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GROUNDWATER POLLUTION WITH WASTEWATER: GENERATED BY INDUSTRIES AND MEGA CITIES OF THE COUNTRY

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by

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Abstract

The Groundwater is very precious gift of Almighty Allah. This resource is readily available for domestic, agriculture and as well as for industrial use. But we do not care this precious gift and are polluting it in different ways. As we are disposing the domestic and industrial wastewaters in fresh water bodies and it is creating a serious problem to human health, flora, fauna and agricultural productivity. The increase in industrialization and urbanization has increased the demands of pure water and contaminate the groundwater and environment.

Most of the major/mega and small cites of Pakistan are disposing their sewage along with industrial contaminated waste water in the rivers and main canals flowing in the area. It pollutes the surface water and this surface water seeps down in the soil and it reached and mixed with groundwater, it contaminates the aquifer having fresh groundwater. The study regarding groundwater contamination in different cities, financially assisted by Ministry of Water and Power, Government of Pakistan was conducted in Faisalabad, Gujranwala, Sialkot and Multan Districts", during July-2015 to December-2016.

The surface drain samples and groundwater samples were collected and got analyzed from Pakistan Council of Scientific and Industrial Research (PCSIR). The results of the samples were compared with the National Environmental Quality Standards (NEQS). The analysis of the parameters showed that some parameters were above the permissible limit of NEQS.

Therefore, it is recommended that domestic and industrial waste effluent must be treated before throwing it in the surface drains. Surface drains should also be lined, because through lining of the drains, seepage of waste water can be controlled and pollution of the groundwater would be avoided. **Keywords:** groundwater, wastewater, pollution, chemical analysis, seepage, drains and environment.

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I. Introduction

It is well known fact that with the increase of population of the country, the development of different kinds of industries like tanneries, textile, sugar and food processing is being carried out for fulfilling the requirements of our population. These industries are producing different types of effluents and these effluents ultimately are being thrown in the surface drains along with urban areas sewage water. As the irrigation supplies are limited and not sufficient to fulfill the crop water requirements, therefore this effluent is being used for the irrigation of the crops. This contaminated effluent seeps from the surface drains as well as from the crop fields and it reaches to the groundwater and it also pollutes to the groundwater.

1.1 Waste Water Production in Pakistan

The study was carried out by National Network of Community Watches (NNCW) and World Wildlife Fund (WWF) in the year 2000 under Pakistan's Wetland Action Plan-2000, sector wise waste water production was estimated in Pakistan. The waste water generation by the rural residential was 48% of the total waste water generation and the second largest waste water producer were urban residential i.e. 25% as shown in Table 1.1.

Table 1.1: Sector-wise Estimated Wastewater Productions in Pakistan

Sr.No.	Source	Volume	
		MCM/year	Percent of Total
1	Industry	395	6
2	Commercial	266	5
3	Urban residential	1,628	25
4	Rural residential	3,059	48
5	Agriculture	1,036	16
	Total	**6,384**	**100**

Source: Pakistan's Wetlands Action Plan, 2000, prepared by NNCW and WWF.

The report of Master Plan for Urban Wastewater, (Municipal and Industrial) Treatment Facilities in Pakistan was prepared by Engineering, Planning and Management Consultants in 2002 and given the data of waste water generated annually by each city of Pakistan as given in Table 1.2. The waste water production by the cities comprises on the basis of 1998 census. Waste water production is given of cities of Pakistan along with percent of total effluent of the city and percent of treated effluent of total effluent of the city.

Table 1.2: Wastewater Produced Annually by Cities

City	Urban Population (1998 census)	Total Wastewater produced (MCM/year)	% of Total	% of Treated	Receiving water Body
Lahore	5,143,495	287	12.5	0.01	River Ravi
Faisalabad	2,008,861	129	5.6	25.6	River Ravi, River Chenab and vegetable farms
Gujranwala	1,132,509	71	3.1	-	SCARP drains, vegetable farms
Rawalpindi	1,409768	40	1.8	-	River Soan and vegetable farms
Sheikhupura	870,110	15	0.7	-	SCARP drains
Multan	1,197,384	66	2.9	-	River Chenab, irrigation canals and farms
Sialkot	713,552	19	0.8	-	River Ravi, irrigation canals and farms
Karachi	9,339,023	604	26.3	15.9	Arabian Sea
Hyderabad	1,166,894	51	2.2	34.0	River Indus, irrigation canals and SCARP drains
Peshawar	982,816,	52	2.3	36.2	Kabul River
Other	19,475,588	967	41.8	0.7	-
Total Urban	**43,440,000**	**2.301**	**100.0**	**7.7**	**-**

Source: World Bank, Country Water Resources Assistance Strategy (WB-CWRAS Paper 3, 2005), Master Plan for Urban Wastewater (Municipal and Industrial) Treatment Facilities in Pakistan. Final Report, Lahore: Engineering, Planning and Management Consultants, 2002.

This study was designed to check the impact of industrial effluent on groundwater quality of Faisalabad, Gujranwala, Sialkot and Multan Districts. To check the contamination of groundwater, the industrial effluent samples were collected from surface drains and groundwater samples from the hand pumps which are on shallow depth. These water samples were analyzed by the PCSIR Laboratory, Lahore. The brief introduction of the cities from where waste water and groundwater samples were collected is given in the following;

1.2 Faisalabad

Faisalabad is known for its various industries such as textile, ghee, paper and tanneries etc. There is scarcity of water so irrigation around Faisalabad city is mostly performed with sewage waste water and industrial effluent. It focuses on effects of domestic and different industrial effluents on groundwater in the Faisalabad city. Waste water from

sewage and different industries such as textile and paper industries etc. is discharged into streams/surface drains without any treatment. This results in severe effect on the surface and groundwater and also affects the quality of crops.

Waste water from textile, ghee and various industries contains heavy metals that accumulate in vegetables and has negative impacts on vegetables grown. Heavy metals such as Ni, Cr, Zn, Cd, Cu, As and Pb results in inhibition of root growth, reduced yield due to less uptake of water and nutrients and reduced plant growth and seed germination (Aslam et al 2004). Ultimately these chemicals and heavy metals reached to groundwater through seepage and pollute the groundwater too.

1.3 Gujranwala

Gujranwala District of Pakistan which is situated in the Punjab province of Pakistan The population of the region is 3,401,000. Due to its extensive road and rail links, the region has flourished with manufacturing and agricultural markets. The city of Gujranwala also has set up several commercial and industrial centers allowing the manufacturing of ceramics, iron safes, metal utensils, textiles, steel, sanitary and tannery production. Main crops in the region are sugarcane, melons, rice and grains for international export. People grow vegetables by using waste water generated by the city because the waste water is easily accessible to the farmers without any cost (Ghafoor et al 1994).

The surface and groundwater samples were also collected from different locations of Gujranwala city. The groundwater samples were collected from the areas where sewage and industrial waster water is being used for irrigation purpose. These groundwater samples were collected from hand pumps which are installed at different location on the Farm land.

As the study involved determination of groundwater quality parameters at different points, therefore, samples collected from different locations of surface drains and groundwater samples collected from hand pumps from different locations got analyzed from the laboratory.

1.4 Sialkot

Sialkot is known as Pakistan's largest sports and leather goods producing city along-with leather related industries, textile, metallurgical and pharmaceutical industries. It earns annually 1.2 billion dollars annually and contributes to the national exchequer. There are over 264 tanneries, 244 leather garments/products manufacturing and 900 leather sports good manufacturing units are scattered in and around the city.

A total of 52 million liters per day of wastewater along with 1.1 million liters wastewater from tanneries is discharged into Nullah Aik and Pulkhu, sewerage drains, ponds and open agricultural lands from the Sialkot city. According to different estimates, each tannery in the district generates 547-814 m^3/day volume of wastewater. The industrial units have no wastewater treatment facilities. This large volume of industrial and urban waste is considered as the major threat to ground and surface water of the area. Quality of the groundwater - main source of drinking and irrigation is getting deteriorated due to untreated discharge of industrial and urban effluent and chemical substances being used for agriculture (Farooq et al 2008). The concentration of nitrates in ground water is continuously increasing, which is an alarming threat for local people. Pregnant women

are the most concerned to harmful impacts of ground water contamination. Elevated level of nitrates in drinking water can cause abnormalities in blood circulatory system of developing fetus inside mother womb. This situation needs urgent steps to provide clean and safe drinking water to local community.

