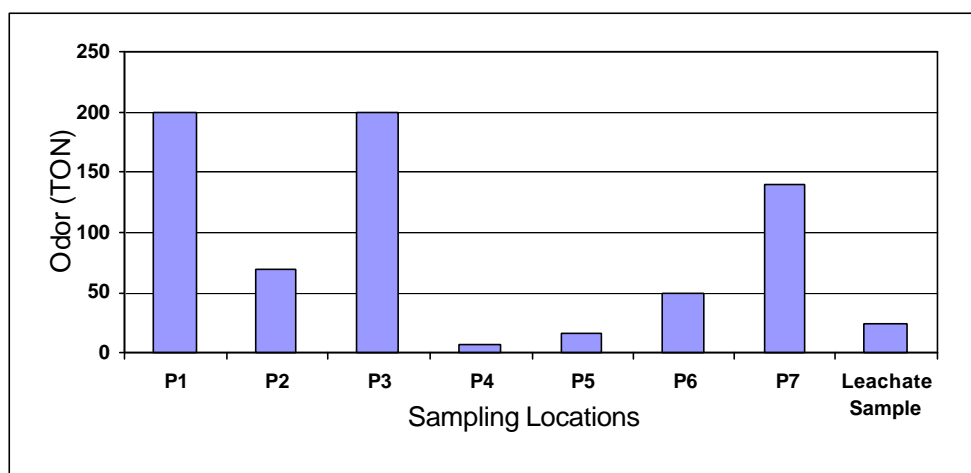


Color in water is caused by the natural metallic ion (iron and manganese). Many industrial wastes are colored. The true color of the samples collected was measured by the visual comparison method using the Platinum Cobalt Standard method. This method is useful for measuring color of potable water and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

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

FIGURE-5

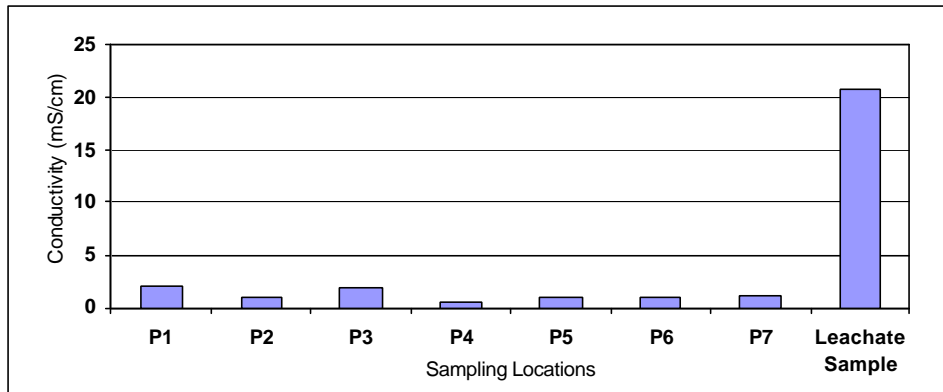
COMPARISON OF ODOR AT SAMPLING SITES IN HAYATABAD



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

FIGURE-6

COMPARISON OF CONDUCTIVITY AT DIFFERENT SAMPLING SITES IN HAYATABAD.

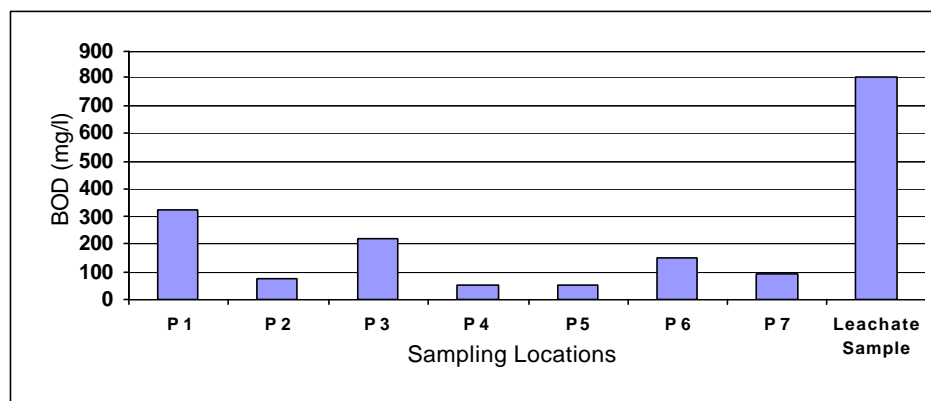


BOD represents the quantity of oxygen required by bacteria and other microorganisms during biochemical degradation and transformation of organic matter present in waste water or leachate under aerobic condition. The BOD test is important in the analysis of sewage, industrial, polluted water and leachate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

