Study of Health & Environmental Risks Associated with Polluted Water Irrigation

M. Aqeel Ashraf[1], K. Mahmood[2], M. Jamil Maah3, I. Yusoff[4] and A. Wajid[5]

Abstract—**A study was conducted in Jamber Khurd, a union council of Tehsil Pattoki, district Kasur in Punjab province, Pakistan, in order to determine the effects of using polluted water for irrigation which disturbed the quality of ground water and then its ultimate effects on the environment and health of common man living in the area. Different water quality parameters were studied in ground water samples that includes physico-chemical variables (pH, temperature, dissolved oxygen, conductivity, turbidity and total dissolved solids), anions (carbonates, bicarbonates and chlorides), cations (sodium, calcium and magnesium), biological variables like total coliform (*faecal coliform* and *E- coli*), heavy metals (manganese, nickel, chromium, lead, copper, cobalt, iron and zinc), sodium absorption ratio and residual sodium carbonate. The results were compared with National Environment Quality Standards. The results of the study show that, the use of polluted water increases the value of conductivity, total dissolved solids, sodium absorption ratio and residual sodium carbonate in ground water and exceeds the acceptable limits of National Environment Quality Standards. The increase in values was statistically significant. After detailed survey by conducting interview, it was concluded that the use of polluted water not only degraded the ground water quality but also have a severe health hazard on the residents of the area. The concentration of heavy metals was also found to be higher than acceptable range. Possible recommendations were given, in order to protect the area from pollution degradation.**

Index Terms—**ground water; pollution; health effects; people; Pakistan**

I. Introduction

Polluted water consists of Industrial discharged effluents, sewage water, and the rain water. The use of this type of water is a common practice in agriculture. Estimation indicates that more than 50 countries of the world with an area of twenty million hectares area are treated with polluted or partially treated polluted water [1]. In poor countries of the world more than 80% polluted water have been used for irrigation with only seventy to eighty percent food and living security in industrial urban and semi urban areas [2].

Polluted water has both advantageous and also disadvantageous. Generally the use of polluted water for irrigation has an advantage of crop production so benefits to farmers and the whole community but also harmful for the people and whole ecosystem. The main reason for the use of this polluted water is the non availability of enough funding to treat polluted water before using for irrigation purposes. As a result it degrades the environment as well as a cause of water borne diseases [3]. Extensive irrigation of polluted water can not only leach down the soil but also has a negative effect on ground water quality [4]. The effects of water pollution are numerous. Some water pollution effects are recognized immediately, whereas others don't show up for months or years. When toxins are in the water, the toxins travel from the water the animals drink to humans when the animals' meat is eaten so the pollutants enter the food chain. Infectious diseases such as typhoid and cholera can be contracted from drinking contaminated water. This is called microbial water pollution. The human heart and kidneys can be adversely affected if polluted water is consumed regularly. Other health problems associated with polluted water are poor blood circulation, skin lesions, vomiting, and damage to the nervous system. In fact, the effects of water pollution are said to be the leading cause of death for humans across the globe [5].

The irrigation system of Punjab Province, Pakistan is accompanied by a network of drainage system. The drains were originally constructed to counter the problem of water logging and to collect the surplus water and flood water. But due to increased population and industrialization, the drains mainly carry the industrial and domestic effluents that are ultimately carried to the canals and rivers. This water adds pollution to our food chain in addition to groundwater contamination when used to irrigate crops. These risks must be kept at a level acceptable to the community [6]. A study was conducted to estimate the contamination in groundwater after irrigation in order to determine the health effects on Environment and on people in relation to health and disease.