1.5 Multan

Multan City is a city in the Punjab Province of Pakistan and capital of Multan District. It is located in the southern part of the province on the east bank of the Chenab River, more or less in the geographic centre of the country. Multan District has a population of over 4.5 million. It is known as the City of Sufis or City of Saints and Madinah-Tul-Oleyah, due to the large number of shrines and Sufi saints from the city. The Sutlej River separates it from Bahawalpur and the Chenab River from Muzaffar Garh. Multan is famous for its crops: wheat, cotton and sugar cane as well as mangoes, citrus, guavas and pomegranates. The Sutlej separates it from Bahawalpur District and the Chenab from Muzaffar Garh district. District Multan is spread over an area of 3,721 square Kilometers. In the city WASA Multan, has installed 102 tubewells for water supply to the urban population having capacity of 300 to 400 cusecs.

2. Methodology

2.1 Study Area

The study was conducted in four major cities i.e. Faisalabad, Gujranwala, Sialkot and Multan. To determine the groundwater pollution from waste water (Sewage + Industrial) in different areas of selected sites, the ground water samples were collected from different locations where the crops were being grown with waste water. Data collection pattern from these cities was described in the following sections.

2.2 Primary Data from Field

(i) Groundwater Samples from the areas where irrigation is being carried out with the waste water.

(ii) Surface Drains Effluent from Main Drains of the Cities (Industrial + Sewage).

2.2.1 Faisalabad District

In Faisalabad city area two drainage systems are working i.e. Maduana-Summandri and Paharang Drainage Systems. The drainage effluent of Industrial and sewerage is being collected through pipes and open sub drain from different parts of the city in the main sump/pumping station and that effluent is being pumped in the main drains i.e. Maduana-Summunadri and Paharang Main Drains. The Mauana-Summundari Main Drain flowing eastern side of the city and carrying discharge of about 350-400 cusecs and finally disposed off in the Ravi River. The Paharang Main Drain flowing western side of Faisalabad city and carrying 300-350 cusecs discharge and finally disposed off in the Chenab River near Chak No. 147/RB.

The effluent of the surface drain in Faisalabad area was collected from Pumping Station No.3 (Chokera). Surface sewage drain sample was collected before treatment of sewage water and after treatment of sewage water (Murtaza et al 2003). The groundwater sample was collected from hand pump which were installed by the local people for drinking purpose in the area Chak No. 295/RB (Pukhpura), near Samanabad-

Gojra Road along railway track. The surface drain sample location is shown in pink color and groundwater sample location is shown in blue color and these points are shown in Figure 2.1.

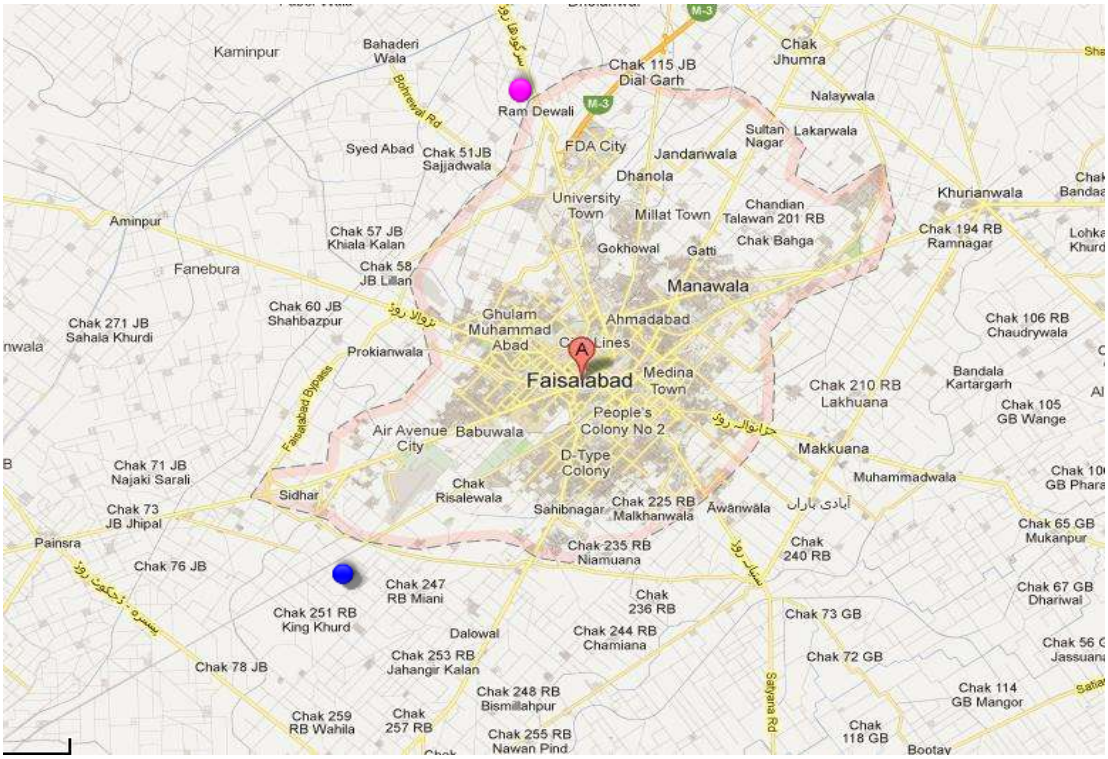


Figure 2.1: Map Showing Locations of Surface and Groundwater Samples in Faisalabad Area.

2.2.2 Gujranwala District

In the Gujranwala District one sample of sewage water from surface drain and one groundwater sample was collected from different locations. One surface water sample was collected from surface drain near Rajkot Disposal No.2 at Godalanwala Drain and the second surface drain water sample was collected from main drain near Khiali Disposal Station at Sheikhupura-Gujranwala Road, Gujranwala.

Three groundwater samples were collected from hand pumps. One groundwater sample was collected from hand pump which was opposite the Masjid & Grave Yard near Alipur Chowk. Second groundwater sample was collected from hand pump which was located along Gujranwala-Sheikhupura crossing of main drain, opposite Narroki village. The third groundwater sample was collected from Madina colony near outfall drain,Gujranwala. The surface drain sample location is shown in pink color and groundwater sample location is shown in blue color and these points are shown in Figure 2.2.



Figure 2.2: Map Showing Locations of Surface and Groundwater Samples in Gujranwala Area.

2.2.3 Sialkot District

In the Sialkot District 2 samples of sewage surface drains and 3 samples of groundwater were collected from the different locations. One sample of surface drain was collected from hand pump near Haji Pura Disposal Station, Chand Tara Chowk at Daska Road Sialkot. Second surface drain sample of sewage water was collected from Mag Town, Sublime Chowk at Wazirabad Road Sialkot. One groundwater sample was collected from Village Shatab Garh near Darbar Pir Muzamil Shah at Fateh Garh Road Sialkot. Second groundwater sample was collected from Village Ghansarpur near Wapda Grid Station, Airport Road Sialkot. Third groundwater sample was collected from Malkey Kalan Town near Wahid Chowk at Head Marala Road Sialkot. Samples collected from surface drain and groundwater were analyzed in the PCSIR Laboratoy, Lahore for following different parameters. The surface drain sample location is shown in pink color and groundwater sample location is shown in blue color and these points are shown in Figure 2.3.



Figure 2.3: Map Showing Locations of Surface and Groundwater Samples in Sialkot Area.

Multan District

Four samples were collected from different locations of Multan City. The sample was taken from hand pump and its location was from disposal station, Bosan Road at depth 100ft. These samples were got analyzed from PCSIR Laboratory, Lahore. The surface drain sample location is shown in pink color and groundwater sample location is shown in blue color and these points are shown in Figure 2.4.



Figure 2.4: Map Showing Locations of Surface and Groundwater Samples in Multan Area.

2.3 Collection of Secondary Data

Information regarding disposal and treatment of wastewater was collected from WASA Faisalabad, WASA Gujranwala and Municipal Office Sialkot. These maps include main sewage drains, disposal stations and drainage channels.

3. Data Processing

The surface water samples were collected from surface drains of Faisalabad, Gujranwala and Sialkot District at the representative places. These surface water samples were mixed with industrial waste water and sewage water of the city. These samples were got analyzed from Pakistan Council of Scientific and Industrial Research Laboratory (PCSIR), Lahore.