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

FIGURE-7

COMPARISON OF BOD AT DIFFERENT SAMPLING SITES IN HAYATABAD



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

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

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

TABLE-22

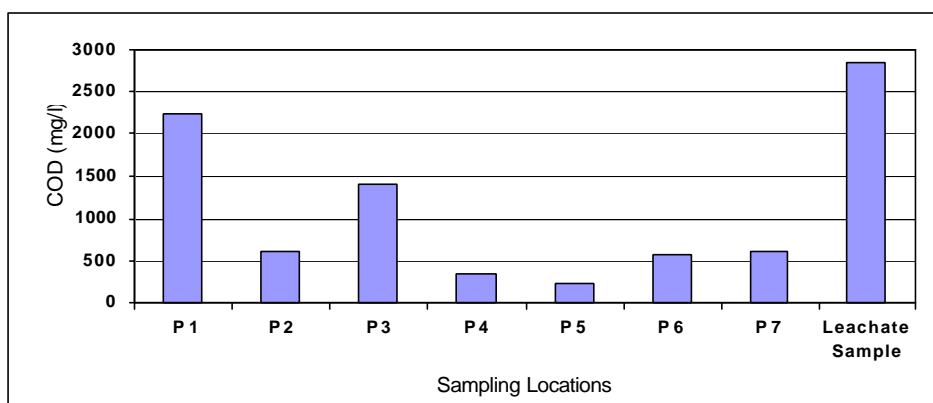
RELATIVE BIODEGRADABILITY OF LEACHATE

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

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

FIGURE-8

COMPARISON OF COD AT DIFFERENT SAMPLING SITES IN HAYATABAD

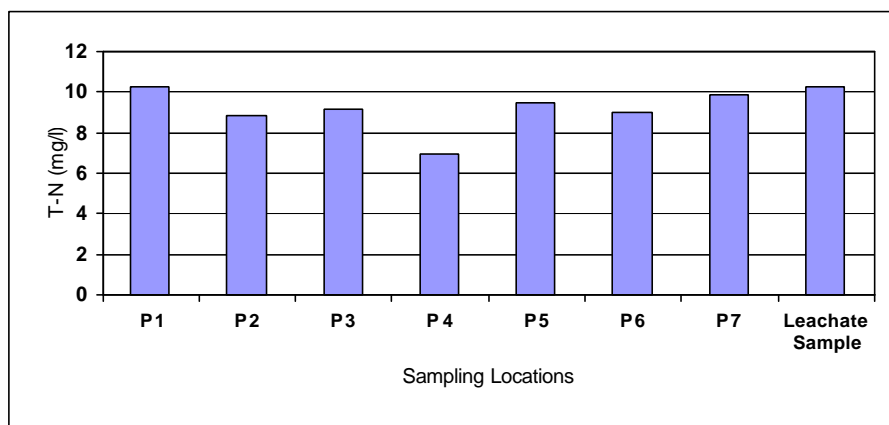


Total nitrogen (T-N) compounds in river and wastewater are important pollution indicating parameters. Nitrogen is considered a pollutant since it requires oxygen for oxidation in its unoxidized state, and because it contributes to the eutrophication of natural waters. The values of T-N detected from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

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

FIGURE-9

COMPARISON OF T-N AT SAMPLING SITES IN HAYATABAD



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

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

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

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

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

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

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

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

Annexure-A shows the 32 Standards of liquid effluents.

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

2-2-5 Pollution Load in Hayatabad Water Channel

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

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

TABLE-23

BOD and COD LOAD at DIFFERENT SAMPLING LOCATIONS in HAYATABAD

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

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

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

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

3- Sewage Treatment Plant in Hayatabad

3-1 Existing System

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

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

3-2 Deficiencies of Existing Sewage Treatment Plant

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