II. Study Area

Kasur is one of the oldest industrial cities of Pakistan. It is located 55 kilometres away on southeast side of Lahore on Indo-Pak border [7]. More than five thousand hectares area of Kasur was irrigated by polluted water mainly from River Ravi. The study was conducted in Jamber Khurd Union Council of Tehsil Pattoki district Kasur. Jamber Khurd is located at (31^0 08' 11.04" N, 73^0 55' 7.68" E). National Highway N5 (Multan-Lahore Road) is present on east while Balloki Sulemanki (BS) Link canal also called Lower Depalpur Canal is present on west of the town which originates from River Ravi at Balloki headworks. According to Population Census Organization of Pakistan (1998), Jamber Khurd has a population thirteen thousands, with an area of 1024 hectares being irrigated from River Ravi which at present the most polluted river in Pakistan. The soil of the study area is Late Pleistocene silty loess but the dating of silty loess is 1-6 million annum [8]. The contents of soils are mainly silt, loamy clay, clay and sand while, the loamy clay increase gradually with distance form riverbed [9]. There are significant changes in lithologies. Short absorb capacity of ground; a large amount of water would naturally cause runoff. The average annual rainfall in the area is about 650 mm, in which 65% occur during the southwest monsoon (June to September) while the contribution from northeast monsoon is nearly 20% and the rest is received during the pre-monsoon period.

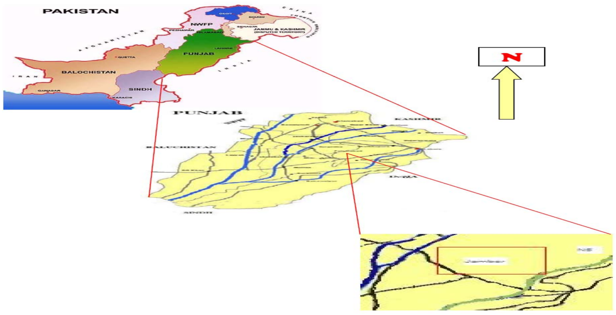


Figure 1. Jamber Khurd town, District Kasur, Pakistan

III. Material And Methods

In order to determine the environmental impacts of polluted water, a study was conducted to estimate the contamination in groundwater after irrigation. Representative sampling is the most difficult in situations where reliable data are needed most [10]. Chemists have struggled for decades with the difficulties involved in obtaining representative analytical results from bulk solid or natural water samples. A site conceptual model was developed which is based on underground water flow, contaminant fate and transport [11] as shown in fig. 2.

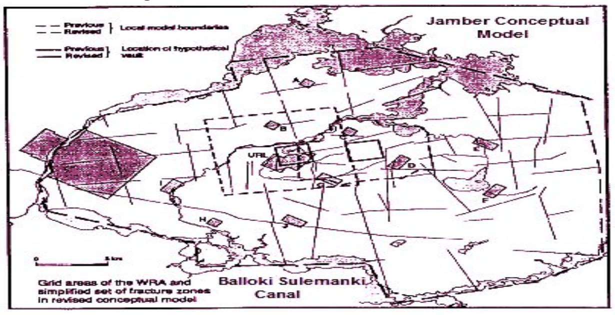


Figure 2. Jamber Khurd Sampling conceptual model

The field study was conducted from 21 February 2007 to 13 December 2007. Twenty sites were selected on the basis of conceptual model for the collection of ground water sample. Global Positioning System (GPS) were used to confirm the final location of the sampling point [12]. Samples were taken by making single level boreholes which were drilled by cable tool percussion method at a depth of 36-48 meters.

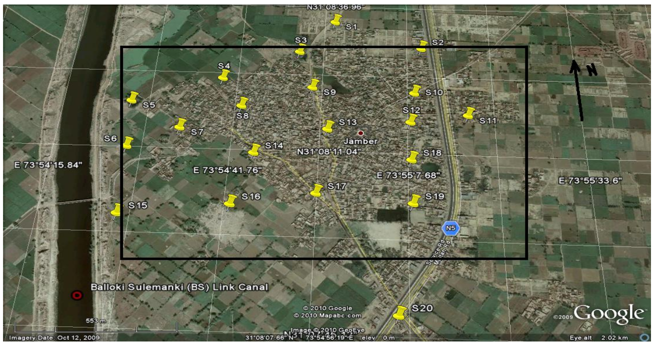


Figure 3. Arial view of the site showing sampling locations

Stainless steel bladder pumps were used at boreholes with flow rate 1L/min due to extremely coarse-textured formation. For sampling low flow purging technique were used [13].The passing of the sampling device through the overlying casing water causes the mixing of stagnant waters and the dynamic waters within the screened interval. There is disturbance to suspended sediment collected in the bottom of the casing and the displacement of water out into the formation immediately adjacent to the well screen. These situations make low flow purging technique with minimal draw drowned extremely useful [11]. Structure of single level piezometer borehole with stainless steel bladder pump is shown in fig. 4.