3.1 Groundwater Samples of Faisalabad Area

All the parameters like COD, BOD, Sulphate, Lead, Silver, Selenium, Nickel, Arsenic, Barium, Iron, Manganese, Zinc, Boron, Total Toxic Metal, Ammonia, Anionic, Fluoride, Sulphides, Total Suspended Solids, Chlorine etc (Guidelines for Drinking Water Quality 1996). The Results of groundwater sample which was collected from hand pump near Chak No. 295/RB, Ammunition Depot, Samanabad-Gojra Road, Faisalabad, is shown in Table 3.1. The results are shown in percentage and these percentages are more than the permissible limits as recommended by National Environmental Quality Standards (NEQS) and these are under (Pakistan environmental Protection Act 1997). These parameters are mainly total dissolved Solids, Turbidity, Total Hardness, Chlorides, Arsenic, Zinc, Reactive Silica and Sodium are 254, 240, 151, 138, 200, 1800, 9757 and 990 respectively. As Arsenic value is 200% more than the permissible limit. It is very alarming situation so the Government of Pakistan may be formulated monitoring committee to look into the matter in detail. The groundwater analysis results of Faisalabad area. The parameters which are excess than the permissible limit of NEQS and WHO Standards (WHO, 1996) are shown in Figures 3.1.

Table 3.1: Groundwater Sample from Hand Pump, Near Chak No.295/RB Ammunition Depot, Samanabad-Gojra Road, Faisalabad.

Description	Groundwater Analysis (mg/L)	NEQS/WHO* (mg/L)	More/less from NEQS (%)
Total Dissolved Solids	1770	100-500	254
Turbidity	17 NTU	< 5 NTU	240
Total Hardness (as $CaCO_3$)	627	250	151
Calcium Hardness	308	-	-
Magnesium Hardness	319	-	-
Chlorides	346	250	138
Sulphates	399	400	-0.25
Barium	0.03	1	-200
Boron	ND	0.3 mg/Lit*	-

Description	Groundwater Analysis (mg/L)	NEQS/WHO* (mg/L)	More/less from NEQS (%)
Iron	0.03	-	-
Copper	ND	-	-
Arsenic	0.03	0.01	200
Cadmium	ND	0.03	-
Lead	ND	0.01	-
Manganese	ND	0.5	-
Zinc	0.19	3.0 (WHO)*	93.66
Silver	ND	-	-
Nitrate	0.3	10.0	-97
Cyanide	ND	-	-
Fluorides	0.1	1.5	-93
Ammonia	ND	-	-
Reactive Silica	6.90	0.07	9757
Non-reactive Silica	ND	-	-
Sodium	297	30	990
Potassium	15	-	-
Total Coliform	ND	0 cfu/100 ml	-

Note: Negative sign shows less value than NEQS, *Permissible limit of WHO.

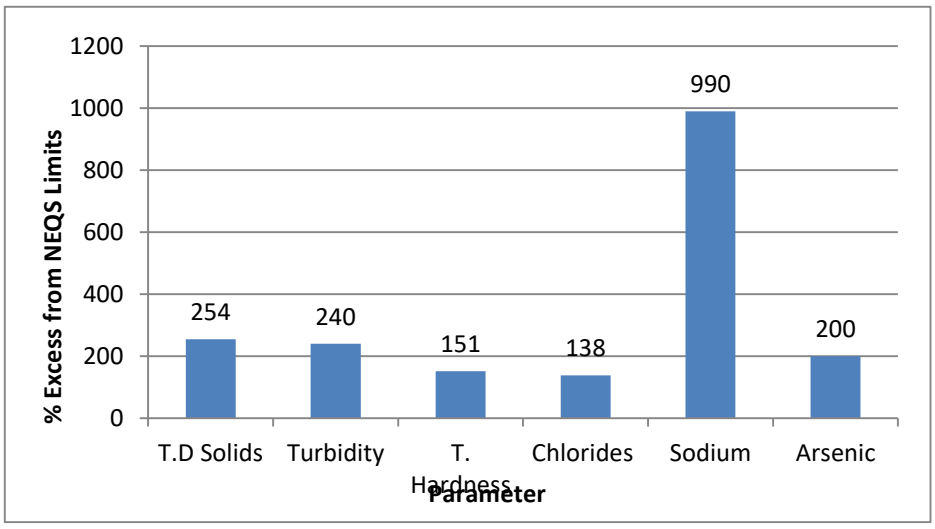


Figure 3.1: Groundwater Sample Analysis near Chak No.295/RB, Gojra Road via Samanabad, Faisalabad

3.2 Surface Drain Water Samples of Faisalabad Area

In Faisalabad city, there is one treatment plant at WASA Pumping Station No.3. To check the effectiveness of the treatment plant two surface drain samples were collected, one sample was collected before the treatment of the effluent and other sample was collected after treatment of the effluent. These both sample were got analyzed from the PCSIR Laboratory. It was observed from the results that some parameters values were decreased significantly after treatment of the affluent. It was also noted that some parameters were non-deducted after treatment of the effluent. Very few parameters have shown excess values after treatment than before treatment of effluent due to unknown reasons. The values which are less after treatment of the effluent are given with negative sign and values are in percentages. The parameters which were non-deducted are shown as 'ND' and parameters which has more value after treatment has given the positive (+) sign. All these values are shown in Table 3.2.

The parameter are like COD, BOD, Sulphates, Lead, Silver, Selenium, Nickel, Arsenic, Barium, Iron, Manganese, Boron, Toxic metal, Ammonia, Anionic detergents, Sulphides, Total Dissolved Solids, Total Suspended Solids and all their value are given in percentage as -50, -27, +27, 66, ND, +50, ND, ND, -9, -9, -29, -20, -50, -50, ND,-52 and -47 respectively. The parameters of excess values of surface drains effluent from NEQS are given in percentages and shown in Figure 3.2.

3.3 Waste Water Treatment Plant at Faisalabad

Faisalabad city is situated on flat topography which does not allow disposal of sewage and storm water from the city through gravity flow. For this purpose, multistage pumping is frequently performed by the WASA Faisalabad for eventual disposal of the waste water that is quite expensive and challenging. The city Faisalabad is divided into two zone (Western and Eastern). The North Western area is drained towards Paharang Drain which eventually discharges into River Chenab. The east area of the canal slops towards the South-East and drains into the Madhuana Drain which discharges into the Ravi River. The WASA Faisalabad has built Waste Water Treatment Plant functioning proficiently. The total capacity of waste water treatment plant is approximately 20 MGD.

Table 3.2: Industrial and Sewage Waste Water Analysis near Chokera Village Pumping Station No.3, WASA Faisalabad

Description	**Before Treatment (mg/L)**	**After Treatment (mg/L)**	**Increase/ Decrease after Treatment (%)**	**NEQS (mg/L)**
COD	448	224	-50	150
BOD	135	98	-27	80
Sulphates	425	540	+27	600
Lead	0.03	0.01	-66	0.5
Silver	0.01	ND	-	1
Selenium	0.02	0.03	+50	0.5

Description	Before Treatment (mg/L)	After Treatment (mg/L)	Increase/ Decrease after Treatment (%)	NEQS (mg/L)
Nickel	0.05	ND	-	1
Arsenic	ND	ND	-	1
Barium	0.11	0.10	-9	1.5
Iron	1.16	1.05	-9	8
Manganese	0.07	0.05	-29	1.5
Zinc	0.31	ND	-	5
Boron	0.35	0.28	-20	6
Total Toxic Metal	0.95	0.47	-50	2
Ammonia	11.2	5.6	-50	40
Anionic Detergents	15	ND	-	20
Fluoride	ND	ND	-	20
Sulphides	3	ND	-	1
Total dissolved Solids	3855	1868	-52	3500
Total suspended Solids	356	188	-47	200
Chlorine	ND	ND	-	1

