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A Study of Drinking Water of Industrial Area of Sheikhupura with Special Concern to Arsenic, Manganese and Chromium

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Abstract

In our current study we focused our attention to analyze the drinking water of industrial area of Sheikhupura that is swarming with small and large industries. Previously no work has been reported related to this area. Samples were collected from the twelve different sites of the mentioned area for six months at frequency of once per fifteen days (map in Fig 1). The samples were analyzed under strict quality control conditions and ASTM (American Standard Testing Methods) methods were employed for strictly precise and accurate results. Four sites showed bacterial contamination, five sites indicated high level of TDS (Total Dissolved Solids) and conductivity. Only one site indicated elevated chromium leve(0.6 mg/L)l, two depicted increased level of arsenic but five sites gave idea about the high level of manganese(highest average value 1.2 mg/L) in the study area.

Key Words: Drinking Water, Sheikhupura Indusrial Area, Toxic Metals, Contamination, TDS

1. Introduction

Water is the most abundant compound on the earth and is essential for the survival of all living organisms. More than 50% population on the earth depends upon ground water. In most areas of the Pakistan the ground water is only source for drinking purpose. Safe drinking-water is a basic need for human development, and health. So it is an internationally accepted human right [1].

Generally, drinking water containing different anions and heavy metals including Cd, Cr, Co, Hg, Ni, Pb, Zn etc, has significant adverse effects on human health either through deficiency or toxicity due to excessive intake [2].

The excessive ingestion of all these heavy metals including Cd, Cr, Co, Hg, Ni, Pb and Zn has carcinogenic effects on human health [3]. Fresh water scarcity is increasing globally because of overpopulation [4, 5]. Many researchers have also worked on the water and human right [6].

The world population is increasing day by day and this continuous increase in population results in shortage of fresh water availability in that area. The continuous increasing population elevates the requirement of water for the production of food stuff, agriculture, industry and the domestic utilization [7]. In Pakistan drinking water is continuously being deteriorated due to untreated municipal and industrial water and drainage from agriculture effluent [8]. According to four years water study conducted by the Pakistan Council of Research in Water Resources (PCRWR) during 2002-2006 concluded that 84-89% of the total sources of water in the country are contaminated. This study revealed that Punjab province contained 81, 91, 92, 90 and 90% unsafe water from 2002 to 2006 respectively [9].

There are a number of potential sources that can cause the contamination of water to make it unsafe for drinking. Bacterial contamination is widespread [10]. General population is at the risk of exposure to the toxic metals through intake of contaminated food, water, soil, dust and air [11]. Acute and chronic symptoms of dizziness, insomnia, nausea, vomiting, decreased conception and diarrhea and loss of appetite is associated with the toxic metals and further extend to Infertility, elevated mortality in infants, heart diseases, central nervous system disorder, anxiety, reduced immunity and growth rate [12]. Ground and surface water in Pakistan is mostly found to exceed the level of the heavy metals impurities as recommended by WHO (World Health Organization) [13, 14, 15]. Human activities [11] including municipal and agricultural wastes and inappropriate industrial waste disposal are responsible for water toxicity. The toxic metals from these disposals are introduced into the drinking water while the water moves down in hydrological cycle [16, 17].

The study area of this research, Sheikhupura is an industrial city of the Punjab, Pakistan. It shares its boundaries with Lahore, Nankana Sahib, Narowal, Hafizabad, and Gujranwala and in east with the international boundary of Amritsar. It is a part of Rachna Doab, and comprises of sediment brought from Chenab River through spill channel.

The District observes severe climate with the summer season from April to October and during this period temperature ranges from 30 to 45 degrees Celsius. The winter season commences from November and finishes in March with the coldest months of December and January. During June, July and August dust storm occur off and on. Average rainfall is about 635mm per year [18]

The Sheikhupura Industrial area/ Estate has been established since 1969 with the sole objective to develop and accelerate industrial pace with the establishment of heavy and large scale industries including paper, seed, leather, steel, stainless steel, chemical, pharmaceutical, rice, stone and marble grinding, textile, poultry and animal feed, flour, soap and many other industries [19]. According to a few studies ceramics, steel, leather, textile, Pharmaceuticals, fertilizer are few of those major industries that are reason for the water pollution [20, 21]. Although being very important due to its role in the economy of Pakistan as one of the major industrial city no work on the drinking water quality of this area has found in literature. So there was a need to analyze the water from this area being used by the inhabitant since its population increased as the people came here in search of employment.