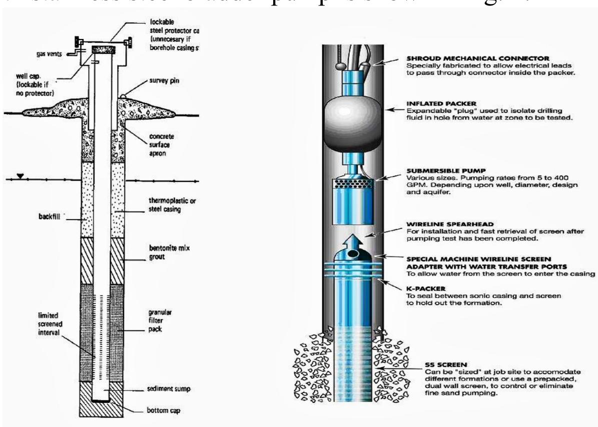


Figure 4. Single Level borehole with Bladder pump

Water Depth is measured by Stevens Contact Meter. Total 200 ground water samples were taken from selected twenty location locations. One field duplicate sampling set was collected for each sampling event. Duplicate samples were collected by sequentially filling all containers as close together in time as practical. Water samples were filtered and collected in 250 ml plastic bottles for anions analysis and cooled at 4 ^{0}C, for cations and metal analysis water samples were collected in 125ml plastic bottles, preserved with 4ml/ L HCl for cations and 8ml/L HNO_3 for metals analysis and preserved at 4 ^{0}C followed by the EPA standards for water sampling and handling [12].

Well drilling/completion, purging, sampling and analysis steps all contribute to error in ground-water monitoring results. Therefore quality assurance procedures and quality control checks were strictly followed and implemented throughout the project in order to get accurate results [14-15].

Following measures were taken for high level QA/QC performance in the field;

A. Trip blank and tepmerature blank samples

Trip blanks and temperature blank for cations, anions and metals were filled and sealed in the same manner as actual samples for cations, anions and metals analysis. Trip blanks consist of a set of pre-filled 40-ml purge-and-trap vials and are to accompany each cooler containing metals sample. The vials were not opened until analyzed in the laboratory along with the actual samples they have accompanied.

B. Equipment blank samples

Equipment blanks are used to determine the adequacy of the decontamination procedures applied to reusable sampling equipment. One equipment blank sample was used each day, by each field sampling crew, for the reusable sampling equipment.

C. Duplicate samples

One field duplicate sampling set was collected for each sampling event. Duplicate samples were collected by sequentially filling all containers as close together in time as practical.

Physio-chemical parameters pH, temperature, conductivity, dissolved oxygen, turbidity and total dissolved solids were measured in situ by AquaSensors DataStick ™ multiparameter probe while total coliform (*Faecal coliform, E- coli*) [17], anions (CO_3^{--}, HCO_3^{-}, Cl^{-}) [17], cations (Na^{+}, Ca^{++} + Mg^{++}) [17], heavy metals like Mn, Ni, Cr, Pb, Cu, Co, Fe, Zn were measured in the laboratory by using AAS Atomic Absorption Spectrophotometer (Perkin Elmer Mode 2380) and compared with NEQS standards (NEQS, 2002). AAS was calibrated for each element using standard solution of known concentration before sample injection [16].

Cations and Anions are determined only to calculate Sodium Absorption Ratio (SAR) and Residual Sodium Carbonate (RSC); which were calculated by the following equations;

$$SAR = Na / \{(Ca + Mg) / 2\}^{1/2}$$

$$RSC\ (me\ L^{-1}) = (CO_3^{--} + HCO_3^{-}) - (Ca^{++} + Mg^{++})$$

Where the concentrations are expressed in milli equivalents per liter (me L^{-1}) [18].