Note: Negative sign shows less value than NEQS

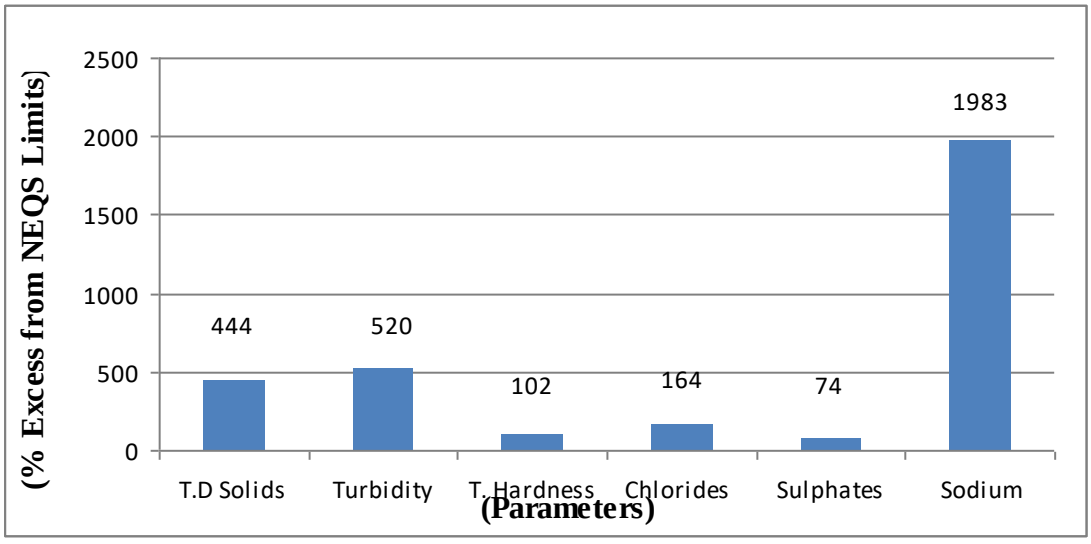


Figure 3.2: Analysis of Sewerage Water Sample from Surface Drain near Pumping Station No. 3 (Near Chokera Village), WASA, Faisalabad

3.4 Groundwater Samples of Gujranwala Area

Groundwater samples were collected from different location of Gujranwala city. One sample of groundwater was collected from Ali Pur Chowk, Gujranwala from hand pump. The analysis of the groundwater sample is given in Table 3.3. Results of groundwater sample shows that total dissolved solids, turbidity, total hardness, chlorides, sulphates, barium, Boron, Iron, copper, Arsenic, Cadmium, Lead, Manganese, Zinc, Silver, Nitrate, Cyanide, Fluorides, Ammonia, reactive Silica and non-reactive Silica are 96, 280, 29, -66, 69, ND, ND. 0.02, ND, 0.02, ND, ND, ND, ND, ND, -95, -26, -80 and ND respectively. All the values are given in percentages. The positive (+) sign shows increase from NEQS and negative sign (-) shows decrease from NEQS and ND shows non-deductive parameter in the sample. The total dissolved solids, turbidity, total hardness and sodium are more than the NEQS permissible limit in groundwater sample and is shown in Figure 3.3.

Table 3.3: Groundwater Sample Analysis near Gondalanwala Road, Ali Pur Chowk, Gujranwala

Description	G/Water Analysis (mg/L)	NEQS/WHO* (mg/L)	More/less from NEQS (%)
Total Dissolved Solids	980	100-500 mg/1	96
Turbidity	19	< 5NTU	280
Total Hardness (as $CaCO_3$)	322	250	29
Calcium Hardness	240	-	-
Magnesium Hardness	152	-	-
Chlorides	83.8	250 mg/L	-66
Sulphates	122	400 mg/L	-69.5
Barium	ND	1.0 mg/L	-
Boron	ND	0.3 mg/L*	-
Iron	0.02	-	-
Copper	N.D.	-	-
Arsenic	0.02	0.01mg/L	100
Cadmium	N.D.	0.003mg/L	-
Lead	N.D.	0.01mg/L	-
Manganese	N.D.	0.5 mg/L	-
Zinc	N.D.	3*mg/L	-
Silver	N.D.	0.5mg/L	-

Description	G/Water Analysis (mg/L)	NEQS/WHO* (mg/L)	More/less from NEQS (%)
Nitrate	0.5	10.0 mg/L	-95
Cyanide	0.052	0.07 mg/L	-26
Fluorides	0.3	1.5 mg/L	-80
Ammonia	N.D.	0.02mg/L	-
Reactive Silica	6.7	0.07mg/L	9471
Non-reactive Silica	ND	-	-
Sodium	121	30 mg/L	303
Potassium	5.0	-	-
Total Coliform	N.D.	-	-

Note: Negative sign shows less value than NEQS

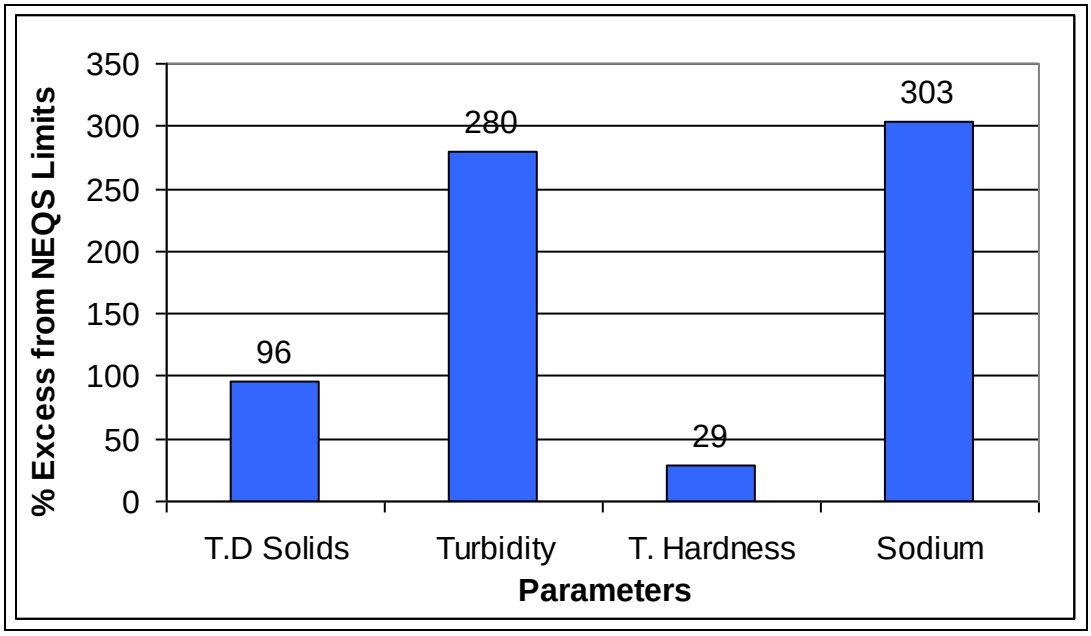


Figure 3.3: Groundwater Sample Analysis near Ali Pur Chowk Gujranwala City

3.5 Surface Drains Samples from Gujranwala City

In Gujranwala city area there is no any treatment plant as in Faisalabad city. The first surface drain sample was collected from Rajkot Disposal No.2 at Godalanwala drain, Gujranwala. The sample was got analyzed from the PCSIR Laboratory, Lahore. It was observed from the results that some parameters values were more than the permissible limit of NEQS. The results of the sample are given in Table 3.4 in percentages. It was

also observed that very few parameters have shown excess values from the NEQS and most of the parameters less than the NEQS permissible limit. The values which are less than NEQS are given with negative (-) sign. The parameters which were non-deducted are shown as 'ND' and parameters which have more value than the NEQS has given the positive (+) sign. The parameters are like COD, BOD, oil & greases, pesticides/herbicides, phenotic compound, cyanide, chloride, Sulphates, cadmium, chromium, copper, mercury, lead, silver, Selenium, Nickel, Arsenic, Barium, Iron, Manganese, zinc, Boron, total toxic metal, Ammonia, Anionic detergents, fluorides, Sulphides, Total Dissolved Solids, Total Suspended Solids and chlorine, and all these values are given in percentage as +177, +81, ND, ND, +240, -88, -45, ND, -69, -90, ND, -80, ND, -88, -93, ND, ND, -89, -71, -85, -98, -61, -58, ND, ND, +1500, -69, +23 and ND respectively.

