Vol. 5(4), pp. 33-42, October 2018
DOI: 10.5897/ISAAB-JHE2018.0045
Article Number: D51D0B458968
ISSN: 1684-5315

http://www.academicjournals.org/ISABB-JHE

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ISABB Journal of Health and Environmental Sciences

Full Length Research Paper

An analysis of wastewater irrigation practices and its impacts on the livelihood generation and food chain contamination in Faisalabad District, Pakistan

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Received 6 June, 2018; Accepted 4 October, 2018

In the irrigated agricultural areas of Pakistan, the major sources of irrigation are canal water and groundwater. Due to the scarcity of canal water the dependency on groundwater is rapidly increasing in many areas of Pakistan. The groundwater is not only expensive, inadequate, and non-affordable for the small farmers but also of inferior quality. Much of the wastewater which is produced in urban and peri-urban areas is directly or indirectly used for irrigation without any kind of treatment. It appears that suitable technologies for decentralized treatment are avoided but other barriers to the wide adoption of the decentralized approach also exists. These barriers include lack of finance and suitable land, devoid of knowledge and skills and a lack of flexibility in official design standards. This study is an effort to check the status of treatment of the wastewater generated in Faisalabad: The area irrigated with wastewater in and around Faisalabad, quality of wastewater used to grow crops in wastewater irrigated areas, types of crops grown with wastewater, mechanism and composition of wastewater used and supplied to the farmers and farmer's perception about the social and adverse impacts on human health and constraints in wastewater irrigation. To reduce these barriers several opportunities for improving wastewater management are to be considered via improved policies, institutional dialogues and financial mechanisms, which would reduce the risks in food chain contamination in agriculture practices. Effluent standards combined with incentives or enforcement can motivate improvements in water management by household and industrial sectors discharging wastewater from point sources. Segregation of chemical pollutants from urban wastewater facilitates treatment and reduces risk. Strengthening institutional capacity and establishing links between water delivery and sanitation sectors through inter-institutional coordination leads to more efficient management of wastewater and risk reduction.

Key words: Wastewater irrigation, wastewater implication, constraints, farmer 'perception, food chain contamination.

INTRODUCTION

Globally just 20% of wastewater is being dealt with, leaving low-income nations hard hit by polluted water supplies. With urban populaces evaluated to twofold in the following four decades, and low-income nations having just 8% of the expected ability to treat wastewater viably. Around 70% of industrial release in developing nations goes untreated; eutrophication from wastewater and agrarian run-off – has, as per ongoing appraisals, diminished biodiversity in waterways, lakes, and wetlands by around 33% all inclusive (UNEP, 2015). At the worldwide level, treatment of wastewater is one of the key parts of ensuring water resources. It presents a dual public health and environmental protection challenge for emerging and developed nations of the world. By 2020, the Organization for Economic Co-operation and Development (OECD) predicts waste production to have expanded more than 45% contrasted with that in 1995. It is, along these lines, essential that we should restrict the effect of waste on nature and additionally recuperate it to make new vitality resources. Today, the peasants are gone up against with a perplexing issue: how might they continue delivering more to meet financial demands and a regularly soaring population while guaranteeing that water resources are secured (SUEZ e-mag, 2016). As urban populations in developing nations go on increasing and occupants look for better expectations for everyday comforts, bigger measures of freshwater are occupied to residential, business, and modern divisions, which produce more prominent volumes of wastewater (Lazarova and Bahri, 2005; Qadir et al., 2010; Asano et al., 2007).

The Indus Basin Irrigation System in Pakistan is the biggest water system framework on the globe and is the backbone of the nation's economy (Alam et al., 2007). Pakistan, once a water-surplus nation, is presently a water lacking nation. The water accessibility has diminished from 1,299 m^3 per capita in 1996-1997 to 1,100 m^3 per capita in 2006 and it is anticipated to under 700 m^3 per capita by 2025. In this manner, look for other non-conventional water resources for water system that is, wastewater, has turned out to be essential. In Pakistan, domestic and industrial wastewater is either released straightforwardly to a sewer framework, in a natural drain or water body, or in an internal septic tank. For the most part, this wastewater isn't dealt with and none of the urban communities have any natural treatment process aside from Islamabad and Karachi, and these urban communities treat just a little extent (<8%) of their wastewater before disposal. The wastewater utilized for irrigation is esteemed by farmers, mainly because of its nutrient contents and reliability of supply and exert positive impacts on agriculture land values, in spite of the fact that it is a source of contamination of human food chain and is responsible for health risks as well. There appears to be no national strategy as a result on manageable utilization of wastewater in this nation (Murtaza and Munir, 2012).