D. health effects of polluted water irrigation

In the second phase of study, a community survey was conducted among 3,222 inhabitants in 6 hospitals, 11 health care units and 755 houses of the study area from January 2008 to December 2008 in order to determine the health effects of polluted water irrigation by doing interview of the people of different ages and sex. The results of survey data were compared with the data of same size population of Changa Manga area, same Division (Kasur) but being irrigated from normal irrigation water. Changa Manga is the largest planted forest in the world. It is spread over an area of 50 km2. Chang Manga is located in the Chunian District 70 km South of Lahore. It was initially planted during the British era to provide timber for steam locomotives. Most of the trees found here are Kikar and Mulberry. Presently, a portion of the forest has been turned in to a park for recreational purposes. Lots of people visit Changa Manga every year. There are many activities to keep the visitors interest alive. The main activity being a small rail ride which takes the visitors on a 5 km ride through the forest.

IV. Results And Discussion

A. Ground water quality analysis

The data of water quality obtained from study area was analyzed statistically for mean, standard deviation and percentage following the standard procedure [19]. Data in Table (1, 2) shows range, mean and standard deviation with quality criteria of total two hundred samples analyzed from each location. pH of water samples ranged from 8.4-9.1 with 80 (35%) samples out of 200 are fit, 108 (47%) marginally fit and 12 (18%) are unfit, temperature ranged from 22-26 ^{0}C with 134 (67%) samples out of 200 are fit, 62 (31%) marginally fit and 4 (2%) are unfit while dissolved oxygen ranged from 5-8 mg/L with 98 (49%) samples out of 200 are fit, 74 (37%) marginally fit and 28 (14%) are unfit. Overall these parameters are within the permissible limits set by National Environment Quality NEQS for irrigation water quality. The values found for parameters such as conductivity, turbidity, TDS, RSC, SAR, chlorides, FC and *E.coli* of water samples did not follow the criteria set by NEQS for irrigation. So by comparing results of (Table 3) with (Table 4), it was again found that different parameters exceeding the water quality limits for irrigation. Similar kinds of results have also been reported by different researchers [21-22].

Table 1. Range, mean and standard deviation (S.D.) of irrigation quality parameters with NEQS

Serial No.	Parameter	Experimental Results (Range)	Mean	Standard Deviation	NEQS
1	pH	8.4-9.1	8.73	0.24	6-10
2	Temperature	22-26	24	0.42	20-26
3	Dissolved Oxygen (DO) mg/L	5-8	6	1.46	6-8
4	Conductivity µS/cm	3,500-4970	4,600	677.43	1,500
5	Turbidity NTU	25-100	78	78.67	25-50
6	Total dissolved solids mg/L	3000-5000	3498	562.34	1000
7	RSC me L^{-1}	0-21.4	6.51	4.82	2.5
8	SAR $(mmol/L)^{0.5}$	0.1-33.5	18.69	12.44	10.0
9	Cl me L^{-1}	0.1-6.8	3.28	3.32	2.5
10	Faecal Coliform mg/L	1.0-1.5	1.2	0.0056	0.5
11	E.Coli mg/L	1.2-2.0	1.6	0.0042	0.5
12	Fe mg/L	4.10-5.0	4.34	0.77	5.0
13	Mn mg/L	1.10-1.15	1.12	1.23	0.12
14	Ni mg/L	0.19-0.24	0.20	1.26	0.20
15	Cu mg/L	1.56-1.80	1.62	2.56	1.0
16	Cr mg/L	0.09-1.50	1.16	23.24	1.0
17	Pb mg/L	0.36-0.55	0.47	25.10	0.50
18	Co mg/L	0.17-0.22	0.20	45.10	0.05
19	Zn mg/L	1.84-2.0	1.86	1.28	0.77

Table 2. Conditions of water use and irrigation water quality parameters

Condition of Use	Conductivity µS/cm	SAR	RSC me L^{-1}
Coarse Textured Soil	3000	10	2.50
Medium Textured Soil	2300	08	2.30
Fine Textured Soil	1500	08	1.25

Irrigation water quality guidelines for Pakistan, proposed by WWF (2007) [32]