Table 3.4: Surface Drain Water Sample from Rajkot Disposal No.2 at Godalanwala Drain Gujranwala

Description	S. Drain Water Analysis (mg/L)	NEQS (mg/L)	More/Less from NEQS (%)
COD	417	150	177
BOD	145	80mg/L	81
Oil & Greases	N.D.	10mg/L	-
Pesticides/Herbicides	N.D.	0.15mg/L	-
Compounds	N.D.	0.1mg/L	-
Phenolic Cyanide	6.8	2.0mg/L	240
Chlorides	115.9	1000mg/L	-88
Sulphates	329	600mg/L	-45
Cadmium	N.D.	0.1mg/L	-
Chromium	0.31	1.0mg/L	-69
Copper	0.11	1.0mg/L	-90
Mercury	N.D.	0.01mg/L	-
Lead	0.1	0.5mg/L	-80
Silver	N.D.	1.0mg/L	-
Selenium	0.06	0.5mg/L	-88
Nickel	0.07	1.0mg/L	-93
Arsenic	N.D.	1.0mg/L	-
Barium	N.D.	1.5mg/L	-

Description	S. Drain Water Analysis (mg/L)	NEQS (mg/L)	More/Less from NEQS (%)
Iron	0.86	8.0mg/L	-89
Manganese	0.43	1.5mg/L	-71
Zinc	0.74	5.0mg/L	-85
Boron	0.13	6.0mg/L	-98
Total Toxic Metals	0.78	2.0mg/L	-61
Ammonia	16.8	40.0mg/L	-58
Anionic Detergents	N.D.	20mg/L	-
Fluorides	N.D.	20mg/L	-
Sulphides	16	1.0mg/L	1500
Total Dissolved Solids	1076	3500mg/L	-69
Total Suspended Solids	246	200mg/L	23
Chlorine	N.D.	1.0mg/L	-

Note: Negative sign shows less value than NEQS

3.6 Groundwater Samples of Sialkot City Area

The groundwater sample was collected from Sialkot City. The sample was taken from hand pump and its location was in Malkey Kalan Town near Wahid Chowk at Head Marala Road, Sialkot. The samples were got analyzed from PCSIR Laboratory, Lahore. Different parameters were analyzed in laboratory. The values which are less than NEQS are given with negative (-) sign. The parameters which were non-deducted are shown as 'ND' and parameters which have more value than the NEQS has given the positive (+) sign and all these values are given in percentages. The results of groundwater are depicted in Table 3.5 like, Total Dissolved Solids -11, Turbidity -47, Phenolphthalein alkalinity ND, Total Hardness (as $CaCO_3$) +19, Chlorides -88, Sulphates -92, Barium ND, Boron ND, Iron -100, Copper ND, Arsenic ND, Cadmium ND, Lead ND, Manganese ND, Zinc ND, Nitrate ND, Nitrite ND, Cyanide -43, Fluorides ND, Ammonia ND, Reactive Silica +486, Non-reactive Silica ND, Sodium -7, Total Coliform ND. It is observed from the results that groundwater quality of the Sialkot city is excellent and can be used for drinking purpose.

3.7 Surface Drain Sample from Sialkot City

In Sialkot City there is no any treatment plant as in Faisalabad City. The first surface drain sample was collected from Mag Town, Sublime Chowk, Wazirabad Road Sialkot. The sample was got analyzed from the PCSIR Laboratory, Lahore. It was observed from the results that some parameters values were more than the permissible limit of NEQS. The results of these samples are given in Tables 3.6 in percentages. It was also noted that most of the parameters have less values than the NEQS given permissible limit.

The values which are less than NEQS are given (-) sign. The parameters which were non-deducted are shown as 'ND' and parameters which have more value than the NEQS has given the positive (+) sign. The parameters are like COD -23, BOD -10, oil and greases ND, pesticides/herbicides ND, phenolic compound ND, cyanide +220, chloride -92, Sulphates -78, Cadmium ND, Chromium -81, Copper ND, Mercury ND, lead -88, Silver -94, Selenium -98, Nickel -98, Arsenic ND, Barium ND, Iron -96, Manganese -90, Zinc -94, Boron -98 , total toxic metal -77, Ammonia -78, Anionic detergents ND, fluorides ND, Sulphides 160, Total Dissolved Solids -76, Total Suspended Solids -26 and Chlorine ND, and all these values are given in percentage.

Table 3.5: Groundwater Sample, Malkey Kalan Town Near Wahid Chowk at Head Marala Road Sialkot.

Description	**Groundwater Analysis mg/L**	**NEQS/WHO* mg/L**	**More/less from NEQS (%)**
Total Dissolved Solids	882.0	100-500 mg/L	76.4
Turbidity	2.59	< 5NTU	-48.2
Methye orange alkalinity	359.0	-	-
Phenolphthalein alkalinity	N.D	-	-
Total Hardness (as $CaCO^{-}_{3}$)	428.0	250 mg/L	71.2
Calcium Hardness	248.0	-	-
Magnesium Hardness	180.0	-	-
Chlorides	81.0	250 mg/L	-67.6
Sulphates	160.0	400 mg/L	-60
Barium	N.D.	1.0mg/L	-
Boron	N.D.	0.3* mg/L	-
Iron	0.07	-	-
Copper	N.D.	1.0mg/L	-
Arsenic	N.D.	0.01mg/L	-
Cadmium	N.D.	0.003mg/L	-
Lead	N.D.	0.01mg/L	-
Manganese	0.54	0.5mg/L	08
Zinc	N.D.	3* mg/L	-
Silver	0.04	-	-

Description	Groundwater Analysis mg/L	NEQS/WHO* mg/L	More/less from NEQS (%)
Nitrate	N.D	10.0mg/L	-
Nitrite	N.D.	0.02mg/L	-
Cyanide	0.56	0.07mg/L	700
Fluorides	0.8	1.5mg/L	-46.66
Ammonia	N.D.	-	-
Reactive Silica	0.78	-	-
Nonreactive Silica	N.D.	-	-
Sodium	92.0	30.0mg/L	206.66
Potassium	6.0	-	-
Total Viable Count	70.0	-	-
Total Coliform	6.0	o cfu/100ml	-

Note: Negative sign shows less value than NEQS

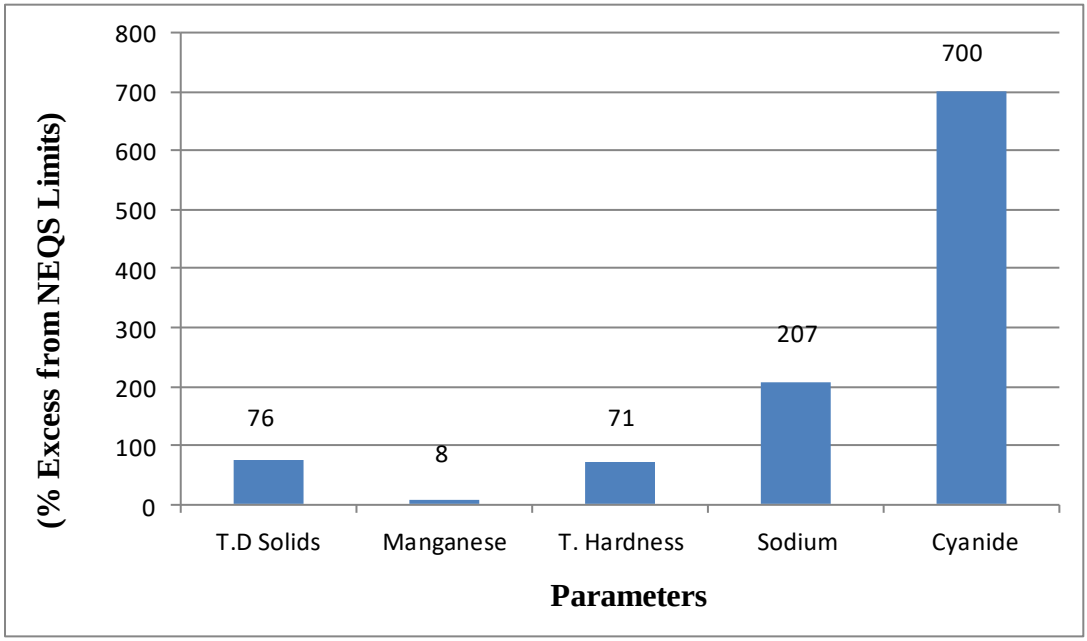


Figure 3.6: Groundwater Sample Analysis of Malkey Kalan Town, near Wahid Chowk, Head Marala Road Sialkot.

Table 3.6: Surface Drain Sample Analysis near Mag Town, Sublime Chowk, Wazirabad Road Sialkot.