2. Experimental

2.1 Sampling

The whole industrial area of Sheikhupura was divided into twelve parts. From each site six fresh samples were collected in polypropylene bottles through different available sources such as tap, well or hand pump etc for six months with a frequency of once per fifteen days, as recommended in WHO guidelines[22, 40]. Six samples of single site were then homogenized to get a single sample that was further preceded for analysis. In this way twelve samples were collected from a single site per month which further gave us two representative samples of each site prior to their analysis. A total of 720 samples were collected that gave us 144 true representative samples of the study sites for their analysis in six month. Special attention was given to sampling to prevent any contamination that can cause an ambiguity in results. Nestle water was purchased from the local market and it was analysed for all the parameters for which samples were analysed to compare their result.

2.2 Analysis Method

pH was determined by ASTM D1293-99 (Re-approved 2005), Conductivity by ASTM D1125-95 (Re-approved 2005), turbidity by ASTM D1889-00, Chloride by ASTM D 512-04, Sulfate by ASTM D 516-07, Chromate by ASTM D1687-02, Silica by ASTM 859-05, Iron by 3500-Fe B (Phenanthroline method). Hardness was determined by the titrimetry. Sodium, Chromium, Arsenic and Manganese were determined by Atomic Absorption flamephotometer manufactured by Perkin Elemer (A Analyst 400) equipped with an auto dilutor. For microbial studies Envirocheck TVC (Total Viable Count) slides manufactured by Merck were used according to the manufacturer directions.

2.3 Quality Control

All the reagents used were highly purified and traceable to Merck. Ultrapure water was used during the entire study instead of conventionally used deionized water. All the analysis was carried out in strict quality control conditions and their accuracy was assured using certified reference control samples. Co-efficient relation of all calibration curves was greater than 99.90%. Where results were at the edge of control limits, further confirmation was carried out by standard addition method and results were considered correct if yielded above 99.0%. All the samples were analyzed thrice and mean of three readings were taken. Results here are depicted as minimum value, maximum value and average value of all samples during the six months. Calibration curves of spectrophotometer were prepared with the NIST (National Institute of Standard and Technology, United States) traceable standards while AAS (Atomic absorption spectrophotometer) curves were freshly prepared with the mono element calibration standards from CPA Ltd Bulgaria with the help of an auto dilutor operated by Winlab32 software.

2.4 Data Representation

Each sample was analyzed thrice and its mean was included in the results. Each cell represents minimum value at the top and maximum beneath it while the value in parenthesis represents the average of all twelve values obtained during six months.

3. Results and Discussion

3.1 Bacterial contamination

Contaminated drinking water in the entire country is one of the serious problems in most of the urban as well as rural areas and bacteriological contamination play a very important role in it [22, 23]. The samples from four sites out of 12 showed contamination. The general source of this contamination is usually due to leakage of pipes, pollution broken sewerage pipes, and municipal wastes. Industrial waste streams are usually stagnant and contaminated with the chemicals on which micro organisms depend for their growth.

3.2 pH

pH was determined by ASTM D1293-99 (Re-approved 2005) using HANNA HI 2122 pH bench type meter. pH is the determination of acidic or basic nature of the water. Average pH of all the sites was found in the range of WHO standard.

3.3 Electrical Conductivity & TDS

Conductivity, Electrical Conductivity was measured by ASTM D1125-95 (Re-approved 2005) using HANNA HI 2314 bench top conductivity meter. It is related to the conduction of electricity through the water and is measurement of total dissolved solids present in the water. Six sites showed electrical conductivity above the permissible limit. It can be attributed to the high amount of TDS. The samples with the high electrical conductivity also showed high TDS too. Limit of TDS set by WHO is 500ppm [24]. Five samples depicted the elevated values of TDS. These elevated values of conductivity and TDS can be attributed to the waste effluents of the swarming industries situated in the study area.

3.4 Carbonate and Bicarbonate

Carbonates & Bicarbonates were determined by using potentiometric titration. Carbonates were absents in all the samples. All the sites showed bicarbonates with in the limits. This may be due to the atmospheric CO_2 which reacts with the water and forms H_2CO_3. This acid further reacts and can form bicarbonates.