Conductivity ranged from 3500-4970 µS cm^{-1} with 24 samples (12%) out of 200 are fit, 38 (19%) marginally fit and 138 (69%) are unfit. Turbidity ranged from 25-100 NTU with 56 samples (28%) out of 200 are fit, 49 (24.5%) marginally fit and 95 (47.5%) are unfit. TDS ranged from 3000-5000 mg/L with 12 samples (6%) out of 200 are fit, 19 (9.5%) marginally fit and 169 (84.5%) are unfit. SAR represents the relative proportion of Na to Ca + Mg. The SAR of water samples ranged from 0.1 to 33.5 with mean of 18.69 and standard deviation of 12.44 (Table 1). Considering relative frequency distribution regarding SAR (Table 3), 76 samples (38%) were fit, 21 samples (10.5%) were marginally fit and remaining 103 samples (51.5%) were unfit. Sodium adsorption is stimulated when Na proportion increases as compared to Ca + Mg resulting in soil dispersion [24]. At high levels of sodium relative to divalent cations in the soil solution, clay minerals in soils tend to swell and disperse and aggregates tend to slake, especially under conditions of low total salt concentration and high pH. As a result, the permeability of the soil is reduced and the surface becomes more crusted and compacted under such conditions. Soil's ability to transmit water is severely reduced by excessive sodicity [23]. The irrigation water containing excess of CO_3 and HCO_3 will precipitate calcium and hence sodium will increase in soil solution. It leads to saturation of clay complex with sodium and consequently decreased infiltration rate. The RSC values of water samples ranged from 0-21.4 me L^{-1} with mean of 6.51 me L^{-1} and standard deviation of 4.82. Forty three samples (21.5 %) out of 200 were fit, 56 samples (28 %) were marginally fit and remaining 101 samples (50.5 %) were unfit (Table 2). Data in (Table 1, 2) also indicates high percentage of total coli-form that is *faecal Coli-form* and *E.Coli* then the acceptable limits according to NEQS.

The quality of water of different sites depends upon the average condition of soil texture, quantity of irrigation water applied, soil drainage, infiltration rate etc along with other variables like climate and tolerance of crop to salts. It was observed that most of the water samples were unfit due to high RSC. Farmers can use high RSC water for growing crops after gypsum amendment. Gypsum requirement can be calculated by following formula:

Gypsum requirement (kg) = RSC (me L^{-1}) × discharge (cusec) × working hours × 8.8

Water quality also depends upon texture of the soil. Irrigation water unfit for fine textured soils might not be so for coarse textured soils (Table 1). Farmers can use marginal and unfit water for salt tolerant crops like *Triticum aestivum, Sorghum bicolor (L.)* etc as these crops have physiology for moderating the ill effects of salts. An integrated, holistic approach is needed to conserve water and prevent soil salinization and water logging while protecting the environment and ecology.

Efficiency of irrigation must be increased by the adoption of appropriate management strategies, systems and practices and through education and training. There is usually no single way to achieve salinity control in irrigated lands and associated waters. Many different approaches and practices can be combined into satisfactory control systems. The appropriate combination depends upon economic, climatic and social as well as hydro-geologic situations [23].

(Table 1) represents the maximum concentration of Fe which has 58% of the total metal concentration while the concentration of Mn, Zn, Cu, Cr and Co are higher than the permissible level of NEQS but the concentration of Ni and Pb is in the acceptable range. These elements may react with the other and the equilibrium of system may alter and may enter the food chain due to the changing in redox equilibrium. The presence of other trace metals is not out of question. So The Balloki and Sulemanki head works, water distributor to Jamber area may have heavy pollution of other metals which are need to be determined. The odour and color of irrigation channels especially at Head Balloki, Sulemanki may be due to the presence of some toxic species and microbial activities, which also need to be analyzed.