Description	**Drain water Analysis (mg/L)**	**NEQS (mg/L)**	**More/less from NEQS %**
COD	116.2	150mg/L	-23
BOD2 at 20°C	72.0	80mg/L	-10
Oil & Greases	N.D.	10mg/L	-
Pesticides/Herbicides	N.D.	0.15mg/L	-
Phenolic Compounds	N.D.	0.1mg/L	-
Cyanide	6.4	2.0mg/L	220
Chlorides	82.8	1000mg/L	-92
Sulphates	133.0	600mg/L	-78
Cadmium	N.D.	0.1mg/L	-
Chromium	0.19	1.0mg/L	-81
Copper	N.D	1.0mg/L	-
Mercury	N.D.	0.01mg/L	-
Lead	0.06	0.5mg/L	-88
Silver	0.06	1.0mg/L	-94
Selenium	0.01	0.5mg/L	-98
Nickel	0.02	1.0mg/L	-98
Arsenic	N.D	1.0mg/L	-99
Barium	N.D.	1.5mg/L	-
Iron	0.3	8.0mg/L	-96
Manganese	0.15	1.5mg/L	-90
Zinc	0.30	5.0mg/L	-94
Boron	0.12	6.0mg/L	-98
Total Toxic Metals	0.46	2.0mg/L	-77
Ammonia	9.0	40mg/L	-78
Anionic Detergents	N.D.	20mg/L	-
Fluorides	N.D.	20mg/L	-

Description	Drain water Analysis (mg/L)	NEQS (mg/L)	More/less from NEQS %
Sulphides	2.6	1.0mg/L	160
Total Dissolved Solids	840.0	3500mg/L	-76
Total Suspended Solids	148.0	200mg/L	-26
Chlorine	N.D.	1.0mg/L	-

Note: Negative sign shows less value than NEQS

3.8 Groundwater Sample of Multan City Area

The groundwater sample was collected from hand pump and its location was near the Disposal Station, Bosan Road, Multan at depth 100ft. The sample was got analyzed from PCSIR Laboratory, Lahore. Different parameters were analyzed and the values which are less than NEQS are given with negative (-) sign. The parameters which were non-deducted are shown as 'ND' and parameters which have more value than the NEQS has given the positive (+) sign and all these values are given in percentages are given in Table 3.7.The parameters are like, Total Dissolved Solids +49, Turbidity ND, Phenolphthalein alkalinity ND, Total Hardness (as $CaCO_3$) +76, Chlorides -57, Sulphates -63, Barium -93 ND, Manganese -96, Zinc ND, Nitrate ND, Nitrite ND, Cyanide ND, Fluorides ND, Ammonia ND, Reactive Silica +486, Non-reactive Silica ND, Sodium -66, Total Coliform ND. It is observed from the results that groundwater quality of the Multan city is not bad and can be used for drinking purpose.

Table-3.7: Ground Water Sample Collected from Disposal Station, Bosan Road, from pump at depth 100ft, Multan.

Sr. No.	Parameters	Results	NEQS (mg/L)	More/Less from NEQS (%)
1	Color	Colorless	40^{o}C	-
2	Odour	Odorless	-	-
3	pH value at 25^{o}C	7.14	150mg/L	-
4	Total Dissolved Solids	745.0	800mg/L	49.0
5	Turbidity	N.D.	10mg/L	-
6	Methyl orange alkalinity	251.0	0.15mg/L	-
7	Phenolphthalein alkalinity	N.D.	0.1mg/L	-
8	Total Hardness (as $CaCO_3$)	440.0	2.0mg/L	76.0
9	Calcium Hardness	240.0	1000mg/L	-

Sr. No.	Parameters	Results	NEQS (mg/L)	More/Less from NEQS (%)
10	Magnesium Hardness	200.0	600mg/L	-
11	Chlorides	106.4	0.1mg/L	-57.44
12	Sulphates	145.0	1.0mg/L	-63.75
13	Barium	0.07	1.0mg/L	-93.0
14	Boron	0.05	0.01mg/L	-
15	Iron	0.01	0.5mg/L	-
16	Copper	N.D.	1.0mg/L	-
17	Arsenic	N.D.	0.5mg/L	-
18	Cadmium	N.D.	1.0mg/L	-
19	Lead	N.D.	1.0mg/L	-
20	Manganese	0.02	1.51mg/L	-96.0
21	Zinc	N.D.	8.0mg/L	-
22	Silver	N.D.	1.5mg/L	-
23	Nitrate	N.D.	5.0mg/L	-
24	Nitrite	N.D.	6.1mg/L	-
25	Cyanide	N.D.	2.0mg/L	-
26	Fluorides	N.D.	40mg/L	-
27	Ammonia	N.D.	20mg/L	-
28	Reactive Silica	4.88	20mg/L	-
29	Nonreactive Silica	N.D.	1.0mg/L	-
30	Sodium	50.0	3500mg/L	66.66
31	Potassium	3.0	200mg/L	-
32	Total Viable Count	17x10	1.0mg/L	-
33	Total Coliform	N.D.		

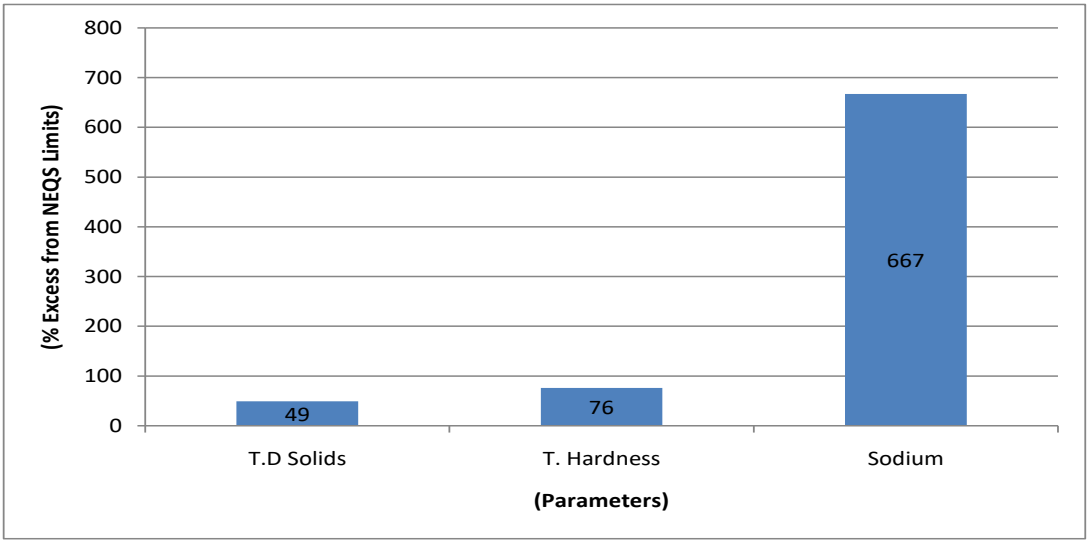


Figure No.3.7: Groundwater Water Analysis from Disposal Station, Bosan Road Multan (depth at 100 ft.).

3.9 Surface Drains Samples from Multan City

The surface drain sample was collected from Basti Siallian, Muhalla Farooq-e-Azam, Mouza Binda Sandhila (before treatment), Multan and second sample was collected from Dera Major Abrar Khakwani and Akbar khakwani at out fall after treatment plant, Multan. The sample was got analyzed from the PCSIR Laboratory, Lahore. It was observed from the results that only few parameters have more values than the permissible limit of NEQS and these results are given in Table 3.8 in percentages. The values which are less than NEQS are given with negative (-) sign. The parameters which were non-deducted are shown as 'ND' and parameters which have more value than the NEQS has given the positive (+) sign. In the following table sewage water of surface drains, before and after treatment is compared and it is observed that most of the parameters have less values after treatment of the sewage water.

3.10 Multan Treatment Plant

The channel was constructed of 31 Km long for carrying waste water of varying width & depth, starting from Sameejabad Disposal Station upto River Chanab, intercepting waste water of Smajeebad, Vehari Road, Kiri Jamandan, Farooq Pura and Old Shujabad Disposal Stations. The waste water treatment plant was constructed to accommodate the waste water of Shah Shamas, Jahangeerabad & Muzafarabad Disposal Stations waste water is being disposed in wastewater treatment plant in the shape of stabilization ponds and having capacity of 113 MGD will also be taken for ultimate disposal into River Chanab. The Treatment Plant was constructed before disposing into the River. It covered about 626 acres.