The wastewater is critical resource of livelihoods in peri-urban zones (WHO, 2006). Water is at the core of a large portion of industrial activities. Expected to guarantee that offices work appropriately, it must be dealt with after use to restrict ecological waste. The industrial organizations have an enthusiasm for waste management and asset protection forms, particularly advancing water treatment offices is a key to pick up an upper hand (Suez e-mag, 2016). In all the significant towns in Pakistan, having a sewage framework, wastewater is specifically utilized for water system (Ahmad, 2007).

Faisalabad is the center of textile industry in Pakistan and is known as the Manchester of Pakistan for more than six decades. This investigation is a push to check the status of treatment of wastewater created in Faisalabad, that is, area irrigated with wastewater in and around Faisalabad, nature of wastewater used to grow crops in wastewater flooded regions, sorts of harvests developed with wastewater, system and synthesis of wastewater utilized and provided to the farmers and agriculturist's recognition about the social effect and limitations in wastewater water system.

LITERATURE REVIEW

Wastewater generation, treatment, and current use around the world

In many Asian and African cities, population growth has outpaced improvements in sanitation and wastewater infrastructure, making management of urban wastewater a tremendous challenge for the government as well as for the local bodies. Take the example of India where only 24% of wastewater from industry and household is treated. Whereas in Pakistan. Only 2% wastewater is treated by the treatment plants (IWMI, 2003; Minhas and Samra, 2003). Usually less than 10% of the generated wastewater in West African cities is collected in piped sewage systems and receives primary or secondary treatment (Drechsel et al., 2006). Large centralized wastewater collection and treatment systems in many developing countries have proven difficult to sustain. For long-term operation and financial sustainability decentralized systems are more flexible and compatible,

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with demands for local effluent use have been promoted in many areas, although not without challenges (Raschid-Sally and Parkinson, 2004). For example, in Ghana, only 7 of 44 smaller treatment plants are functional and probably none meets the designed effluent standards (Obuobie et al., 2006).

Implications for farmers' and consumers' health

From wastewater irrigation, human health risks include farmers' consumers' exposure to pathogens including helminth infections and organic and inorganic trace elements. The farmers and their respective families using wastewater are normally exposed to health risks from parasitic worms such as protozoa, viruses, and bacteria (Ayers and Westcot, 1985). In the developing country like Pakistan, most of the farmers cannot afford treatment for some of the health problems caused by the exposure of wastewater and the contaminated food they use. Generally, farmers irrigating with wastewater have higher rates of helminth infections than farmers using freshwater, but there are exceptions (Trang et al., 2007). Skin and nail problems, in addition, may occur among farmers using wastewater (Van der Hoek et al., 2002; Trang et al., 2007). Women are a particularly important target group not only for being a vulnerable group but also to apply risk-reduction methods. In many countries of the world women provide much of the labor required to produce vegetables and perform much of the weeding and transplanting that can expose them to long periods of contact with wastewater. Women generally prepare meals, creating the opportunity for transferring pathogens to the family members unless good hygiene is maintained. In West Africa, where in 10 of 13 countries mostly men grow vegetables, women dominate the marketing process, especially retail, of most vegetables; thus, the main target group for risk reduction measures is markets (Drechsel et al., 2008).