3.5 Total Hardness

Total Hardness was determined by Complexo-metric titration. The total hardness of the water refers to amount of Ca and Mg present in the form of soluble and insoluble salts. The limit of total hardness in the drinking water is 500ppm [**24**]. All the sites showed hardness less than 500ppm except the sample from site 3 showed maximum hardness of 535ppm. However average value of its hardness was found to be 505ppm. Moreover according to WHO hardness of water does not cause any effect to the human health but in contrast a few studies claim that it protects against a number of diseases [**25**].

3.6 Sulfate

Turbidimetric test method was used to determine sulfate ion using Hach 2100N Laboratory Turbidity Meter. Sulfate was found in low amount in all ground water however its elevated amount may be due to sulfate fertilizers. Three of our samples showed the sulfate above the WHO limit of 250ppm **[25**].

3.7 Chloride

Chloride was determined by potentiometric titration with a standard silver nitrate solution. Chloride is found in almost all type of natural water however their elevated amount may be due to geological sources or due to anthropogenic activities. All the samples depicted the chloride with in the limit.

3.8 Sodium

Sodium was analyzed by Atomic Absorption flame photometer manufactured by Perkin Elemer (A Analyst 400) equipped with an auto dilutor. Natural source of sodium in the ground water is weathering of the rocks. Average value of 9 sites were above 200ppm, the permissible level of WHO. The high values of sodium may be due to effluents of leather industry where high amount of salt is usually used. But comparatively low value of chloride contradicts our assumption and hence this high amount of sodium may be attributed to some other unknown reason.

3.9 Total Iron

Iron in the water samples were determined by AAS technique, using PerkinElmer 3100 Atomic Absorption Spectrometer. Iron is an element that is required in human diet. It makes complex with the Hemoglobin that helps to carry oxygen in cell. The required amount of iron in water is 0.3ppm. All the samples show good amount of iron [24].

3.10 Silica

Silica was determined by Spectrophotometer (CHROMA Model 260 Programmable Colorimeter) using (Molybdate/ Aminonaphtholsulphonic Acid) system. No limit of silica in water has been given either by WHO or PAKEPA. Silica level in all sites fell in the range of 1.29 to 76.99ppm.

3.11 Turbidity

Turbidity was measured by using Hach 2100N Laboratory Turbidity Meter. It is the haziness of the solution. All the samples were having turbidity in the limit of USEPA however three samples showed turbidity above the limit of WHO and PAKEPA [**23**].

3.12 Chromium

Chromium was analyzed by using AAS technique. Chromium is an essential element for growth [25]. However elevated level of chromium may cause lungs and air passage problems. All the samples sites showed chromium level with in the limit however one sample site showed elevated level of chromium. However minimum level of this site was also with in the limit. This elevated level of chromium can be due to tanneries' effluent as previously suggested [26, 27]. Although already a study have reported high level of chromium in drinking water of Karachi [28, 29] but the area under our study didn't showed a very severe potential of chromium toxicity however there is a possible threat for the inhabitants if its concentration increases in the future. Hence a constant monitoring of Cr level in the drinking water of this area is necessary.

3.13 Arsenic

Arsenic was analyzed by using AAS technique. Arsenic is naturally occurring metalloid. Mineral deposits in many areas contain high arsenic level. This arsenic is dissolved by the ground water and hence contributes to the well water. Arsenic poisoning can cause the thickness and discoloration of the skin and even cancer. Some recent studies showed an extremely high arsenic level [30-34] in different parts of Pakistan. EPA limit for Arsenic has there been increased to 0.05µg/L as compared to 0.01 µg/L of the WHO limit [23]. Our study area indicated four sampling sites with elevated arsenic level. However minimum value of two sampling sites and the average of only one sampling site were above the limit. As the number of studies already has depicted an increased arsenic level hence this area should be considered to be monitored continually for arsenic level.

3.14 Manganese

Atomic Absorption flame photometer manufactured by Perkin Elemer (AAnalyst 400) was used to detrermined by Maganese. Manganese is an essential element in the food however its elevated amount can cause nervous disorder in adults [35] and children [36, 37]. A number of studies conducted in different part of Pakistan have previously indicated an increased level of Mn in the drinking water [30, 38].

Weathering and leaching of manganese containing minerals and rocks increases its level into the aquifers and its concentration may vary [39]. Four of our sampling sites indicated high Mn content. However totally five of the sites were bearing the maximum level of Mn above the limit with the maximum value of 1.5 that is two times greater than the limit of WHO and PAKEPA [23].