Table 3.8: Sewage Water Analysis Results of Surface Drains before and after Treatment in Multan Area.

Parameter	Results Before Treatment (mg/l)	Results After Treatment (mg/l)	NEQS Limits (mg/l)	More / Less from NEQS limit Before Treatment (%)	More / Less from NEQS limit Before Treatment (%)
pH	7.03	7.16	-	-	
COD	428	170	150mg/L	185	13.33
BOD	265.5	106	80mg/L	232	32.5
Oil & Greases	N.D.	N.D.	10mg/L	-	-
Pesticides/Herbicides	N.D.	N.D.	0.15mg/L	-	-
Phenolic Compounds	N.D.	N.D.	0.1mg/L	-	-
Cyanide	0.68	0.21	2.0mg/L	-66	-89.5
Chlorides	285	209.6	1000mg/L	-71.5	-79.1
Sulphates	257	317	600mg/L	-57.16	-47.16
Cadmium	N.D.	N.D.	0.1mg/L	-	-
Chromium	0.08	0.018	1.0mg/L	-92	-98.2
Copper	0.07	N.D.	1.0mg/L	-93	-
Mercury	N.D.	N.D.	0.01mg/L	-	-
Lead	0.04	N.D.	0.5mg/L	-92	-
Silver	N.D.	N.D.	1.0mg/L	-	-
Selenium	N.D.	N.D.	0.5mg/L	-	-
Nickel	N.D.	N.D.	1.0mg/L	-	-
Arsenic	0.08	0.05	1.0mg/L	-92	-95
Barium	0.13	0.07	1.51mg/L	-91.3	-95.33
Iron	0.5	0.6	8.0mg/L	-93.75	-493
Manganese	0.17	0.14	1.5mg/L	-88.6	-90.6
Zinc	0.27	0.07	5.0mg/L	-94.6	-98.6
Boren	0.05	0.08	6.1mg/L	-99.1	-98.6
Total Toxic Metals	0.45	0.22	2.0mg/L	-77.5	-89
Ammonia	N.D.	N.D.	40mg/L	-	-
Anionic Detergents	6	10	20mg/L	-70	-50
Fluorides	0.3	0.1	20mg/L	-98.5	-99.5
Sulphides	4.4	2.1	1.0mg/L	-340	110
Total Dissolved	975	1225	3500mg/L	-72.14	-65

Parameter	Results Before Treatment (mg/l)	Results After Treatment (mg/l)	NEQS Limits (mg/l)	More / Less from NEQS limit Before Treatment (%)	More / Less from NEQS limit Before Treatment (%)
Solids					
Total Suspended Solids	218	66	200mg/L	-9	-67
Chlorine	N.D.	N.D.	1.0mg/L	-	-

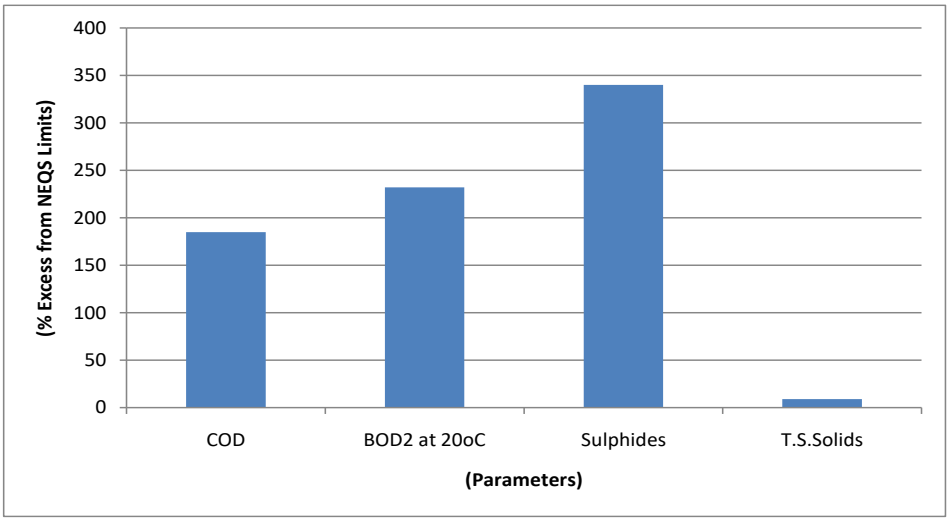


Figure No. 3.7: Sewage Water from Basti Siallan Wali Muhalla Farooq-e-Azam Multan (Before Treatment)

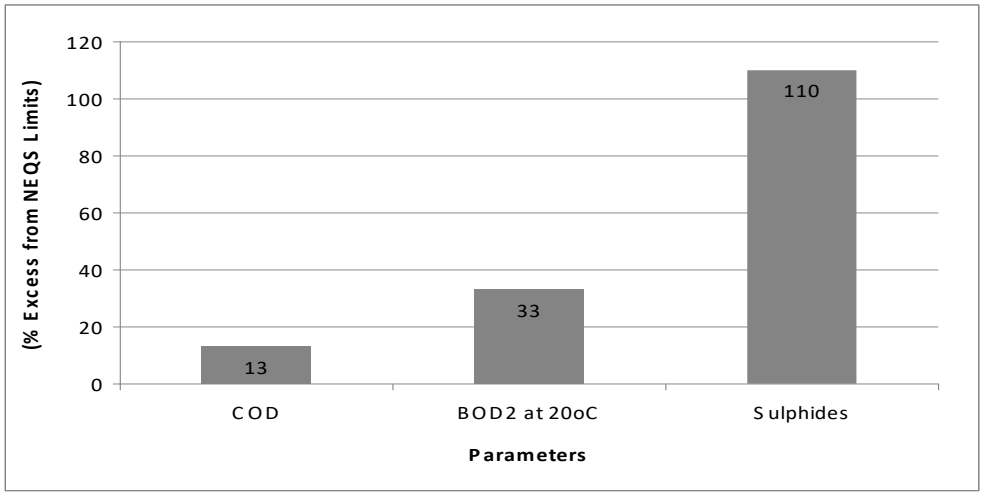


Figure No.3.8: Surface Drain near Dera Major Akbar Khakwani at Outfall Treatment Plant Multan (After Treatment)

4. Safe Disposing of Domestic and Industrial Waste Water in Rivers or other Water Bodies

4.1 Treatment of Domestic Waste Water through Stabilization Ponds

Waste water treatment process is the method by which waste water stabilization ponds or algal ponds are constructed. This is the simplest method of treatment of domestic waste water. The method relies on the use of shallow ponds i.e. 1-2 m deep in which the wastewater is held for several days depending on the temperature and other climatic conditions under which the algae can flourish and at the same time provide oxygen through photosynthesis.

Algal growth is important for meeting the oxygen demand of the wastewater, Algal growth depends on the surface area of the pond and it is an important design parameter in stabilization pond. It needs relatively large area for the treatment of domestic waste water.

4.2 Industrial Effluent Treatment

Industrial wastewater treatment has become an important issue in the countries of the West Asia region, due primarily to the increasing environmental considerations that are beginning to become a priority in the region. Industries have long discharged their effluents into nearby river courses, public sewers, and fields or the sea, resulting in a number of environmental and health problems. The increasing environmental awareness has led to issuing of obligatory regulations and definite specifications for effluent quality in virtually every country in the region before it can be discharged into public sewers or surface watercourses. Further, within the framework of rational water use in industry, particularly to reduce water losses, technological advancements have facilitated the reuse of properly-treated industrial drainage water. Thermal plants for power generation are considered the largest use of such treated water, requiring about 2 liters/kilowatt hour of generated power. Considering the large quantity of electricity produced, it is estimated that millions of cubic meters of treated water are used for this purpose.

Industrial effluents (primarily from factories and plants) contain various materials, depending on the industry. Some effluents contain oils and grease, and some contain toxic materials (e.g., cyanide). Effluents from food and beverage factories contain degradable organic pollutants. Some effluents contain, while others lack, nutritious materials suitable for microbiological growth. Effluents of canned fruit and soda beverages, for example, contain high percentages of sugar, very low percentages of protein, and little nitrogen or phosphorus. Biological growth in these effluents, therefore, is rather weak. Thus, every industrial effluent (pollutants) requires a specific treatment technology.

a) Treatment of Food Industry Effluents

Food industry effluents are generally characterized by a high content of biodegradable pollutants. Suspended substances constitute a large part of these pollutants, in addition to the high BOD and COD concentrations of the effluents. These effluents are treated with biological methods as a primary treatment. The nitrogen and phosphorus concentrations in the effluents also are reduced. The removal of suspended substances

is sometimes done via a settling process after adding coagulation materials to the effluent.

b) Treatment of Textile Industry Effluents

The pollutant content of textile industry effluents typically contains (1) natural and artificial treated fibers, (2) dyes, and (3) used materials (especially coloring materials).