STUDY OBJECTIVES

The following were the objectives of this research study:

(1) To examine local experience regarding wastewater utilization for irrigation purpose
(2) To investigate the impact of wastewater on the food chain contamination
(3) To explore the magnitude of wastewater consumption in irrigation
(4) To access institutional arrangements, obstacles, and policy inferences for sustainable livelihood based on irrigation in agriculture sector

MATERIALS AND METHODS

According to Nachmias and Nachmias (2007) "Scientific methodology is a system of explicit rules and procedures upon which research is based and against which the claims for knowledge are evaluated". The present study was conducted in District Faisalabad of the Punjab Province, Pakistan. Survey method was the prime method which was utilized throughout the process of the study. The methodology of this research study was divided into two phases. In the first phase water samples were taken from the drains containing waste water flowing to the areas such as "Parokian Wala", Chak # 219 (Gurhi and Dufrana), "Merzi Pura", Uchkera", Bawa Chak, Islam Pura, Sidhu Pura, and Chohar Majra. The above- mentioned areas are widely irrigated with the help of wastewater. The samples of waste water were also collected from the drains situated near the textile and Chimical mills such as Kohinoor Textile Mills Ltd, Kalash Textile Mills Ltd, Rafhan Maize Product Company, Sadaqat Textile Mills (Pvt.) Ltd, and M. K. Sons (Pvt.) Ltd. The samples collected from the above-mentioned areas were tested in the laboratories of the University of Agriculture, Faisalabad. The chemical analysis of the wastewater helped the researchers to know about the chemical composition of the water and its hazardous effect on the lives of the people who are still consuming the vegetables grown with the help of this water. In the second phase of the methodology, a survey was conducted to know about the crops and vegetables grown with the help of waste water (a list of crops is given in Table 2) in the irrigation sites mentioned above. The qualitative method, the focused group discussions were conducted to know about the knowledge of the farmers and community members keeping in view the research objectives of the research study. The owners of the textiles and chemical mills were also approached to discuss the results of the samples obtained from the drains situated near the mills.

RESULTS AND DISCUSSION

Over view of wastewater irrigation practices-Faisalabad

Status of treatment of wastewater generated in Faisalabad

The use of wastewater for agriculture purposes in district Faisalabad is common. At least nine different sites could be identified, varying in size up to 1,000 ha. Common crops grown at these sites include fodder, wheat, cotton and vegetables (cauliflower, spinach, turnips, peas, sugarcane, carrots, radishes, and aubergine). Few of these sites have been receiving wastewater for the last 30 years (Baig et al. 2011).

Recently, a wastewater treatment plant was developed that consists of 16 ponds (oxidation ponds system) in two rows and covering an area of 16 ha. Of these, six are aerobic and six are facultative while four are sludge dewatering ponds. The plant has been designed for an average flow of 90,000 m^3/day. Private wastewater treatment units in Faisalabad (Functional):

(i) Kohinoor Textile Mills Ltd. = 150 m3/h
(ii) Kalash Textile Mills Ltd. = 150 m3/h
(iii) Rafhan Maize Product Company = 110 m3/h
(iv) Sadaqat Textile Mills (Pvt.) Ltd. = 120 m3/h
(v) M. K. Sons (Pvt.) Ltd. = 170 m3/h

The environmental protection department reported that

Table 1. A brief profile of the Paharang drain.

Structures	Numbers
Total length (km)	30
No. of Bridges	38
No. of Industries	45
No. of Out falls	312
Branches coming in Paharang Nallah	5*
Pump stations	3**

*(i) Bawa chak (ii) Khusan purah (iii) Bye pass (iv) Ghulam Muhammad Abad
** (i) Bawa chak (ii) Chakeera

more than 9000 industries are operating in Faisalabad city including the residential localities. Out of these industries, majority are related to textile and dying where generally weaving, dying, printing and finishing of cloth are accomplished. Increasing air and water pollution in Faisalabad city has been reported by the Environmental Protection Department of district Faisalabad. These industries can produce wastewater containing hazardous chemicals and dense smoke and only a few industries meet the international and national standards. This is damaging the quality of underground water causing severe damage to flora and fauna of the suburb of the Mega city of Pakistan, Faisalabad. The offensive smell of stagnant pools of wastewater is also a reliable source of nuisance to the local residents.