B. *Health effects on people*

To analyze the effects of polluted water on health of common man, people were interviewed for 12 months. Total 3222 inhabitants were interviewed according to their age and sex. The same population was interviewed in Changa Manga Town in the same district Kasur, being irrigated with fresh water, largest man made forest in the world and a picnic spot. (Table 3, Graph 1) shows that in Jamber Town, out of 3222 inhabitants being interviewed, 2351 were effected by different kind of diseases which shows that 76.07% of the population is effected and only 23.93% is normal (Graph 2). Most of the persons being investigated were affected by nail problem, skin problem and fever. In Changa Manga, out of 3222 inhabitants being interviewed, only 1289 were effected diseases (Table 4, Graph 1) which are 40% of the total population investigated while 60% were normal (Graph 3). So it can observe that the ratio of infection in Jamber Town is two times higher then in Changa Manga. It was also found that most of the persons being investigated were affected by nail problem, skin problem, diarrhea and fever. (Table 8) shows that in Jamber, female population (55.12%) is more effected with diseases then male population (44.87%) while in Changa Manga rate of infection is equal in male (50.65%) and female (49.34%). Furthermore in Jamber population with age (1-10, 61 and above) are mostly infected by diseases while in Changa Manga, no such pattern was observed. This study shows that the percentage of the mentioned diseases is higher in Jamber Khurd area where underground water is polluted due to polluted water irrigation as compared to Changa Manga, with fresh water for irrigation. The present study also indicates the percentage of getting ill for a family in one year is also greater in this area as compared to other areas. An immediate action should be taken to save the community as well as the future generation.

Table 3. Affected Inhabitants According to Age in Jamber Town

Age	Diseases							
	Cold/Pneumonia	Typhoid	Fever	Nail Problem	Dysentery	Skin Problem	Diarrhoea with fever	Diarrhoea
15-19	51	38	56	70	48	64	32	30
20-24	40	41	50	68	44	58	38	28
25-34	29	32	41	59	33	49	34	29
35-44	24	29	38	49	29	47	31	25
45-54	35	33	46	56	32	52	36	24
55-64	39	35	49	62	36	56	33	26
65 and above	43	40	52	65	41	60	37	29
Total	261	248	332	429	263	386	241	191
Total Inhabitants	3222		Effected by Diseases	2351		Effected Percentage	76.07%	

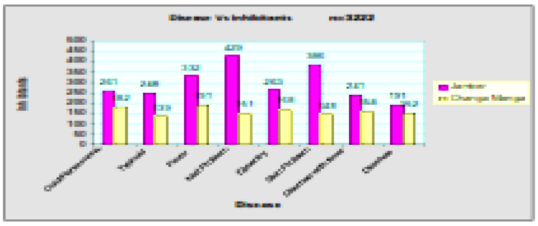
Table 4. Affected Inhabitants According to Age in Changa Manga Town

Age	Diseases							
	Cold/Pneumonia	Typhoid	Fever	Nail Problem	Dysentery	Skin Problem	Diarrhoea with fever	Diarrhoea
15-19	27	14	18	19	32	35	20	30
20-24	26	22	28	21	16	14	31	20
25-34	28	23	31	26	21	32	34	16
35-44	25	24	42	25	14	18	12	25
45-54	23	19	34	20	32	22	10	24
55-64	27	20	22	23	12	17	33	14
65 and above	26	17	16	17	41	10	18	23
Total	182	139	191	151	168	148	158	152
Total Inhabitants	3222		Effected by Diseases	1289		Effected Percentage	40.00%	

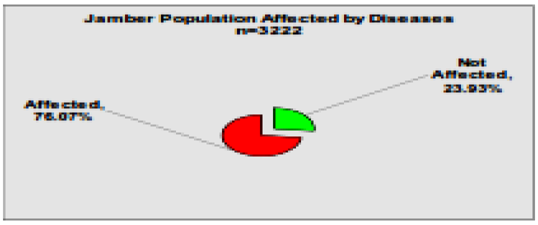
Table 5. Comparison of Inhabitants in Both Towns According to Age & Sex

Age	Total Affected Persons in Jamber	Male	Female	Total Affected Persons in Changa Manga	Male	Female
15-19	389	177	212	195	102	93
20-24	367	199	168	178	98	80
25-34	306	118	188	211	94	117
35-44	272	130	142	185	104	81
45-54	314	126	188	184	90	94
55-64	336	156	180	168	91	77
65 and above	367	149	218	168	74	94
Total	2351	1055	1296	1289	653	636
Percentage		44.87%	55.12%	Percentage	50.65%	49.34%