All the results of Nestle water purchased from local market were in the range of PAKEPA and WHO limits of drinking water.

Table.1 Each result depict maximum value, minimum value and average value in parenthesis from top to bottom

Analysed For	Site 1	Site 2	Site 3	Site 4	Site5	site 6	site 7	site 8	site9	site10	site11	site 12
Cr	ND	ND	ND	0.0	0.0	ND	0.02	ND	0.3	ND	ND	ND
(mg/L)	ND	ND	ND	0.06	0.4	ND	0.09	ND	0.10	ND	ND	ND
	(ND)	(ND)	(ND)	(0.03)	(0.01)	(ND)	(0.04)	(ND)	(0.05)	(ND)	(ND)	(ND)
As	ND	0.0	0.8	ND	ND	ND	ND	ND	ND	ND	ND	0.02
(µg/L)	ND	0.06	0.12	ND	ND	ND	ND	ND	ND	ND	0.06	0.09
	(ND)	(0.03)	(0.09)	(ND)	(ND)	(ND)	(ND)	(ND)	(ND)	(ND)	(0.04)	(0.06)
Mn	ND	0.6	ND	0.4	0.2	0.5	ND	ND	ND	ND	0.5	ND
(mg/L)	0.5	1.7	ND	1.4	0.8	1.5	0.4	ND	ND	ND	0.9	ND
	(0.2)	(1.2)	(ND)	(1.0)	(0.5)	(0.9)	(0.1)	(ND)	(ND)	(ND)	(0.7)	(ND)

Ref (Table 1) : A.E. Klein, A study of heavy metals in lake abbaya, ethiopia, and the incidence of non-parasitic elephantiasis**,** 1977,
Water Research Volume 11, Issue 3, 323–325

Table.2 Each result depict maximum value, minimum value and average value in parenthesis from top to bottom

Analysed For (Unit)	Site 1	Site 2	Site 3	Site 4	Site5	site 6	site 7	site 8	site9	site10	site11	site 12
Bacterial	ND	ND	ND	ND	ND	ND	ND	10^2	ND	ND	10^3	10^2
Testing	ND	ND	ND	ND	ND	ND	ND	10^6	10^6	ND	10^6	10^5
(cfu/ml)	(ND)	(ND)	(ND)	(ND)	(ND)	(ND)	(ND)	(10^4)	(10^3)	(ND)	(10^3)	(10^4)
Ph	7.42	7.92	7.32	7.79	7.96	7.69	7.60	7.48	6.82	7.61	7.79	7.5
	7.93	8.20	7.6	7.92	8.09	7.96	7.70	7.64	7.50	7.85	7.95	7.77
	(7.76)	(8.04)	(7.47)	(7.84)	(8.02)	(7.8)	(7.66)	(7.58)	(7.10)	(7.75)	(7.84)	(7.6)
Conductivity	208.0	1209	2278.0	918.0	923.4	1478.4	460.0	670	290	233	719	394
	407	998	1506.0	433.2	1224.2	1150	525.0	894	456	415	1426	525
	(304)	(1010)	(2070)	(510)	(1010)	(1230)	(517.0)	(715)	(368)	(360)	(1070)	(460)
TDS	170	560	925	221	729	815	478	354	291	345	973	172
(mg/L)	192	780	1116	439	525	696	302	538	396	210	1023	259
	(185)	(660)	(1010)	(318)	(662)	(784)	(356)	(480)	(320)	(280)	(980)	(220)
Bicarbonate	92	310	509	221	396	382	220	322	169	182	55	70
(mg/L)	111	470	593	289	482	478	306	399	229	230	70	107
	(104)	(448)	(551)	(252)	(450)	(428)	(260)	(340)	(200)	(200)	(60)	(84)
Carbonate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
(mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	(ND)	(ND)	(ND)	(ND)	(ND)	(ND)	(ND)	(ND)	(ND)	(ND)	(ND)	(ND)
Total Hardness	45	190	455	53	201	123	97	202	182	174	391	92
(mg/L)	89	256	535	79	256	195	129	258	223	210	448	129
	(68)	(222)	(505)	(64)	(224)	(174)	(78)	(220)	(200)	(196)	(420)	(108)
Sulphate	22.29	72.0	519.0	46.18	132.0	191.0	39.96	43.01	25.34	28.39	503.0	285.0
(mg/L)	41.26	260.0	710.0	78.04	166.0	218.0	54.23	59.23	39.75	33.72	589.0	300.0
	(31.90)	(150.0)	(620.0)	(54.17)	(152.0)	(202.1)	(48.83)	(50.0)	(31.25)	(31.25)	(520.0)	(290.0)
Sulphate	22.29	72.0	519.0	46.18	132.0	191.0	39.96	43.01	25.34	28.39	503.0	285.0
(mg/L)	41.26	260.0	710.0	78.04	166.0	218.0	54.23	59.23	39.75	33.72	589.0	300.0
	(31.90)	(150.0)	(620.0)	(54.17)	(152.0)	(202.1)	(48.83)	(50.0)	(31.25)	(31.25)	(520.0)	(290.0)