An over view - wastewater flows from urban areas of Faisalabad

(i) Estimated Urban Population for the year 2007 = 2,830, 841
(ii) Estimated Wastewater Generation (Liters per capita per day, Lpcd) = 180
(iii) Estimated Wastewater Discharges (m^3/day) = 509,551
(iv) Wastewater Treatment (%) = 20%

Area irrigated with wastewater around Faisalabad

In the different peri-urban areas of Faisalabad, the total area under wastewater irrigation is 2,139 ha located in the different parts of the District. Faisalabad is called the city of textiles and most of the industrial units discharge their untreated wastewater into the fresh water channels and water from these channels is mostly used for the irrigation of food and fodder crops. There are two zones in Faisalabad such as Eastern Zone and Western Zone. The sewage generated in the Eastern Zone drains into Madduana Drain and Western Zone wastewater flows into the Paharang Drain (Table 1). The bank side residents of the Open Paharang and Madduana Drains are under serious threat are exposed to polluted industrial and domestic wastewater laden with toxic chemicals. These above-mentioned drains are also polluting or contaminating the ground water which is very evident from increased TDS levels in groundwater. The residents are also exposed to foul odor and eye irritation due to prevailing anaerobic conditions (Kahlown et al., 2006).

Quality of wastewater used to grow each crop in the wastewater irrigated area

Out of 450,000 m^3 daily wastewater generation, 140,000 m^3 is used for irrigation purposes; 82, 000 m^3 on the eastern and 58,000 m^3 on the western side (Munir et al., 2005). The results indicate that in wastewater irrigated areas land preparation cost is higher as compared to freshwater irrigated areas because land has become more compact, dense and hard due to sustained use of untreated wastewater as mentioned in Table 2.

Types of crops irrigated with wastewater

Typical crop rotations followed in Faisalabad are cotton-wheat, rice-wheat, sorghum-berseem (Table 3). The farmers are reluctant to irrigate root crops such as carrots, radishes, onions and potatoes with wastewater. This is because the irrigation with wastewater can lead to foul smell, poor color and as such they could not be sold in the local market at a reasonable price. The main crops grown are sorghum, cauliflower, spinach, cotton, wheat and tomatoes. No suitable regulations existed for what could be grown with wastewater irrigation. In whole of the city surveyed by IWMI, vegetables, fodder and cotton and to lesser extent rice are grown with wastewater irrigation. The vegetables, generally, received wastewater irrigation twice a week, fodder once a week and cotton once in three weeks.

Mechanism of wastewater supply to the farmers

Some of the farmers used to directly divert the wastewater into their fields and are generally over irrigating their fields. Such as on the Uchkera site in

Table 2. List of wastewater irrigated sites around the city.

Site	Wastewater available (L/sec)	Wastewater Use (L/sec)	Area irrigated (ha)	Waste water Type	Location	Crops irrigated
Narwala Road	860	450	240	Municipal	PS-3 Chakera	*Rabi* season cauliflower, spinach, wheat, sugar cane, fodder. *Kharif* season fodder (maize, millet, sorghum), rice
Chohar Majra	42-55	72-82	65	Municipal	PS-3 Chakera	-do-
Chak No. 279/RB	295	78	120	Industrial	Channel-4	
Sidhu Pura	72	68	48	Hospital waste	Allied Hospital WW	Wheat, fodder, rice
Islam pura	23	24	16	Municipal	Narwala road	Like Narwala Road site
Gaoo Shala Marzipura	27	26	16	Municipal	Narwala Road	Like Narwala Road site
Satiana Road	1398	240	198	Industrial	Satiana Road	Wheat, Rice, sugar cane, Fodder
Channel-4	1020	6800	898	Industrial	Channel-4	Wheat, Rice, Spinach, Fodder (sorghum)

Table 3. Common crops/crop rotations followed in wastewater irrigated areas.