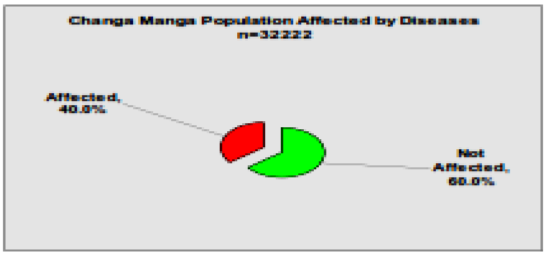
Graph 1. Comparison of Population Affected by Different Diseases in Both Towns



Graph 2. Jamber Population Affected by Diseases



Graph 3. Changa Manga Population Affected by Diseases



V. Conclusion And Recommendations

The analytical data indicate that all sampling stations are fit with respect to irrigation parameters (pH, temperature and DO) while parameters (conductivity, turbidity, TDS, SAR, RSC, *FC* and *E.Coli*) exceeds NEQS limits for irrigation. The trace metal Ni and Pb reflects low while Fe, Mn, Zn, Cu, Cr and Co reflects their higher concentration in the area. The main reason for the water pollution is the discharge of untreated industrial effluents directly into the water reservoirs that results in a high level of pollution in the surface water of reservoirs and also in ground water. This poor quality water causes health hazard and death of human being, aquatic life and also disturbs the production of different crops. The main reasons for this problem are lack of funding, lack of water treatment plants and lack of awareness. From the present study it can be concluded that the results are somewhat in range of NEQS standards but if preventive measures could not be taken then toxic level of harmful material can mix up with the ground water and can cause serious damage to our whole environment.

Following preventive measures can reduce the risk of ground water contamination in Pakistan.

1) Water Quality Standards should be applied strictly to big industrial units draining huge amount of wastewater effluents into drains that ultimately reaches to rivers.
2) Strict actions leading to shutdown of unit should be taken by the Environment Department in Pakistan against the industrial units that are directly draining their waste water effluents without proper treatment.
3) Proper drainage system should be constructed in order to reduce the risk of leakage and overflow and also to avoid the addition of waste material into the drains.
4) Post harvest contamination might occur during transport or at markets. This is due to poor sanitation facilities and lack of water supply for personal hygiene as well as washing and "refreshing" of vegetables. Efforts should be taken to improve cleanliness in markets, washing vegetables before selling, Displaying vegetables on tables instead of the ground, can largely reduce the risk of pathogens.
5) Leafy vegetables should not grown in areas that are directly irrigated by wastewater. If restriction cannot be enforced, public awareness campaigns should be launched to educate people about the health risks involved.

Acknowledgment

The work reported in this paper was carried out in Analytical Laboratory, Department of Chemistry, The Islamia University of Bahawalpur, Pakistan. I take this opportunity to express my gratitude to Prof. Dr. Karamat Mahmood and Mr. Abdul Wajid for facilitating me to carry out my work in Pakistan. Thanks also go the IPPP Unit, University of Malaya for providing me enough funding to complete this work abroad.

References

[1] S. Mahmood, "Waste water irrigation: issues and constraints for sustainable irrigated agriculture," J. Ital. Agron.,Vol. 3, pp. 12-15, 2006.
[2] S. Mara and S. Cairncross, S, "Guidelines for safe use of wastewater and excreta in agriculture and aquaculture: measures for public health protection,". World Health Organization, Geneva, Vol. 3, pp. 187-189, 1989.
[3] A. Gafoor, A. Rauf, M. Arif, and W. Muzaffar, "Chemical composition of effluents from different industries of the Faisalabad Pakistan," J. Agri. Sci., Vol. 33, pp. 73-74, 1994.
[4] M. Ibrahim and S. Salmon, S, "Chemical composition of Faisalabad city sewage effluents. I. Nitrogen, Phosphorus and Potassium contents," Pak. J. Agri. Sci., Vol. 30, pp. 381-390, 1992.
[5] The Asia Water Project, [Online Available: http://www.asiawaterproject.org/water-crises/water-facts/impacts/
[6] WAPDA, Surface water quality monitoring in Punjab, Irrigation and Power Department, Government of Punjab, Pakistan, Monthly Report, 2007.
[7] WIKIPEDIA The free encyclopaedia, [online Available: http://en.wikipedia.org/wiki/Kasur
[8] J. D. Harland Hem, Geological Survey water-supply, paper, Vol. 269, pp. 1473, 1970.
[9] F. U. I. Khan and S. S. Zain Zaidi, J. Sc. Tech. Dev., Islamabad, Pakistan.Vol. 9, pp.113-134, 1990.
[10] B. Kratochvil and J. K. Taylor, "Sampling for chemical analysis," Anal. Chem.,Vol.53, pp. 924A-938A, 1981.