Table 2 Continued

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Chloride (mg/L)	30.0	35.0	46.0	41.0	44.0	120.0	46.8	68.0	14.0	10.1	42.0	42.0
	45.0	56.0	62.0	54.0	53.0	160.0	63.0	83.0	26.0	19.3	54.0	56.0
	(36.0)	(47.0)	(59.0)	(50.0)	(48.0)	(140.0)	(54.0)	(78.0)	(18.0)	(14.2)	(48.0)	(48.0)
Total Iron (mg/L)	0.11	0.6	0.8	0.12	0.19	0.12	0.25	0.29	0.22	0.14	0.89	0.99
	0.92	0.32	0.20	0.26	0.36	0.24	0.32	0.41	0.32	0.22	1.33	1.22
	(0.42)	(0.16)	(0.11)	(0.19)	(0.26)	(0.19)	(0.27)	(0.34)	(0.28)	(0.18)	(1.05)	(1.11)
Sodium (mg/L)	91.3	395.9	398.2	289.0	409.3	470	245.0	210.9	82.9	89.9	193.9	306.9
	117.9	438.9	452.0	318.0	489.0	610	316.9	299.6	121.2	131.2	225.3	379.1
	(103.9)	(423.0)	(422.0)	(292.1)	(426.0)	(596.1)	(294.8)	(248.4)	(101.2)	(117.9)	(208.7)	(318.0)
Turbidity (NTU)	0.12	0.23	0.43	0.8	0.51	1.91	0.71	7.5	6.26	0.71	8.99	10.81
	0.63	0.92	1.68	1.56	1.41	3.47	2.18	14.42	3.8	1.59	10.56	13.35
	(0.43)	(0.66)	(1.09)	(1.21)	(1.06)	(2.82)	(1.62)	(10.01)	(5.02)	(1.04)	(9.23)	(12.05)
Silica (mg/L)	7.92	10.29	9.29	15.94	16.34	26.43	16.92	15.25	1.29	1.98	30.12	50.82
	8.59	22.94	20.83	25.50	22.31	41.24	23.01	18.93	4.71	2.79	51.25	76.99
	(8.06)	(17.10)	(18.11)	(23.84)	(17.10)	(36.65)	(19.8)	(17.1)	(3.19)	(2.32)	(42.6)	(66.94)

Ref. (Table 2)

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Table 3 Some parameters for quality control and for comparison

Analysed For	Units	Nestle water	WHO	Pak EPA	USEPA	CRM value	CRM Value obtained
Bacteriological contamination	cfu/ml	ND	Must not detectable in 100ml sample	Must not detectable in 100ml sample	Must not detectable in 100ml sample	-	-
pH	-	7.47	7.00-8.50*	6.5-8.5	6.50-9.20	7.0	7.03
Conductivity	uS/cm	312.00	600*		-	50.00	50.15
Total Dissolved Solids	mg/L	190.00	500.00*	< 1000	1500.00	100.0	98.7
Bicarbonates	mg/L	38.00	500.0*	-	-	-	-
Carbonate	mg/L	ND				-	-
Total Hardness	mg/L	100.00	100.00	<500	500.00	-	-
Sulphate	mg/L	15.70	200.00	-	400.00	50.00	51.26
Chloride	mg/L	104.00	<250.00	250	250.00	50.00	49.70
Sodium	mg/L	57.70	200-	-	-	-	-
Turbidity	NTU	0.3	5.00	≤0.05	25.00	10.00	10.20
Cr	mg/L	ND	0.05	≤0.05	0.01	0.200	0.198
As	µg/L	ND	0.01	≤0.05	0.01	0.200	0.197
Mn	mg/L	ND	0.5	≤0.5	10.0	0.200	0.199