Site	Location	Crops Irrigated and crop rotation
Narwala Road	PS-3 Uchkera	*Rabi* season cauliflower, spinach, wheat, sugar cane, fodder. *Kharif* season fodder (maize, millet, sorghum), rice
Chohar Majra	PS-3 Uchkera	-do-
Chak No. 279/RB	Channel-3	
Sidhu Pura	Allied Hospital WW	Wheat, fodder, rice
Islam Pura	Narwala road	Like Narwala Road site
Gaoo Shala (Marzipura)	Narwala Road	Like Narwala Road site
Satiana Road	Satiana Road	Wheat-Rice, sugar cane, Fodder
Channel-4	Channel-4	Wheat-Rice, Spinach, Fodder (sorghum-berseem)

Faisalabad, a few wealthy farmers took the lead in discussions with Water and Sanitation Agency (WASA) of Faisalabad. The bulk annual fee for wastewater diverted from the Wastewater Stabilization Ponds at Uchkera site was transferred to WASA, Faisalabad by one influential farmer, who collected the shares of fees from other farmers. Being the central person for access to irrigation water for Uchkera, this position carried a high potential of power over the other farmers, although no indications for abuse of this power were mentioned during the interviews (Weckenbrock, 2010).

Mechanism of wastewater payments

The wastewater from municipal ponds is auctioned and the highest bidder further sells to small farmers on hourly basis. For instance, wastewater channels of 6 (150.0 m^3 h^{-1}) and 8 (266.4 m^3 h^{-1}) inches diameter were auctioned for a year and the highest bid was Rs. 90,000 and 110,000, respectively. The bidder was selling out this wastewater to small farmers at the rate of Rs. 375 per hour for 150 m^3 h^{-1} wastewater (6 inches diameter pipe) and Rs. 500 per hour for 266.4 m^3 h^{-1} wastewater (8 inches diameter pipe).

In Faisalabad WASA has no authority to prevent pollution generated by the textile industry. There is a separate department under the district government for environment protection. The WASA recognizes that these industries are using the sewerage system for drainage of

Table 4. Water quality parameters of wastewater used for irrigation at the Narwala and Channel 4 sites in Faisalabad, Pakistan.

Parameter	Unit	FAO and WHO guidelines	Narwala road	Channel 4
EC	dS m^{-1}	<3	3.1	5.8
Faecal coliform	count 100 ml^{-1}	1000	>10	>10
Helminth eggs	number L^{-1}	<1	763	
SAR		<9	6.3	16.9
N	mg L^{-1}	<30	41.6	35.7
P	mg L^{-1}	7.6	4.7	
K	mg L^{-1}	34.7	35.1	
Mn	mg L^{-1}	0.3	0.18	
Cr	mg L^{-1}	0.1	0.05	
Pb	mg L^{-1}	6	0.45	
Ni	mg L^{-1}	0.2	0.03	
Cu	mg L^{-1}	0.2	0.09	
Co	mg L^{-1}	0.05	0.08	
Cd	mg L^{-1}	0.01	0	
Fe	mg L^{-1}	5	0.16	
Zn	mg L^{-1}	2	0.14	

Table 5. Chemical analysis of sewage and industrial effluents.

Sites	EC (dS m^{-1})	pH	SAR	RSC (me L^{-1})
Kashmir Ghee Mill	7.85	11.22	31.52	52.16
Sattar Dying	5.29	7.84	12.03	7.65
Walayat Flour Mill	2.81	7.17	5.93	12.83
Chenab Fabrics	8.78	7.73	20.28	15.9
Nishat Textile	5.7	7.93	17.54	17.16
Kashmir+abid+noor Hosieries	10	9.24	32.54	20.54

polluted water with heavy chemicals.

Composition of wastewater

The wastewater is of mixed type and there is no arrangement for the separate disposal of industrial, domestic and hospital sewage water. The wastewater contains the following constituents:

(i) Organic matter
(ii) Nutrients (nitrogen phosphorus, potassium)
(iii) Inorganic matter (dissolved minerals)
(iv) Salts
(v) Toxic chemicals
(vi) Pathogens

Chemicals of potential health concern identified in untreated municipal wastewater

(i) Heavy metals
(ii) Cadmium, chromium, lead, mercury, and nickel
(iii) Inorganic chemicals;
(iv) Cyanide, fluoride, hydrogen sulfide, and nitrate
(v) Nutrients
(vi) Nitrogen, phosphorus, and potassium
(vii) Organic chemicals
(viii) Benzene, phenol, toluene, and xylene
(ix) Endocrine disruptors
(x) Pharmaceuticals

Fertilizers used by the farmers using other sources of water around the wastewater irrigated area

The crops which are grown in the sub-urban areas using wastewater include vegetables and fodder crops given. These crops are sold at soaring prices in the nearby local markets. The quantity of N, P and K applied from sewage irrigations of 0.40 m in Faisalabad ranged from 116 to 195, 7 to 21 and 108 to 249 kg ha^{-1}, respectively (Ibrahim and Salmon, 1992). Hence, these quantities of N and K are quite sufficient for any crop, but P is low, and it will need supplementary supply from other fertilizer sources (Tables 4 to 9).