[11] Robert, W. P. and Michael, J. B. (1996), Ground water issue low-flow (minimal drawdown), in: Ground-Water Sampling Procedures, U.S. EPA, Washington, DC. Region 1, Rev2, 2:1-13.
[12] EPA, Standard Operating Procedures, Collection of chemical and biological ambient water samples. U.S. EPA, Module 7, Region 1, Revision 1, 2002.
[13] EPA, Standard Operating Procedures, Low stress (low flow) purging and sampling procedure for the collection of ground water samples from monitoring wells. U.S. EPA, Region 1, Rev2, 2:1-13. 1996.
[14] K. W. Brown and S. L. Black, “Quality assurance and quality control data validation procedures used for the Love Canal and Dallas lead soil monitoring programs,” Environ. Monitor. Assess., Vol. 3, pp.113-122, 1983.
[15] S. W. Sisk, “NEIC Manual for groundwater/subsurface investigations at hazardous waste Sites,”USEPA Office of Enforcement, National Enforcement Investigations Centre, Denver, Colorado, 1981.
[16] APHA, Standards methods of water and waste water examination. American Public Health Association, USA. 1992.
[17] APHA, Standard Methods for the Examination of Water and Wastewater, 20th ed. Washington, DC. 1998.
[18] L. A. Richards, Diagnosis and Improvement of Saline and Alkali Soils. USDA, Agricultural Handbook 60, Washington, pp.160-172, 1954.
[19] R. G. D. Steel and J. H. Torrie, Principles and Procedures of Statistics. 2nd ed. New York: McGraw-Hill, 1980.
[20] R. S. Ayers and D. W. Westcott, Water Quality for Agriculture. FAO Irrigation and Drainage, paper. 29 Rev.1, 1994.
[21] T. J. Downs, E. Cifuentes-Garcian and I. M. Suffet, “Risk screening for exposure to ground water pollution in a waste water irrigation district of the Mexico city region,” Environ. H. Pers.,Vol. 107, pp. 553-561, 1999.
[22] M. Rashid, S. R. Awad, and M. A. Salam,“Monitoring of groundwater in Gabal el Asfar waste water irrigated area (Greater Cairo),” W. Sc. & Tech., Vol. 32, pp. 163-169, 1995.
[23] FAO, The use of saline waters for crop production, Irrigation and drainage paper 48. FAO, Rome. 1992.
[24] W. W. Emerson and A. C. Bakker, “The comparative effects of exchangeable calcium, magnesium and sodium on some physical properties of red-brown earth subsoils,” Aus. J. S. Res., Vol. 11, pp. 151–157, 1973.

Muhammad Aqeel Ashraf is born on 11th of Janury 1983 in a small village of Khanewal District in Punjab province, Pakistan. He got his BSc degree from The Islmia Postgraduate College Khanewal, Pakistan in 2002. He got his M.Sc Chemistry degree from Bahauddin Zakariya University Multan, Pakistan in 2005. He got his M.Phil Chemistry degree from The Iskamia University of Bahawalpur, Pakistan in 2009. He got scholarship from Ministry of Higher Education (MoHE) Malaysia in the year 2009 to complete his PhD Degree at University of Malaya, Kaula Lumpur, Malaysia. Currently he is working on PhD project entitled “Chemical speciation & bioavailability of heavy metals in the former tin mining catchment Bestari Jaya, Peninsular Malaysia”. He has more then 12 research publications in well reputed ISI indexed journals. He has represented his research work in more then 15 national & international conferences. He is member of different national & international organizations including WWF, IUPAC & Chemical Society of Pakistan.