4. Conclusions

The general conclusion about the analytical results of the samples of Drinking water of Sheikhupura is that average pH of all the sites was found in the range of WHO standard. All the samples show good amount of iron. Silica level in all sites fell in the range of 1.29 to 76.99ppm. The samples from four sites out of 12 showed bacterial contamination. Five samples depicted the elevated values of TDS. These elevated values of conductivity and TDS can be attributed to the waste effluents of the swarming industries situated in the study area. All the sites showed carbonates & bicarbonates within the limits. Average value of its hardness was found to be 505ppm. Sulfate was found in elevated amount, may be due to sulfate fertilizers. Three of our samples showed the sulfate above the WHO limit of 250ppm. All the samples depicted the chloride within the limit. Average value of sodium of 9 sites were above 200ppm, the permissible level of WHO. All the samples were having turbidity in the limit of USEPA however three samples showed turbidity above the limit of WHO and PAKEPA.

The area under our study didn't showed a very severe potential of chromium toxicity however there is a possible threat for the inhabitants if its concentration increases in the future. Hence a constant monitoring of Cr level in the drinking water of this area is necessary.

Our study area indicated four sampling sites with elevated arsenic level. However minimum value of two sampling sites and the average of only one sampling site were above the limit. Four of our sampling sites indicated high Mn content.

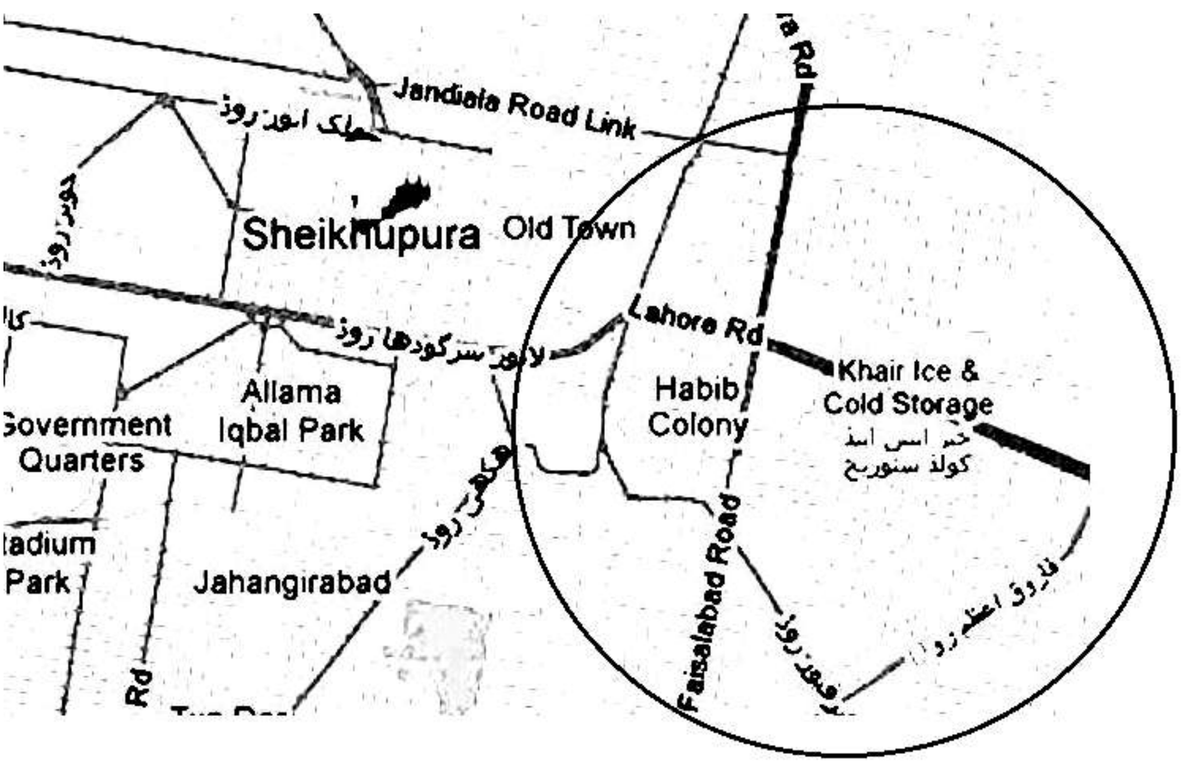

Fig 1: Map of Shekhupura Industrial area (Lahore Road, Faisalabad Road)

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