P applied through sewage is almost completely soluble,

Table 6. Nutrient and heavy metals analysis in sewage and industrial effluents.

Sites	K meq L^{-1}	P ppm	Fe ppm	Mn ppm	Cu ppm	Pb ppm	Ni ppm
Kashmir Ghee Mill	0.22	1.49	1.5	0.83	0.23	0.54	0.29
Sattar Dying + print	1.18	0.16	0.5	0.38	0	0.33	0.16
Walayat Flour Mill	3.39	0.32	0.69	0.53	0	0	0
Chenab Fabrics	0.65	0.17	0.7	0.22	0	0.45	0
Nishat Textile	0.55	0.18	0.69	0.21	0	0	0
Kashmir+abid+noor Hosieries	0.71	1.13	1.05	0.22	0.08	0	0.25

Table 7. Effect of sewage effluent on nutrients and heavy metals in soil.

Depth cm	N ppm	P ppm	Fe Ppm	Mn Ppm	Zn Ppm	Cu ppm	Pb Ppm	Ni Ppm
0-15	0.19	300	131.87	105	166.48	17.53	4.4	0.88
15-30	0.13	95.5	96.88	43.44	120.85	5.16	2.4	1.19
30-60	0.12	144	44.38	26.4	55.87	1.25	1.62	0.88
60-90	0.15	79	27.5	14.22	39.38	1.72	0.75	0.37
90-120	0.13	55.75	31.88	13.13	124.85	3.78	0.87	0

Table 8. Nutrient concentration in sewage effluent of different drains of Faisalabad city.

Nutrient (mg L^{-1})		G.M.abad	Satiana Road	Jaranwala Road	Jhang Road
N	Mean	48.85	29.25	29.05	45.45
	Range	38-66	13-48	18-44	18-71
P	Mean	5.20	1.35	2.10	3.45
	Range	3-7	Tr.-4	1-3	Tr.-6
K	Mean	62.30	38.80	26.85	48.00
	Range	49-74	28-47	20-48	33-65
N,P & K (kg ha^{-1}) supplied through sewage effluent (40 cm ha^{-1})					
N		195.40	117.00	116.20	181.80
P		20.80	6.60	8.30	13.76
K		249.20	155.20	107.90	192.20

that is why its availability is higher than the P applied through inorganic fertilizers. Murtaza et al. (2010) reported that sewage water application to most of the crops may exceed N and P fertilizer needs over the growing season. According to Ensink et al. (2002), efficiencies of nutrients applied through sewage irrigation ranged from 140 to 920 for N, 20 to 790 for P and 125 to 930% for K, depending upon the crop type and the amount of sewage water.

The actual composition of sewage water may differ from site to site as the sewage water contains various organic and inorganic chemicals including nutrients like N, P, K, toxic heavy metals and organics and pathogens. The wastewater users only apply P fertilizer (two bags of single superphosphate or one bag of di-ammonium phosphate (50 kg per bag each). The farmers irrigating their crops with wastewater spend more money on insecticides, labor hiring cost and land rent than those farmers who use canal water. For example, land rent of wastewater irrigated land is about Rs. 150,000 ha^{-1} compared to canal water irrigated land, that is, Rs. 65,500 ha^{-1}. The major input cost for farmers was the use

Table 9. Composition of untreated city effluent collected from suburban area of Faisalabad.