The resultant effluents are treated in two main stages, including (1) chemical-physical treatment -- for removing suspended, coloring and dyeing materials, neutralizing the water pH, and removing phenol by using activated carbon after oxidizing it with ozone, and (2) biological treatment – for removing the remaining organic material.

c) Treatment of Oil Refinery Effluents

The basic constituent of oil refinery wastewaters is hydrocarbons. Other materials include (1) organic materials (phenol, alcohols), (2) sulfuric compounds (sulfide, mercaptan, and sulfate), (3) sodium salts, and (4) suspended solids (sand, etc.).

Treatment of the wastewater is done in two main stages, including (1) physical-chemical treatment – for separating oils, adding coagulation material, and separating the resulting deposits in the settling basins (this stage can remove between 70-90% of the oils in the effluent), (2) biological treatment – for biological removal of the remaining oils. Because of the toxicity of sulfate compounds to biological organisms, these compounds are sometimes removed from the water before it enters the biological ponds. The resulting sludge is dewatered and incinerated in special incinerators.

d) Treatment of Metal Surface Coating Industry Effluents

Some materials are used to coat metals, primarily to prevent corrosion of the metal. The water resulting from this industry typically contains (1) high concentrations of toxic metals, and (2) diluted rinse water. The resulting wastewater is treated with physical-chemical methods. This treatment mode as considered one of the most important, due to the toxic metals in the water that must be removed. The effluents also exhibit a large variability in regard to the chemical materials used during the manufacturing process.

In contrast to domestic wastewater, the chemical and biological content of industrial effluents varies on the basis of the industry producing them. Thus, the associated operation and maintenance problems of the associated treatment facilities vary accordingly. The treatment technology for the leather industry effluents, for example, is more complicated than for other industries, due to primarily, the large water volumes used in this industry (approximately 5 m^3/100 kg of dewatered leather). The wastewater from this industry is very polluted, containing proteins, fats, hair remains, wool, toxic materials (sulfide, chrome), and high BOD concentrations (reaching up to 700-900 mg/L), thereby being more complicated to treat, for example, than effluents from the beverage industry. Thus, treating leather industry effluents requires skilled technicians to operate and maintain the required treatment technology.

In addition, the required specifications of industrial effluents released into public sewers include the following:

i. BOD concentration not exceeding approximately 20 mg/L;

ii. Suspended solids concentration not exceeding approximately 600 mg/L;

iii. No release of grease, oils or nitrogen compounds (due to their impacts on the treatment process);

iv. No release of explosives or toxic materials (due to their potential impacts on the safety and health of the sewer network workers;

v. Sulfate concentration should be less than 100 mg/L, and the pH value should be between 6 to10 (to protect the sewer pipes).

5 CONCLUSIONS & RECOMMENDATIONS

5.1 Faisalabad

- It was observed from groundwater sample from Faisalabad that some parameters results showed more values than permissible limit prescribed by the National Environmental Quality Standards (NEQS), and these parameters are mainly, total dissolved Solids, Turbidity, Total Hardness, Chlorides, Arsenic, Zinc, Reactive Silica and Sodium, and these values are in percentages which are more than the permissible limit such as 254, 240, 151, 138, 200, 1800, 9757 and 990% respectively. The Arsenic value is 200% more than the permissible limit as it is very alarming situation. The quality of groundwater of Faisalabad city is not fit for drinking purpose.

5.2 Gujranwala

- The groundwater samples were collected from hand pump from, Gujranwala city. The results show that heavy metals were not detected in the groundwater samples. Some parameters values were more than permissible limit as defined by NEQS like total dissolved solids, turbidity, total hardness, Arsenic, reactive silica and sodium were 96, 280, 29, 100, 9571 and 303% more than permissible limit respectively. In only one sample the arsenic value was 100% more than the permissible limit in the groundwater sample collected from Ali Pur Chowk Gujranwala.

5.3 Sialkot

- The groundwater sample was also collected from Sialkot City. These sample was got analyzed and only two parameters have more values than permissible limit of NEQS i.e. Total Hardness (as CaCO3) Reactive Silica 19 and 486 respectively. Heavy metals were not deducted in groundwater sample. Some other parameters which were deducted and these have already low values than the permissible limit. It is observed from the results that groundwater quality of the Sialkot city is excellent for drinking purpose.

5.4 Multan

- In Multan area sewage water was analyzed before and after treatment. It was observed that the values of parameters were reduced after treatment as compared with before treatment of sewage water. The values of sewage water were less than the NEQS values.

- The groundwater water was analyzed and observed that drinking water is absolutely fit and the analysis results show that all the parameters of groundwater are less than the permissible limits prescribed by NEQS.

5.5 RECOMMENDATIONS

In the best public interest, high concentration of heavy metals and other hazardous substances in the groundwater quality in the country in general and big cities like Faisalabad, Gujranwala, Sialkot and Multan in particular are being evaluated. Through this, a better balance should be achieved by minimizing the seepage of concentrations and anthropogenic contaminants into the groundwater and open water body areas.

There should be rigorous check on industrial water pollution by implementing strictly the pollution control laws. The government should move forward to ensure control on the disposal of untreated effluents around the industries.

Groundwater is being contaminated by irrigating the crops with (sewage +industrial) waste water surrounding the cities. It could be avoided with treatment of the effluent.

The contamination in groundwater may also be due to cracks in the lined sewerage system and through seepage, it is mixing in groundwater, so the sewerage system should be rehabilitated.

In the big cities, the industry is main source of groundwater contamination, so further studies should be taken to evaluate the role of industry in contaminating the groundwater.

Water treatment plants should be constructed before throwing (sewage + industrial waste water) in the fresh water bodies.

As Arsenic value is 200% more in Faisalabad city than the permissible limit. It is very alarming situation so the Government of Pakistan may be formulated monitoring committee to look into the matter in detail.

Cost effective methodology should be adopted for monitoring and surveillance of all critical parameters of surface and groundwater.

Personnel responsible for monitoring the quality of water should be educated and provided in-service training on a regular basis.

Public awareness of their responsibility towards establishment and maintenance of drinking water quality standards. In this view low cost measures to be applied at a household level (use of chlorination etc.) should be applied.

Prime importance should be given to the issue of quality and quantity of water where water is scarce such as in Baluchistan and efforts should be made to improve the availability and accessibility of the quality water.

In water scarce countries like Pakistan, reuse of waste water for irrigation of various crops after treatment should be very effective method to meet water and food demands.

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FIELD GLIMPSES



Figure 1: Direct Disposal of Industrial Waste Water in Surface Drain.



Figure 2: Another View of Direct Disposal of Waste Water in Surface Drain.



Figure 3: A View of Collecting Waste Water Sample from Main Surface Drain.



Figure 4: Farmers are Using Waste Water for Irrigating the Crops with the help of Tractor PTO Shaft.



Figure 5: A View of Surface Drain out falling in River Chenab.



Figure 6: Lush Green Crops due to irrigation with industrial and domestic waste water in Gujranwala Area.



Figure 7: Field Channel Carrying Domestic and Industrial Waste Water in Gujranwala Area.



Figure 8: Pumping of Domestic and Industrial Waste Water from Main Drain for irrigating the crops in Gujranwala Area.



Figure 9: A view of Domestic and Industrial Waste Water carrying Main Drain Passing through the Agricultural Lands.



Figure 10: Field Channel Carrying Domestic and Industrial Waste Water for Irrigating the Agricultural Lands.



Figure 11: Another View of Collection of Groundwater Sample from Hand Pump for Analysis in Gujranwala Area.



Figure 12: A View of Surface Sewage Drain at Commissioner Road Sialkot.



Figure 13: Disposal Station near Chand Tara Chowk at Sialkot.



Figure 14: Disposal Channel passing through Agricultural Lands for Irrigation in Multan Area



Figure 15: A View of Stabilization Treatment Ponds in Multan Area.



Figure 16: Another View of Stabilization Treatment Ponds in Multan Area.