Parameter	Range	Critical limit
pH	7.04-9.88	--
EC dS m^{-1}	0.72-5.64	1.00ş
SAR	3.76-36.17	10.00ş
RSC $mmol_c$ L^{-1}	Trace-25.80	2.50ş
Cd mg L^{-1}	0.001-0.018	0.01§
Cr ″	0.01-2.40	0.10§
Cu ″	0.04-0.75	0.20§
Fe ″	0.27-3.95	5.00§
Pb ″	0.01-1.19	5.00§
Mn ″	0.12-1.88	0.20§
Ni ″	0.02-0.59	0.20§
Zn ″	0.02-0.34	2.00§

n = 156.

Table 10. Fertilizer, nutrient and market price (Rupee per kg or bag – how much kg in bag).

Fertilizer	% N	% P_2O_5	%K_2O	%S	kg per bag	Price Rs/bag
Urea	46.0	-	-	-	50	1815
Diammonium phosphate (DAP)	18	46	-	-	50	4204
Single superphosphate (SSP)	-	18	-	-	50	1259
Murate of potash (KCl)	-	-	60-62	-	50	3580
Sulfate of potash (K_2SO_4	-	-	50	18	50	4049
Nitrophos (NP)	23	23	-	-	50	2700
NPK	17	17	17	-	50	3127

of fertilizers; although this was a substantial cost, on an average the total cost for canal water farmers was less than those for wastewater depending farmers. However, the average gross margin for a wastewater farmer (Rs 10,000/ha), was substantially higher than for a freshwater farmer using canal water, about (Rs 2,500/ha) because of higher cropping intensities and the ability to cultivate crops with higher market values.

The absence of other water sources is the main reason of using wastewater. The Uchkera site farmers in Faisalabad chose untreated wastewater over treated wastewater due to its higher N content and lower salinity levels (Clemett and Ensink, 2006). The University of Agriculture Faisalabad has 40 ha of agricultural land in Uchkera. It was observed when canal water irrigation was replaced with wastewater irrigation fertilizer application for wheat was reduced by 30%, but average wheat yield increased by 10% (Sadiq, et al., 2005).

According to information collected from the Uchkera site farmers, fertilizer use was reduced to one to two bags of urea for vegetables, while groundwater irrigating Kehala farmers also applied di-ammonium phosphate (DAP) and single super phosphate (SSP). The cost of fertilizer for wastewater relying farmers was about US $32/ha compared to a cost of approximately US $130/ha for Kehala farmers. The farmers using canal water are considered to spend more money on the utilization of fertilizers than those farmers relying solely on wastewater for irrigation of the crops. But total agricultural input costs were almost similar – that is, wastewater using farmers spent more money on insecticides, labor hiring and land rent. On an average, Uchhkera farmers achieved a gross margin of approximately $163/ha and Kehala farmers of approximately $66/ha for cauliflower. Calculations for berseem also show considerably greater gross margins for Uchkera farmers (Table 10).

Farmer's perception about social impact and constraints in wastewater irrigation

Due to scarcity of canal water, the dependency on groundwater is rapidly increasing in Pakistan. Groundwater is becoming expensive and unaffordable for small farmers due to increasing prices of POL and electric shutdown. Sometimes the same piece of land must irrigate twice (qualitative observations). Unfortunately, the groundwater is also of inferior quality.

Besides all negative impacts the farmers are happy to use untreated wastewater because in most of the cases they do not have alternate source of water for crop production. But due to physical, institutional and social factors its use is not so extensive.

A comparative study was conducted in Chokera and Prokianwala villages near wastewater treatment ponds in Faisalabad to evaluate farmers' perception on social impact of wastewater use. This study showed that one village (Chokera) used untreated wastewater for irrigation and was the nearest to treatment ponds whereas the other village used treated wastewater for irrigation purpose.

A substantial proportion of the farmers irrigating with wastewater are of the view that wastewater offers benefits in the form that it is useful for crops and there is no use of fertilizer and sprays. While wastewater losses in the form that it is not good for health of humans and other living organisms. Farmer's preference is to use untreated wastewater to irrigate their lands as it has more nutrients than any other water source as discussed above. Farmer's became habitual by the annoyance of wastewater odor and filthiness. Farmers are not aware with the religious acceptability for using wastewater for irrigation.

In Chakera women are involved in wastewater farming, Prokianwala did not involve women in wastewater farming. Children in both of villages were not getting any kind of education. Every farmer has its own perception about the cost and benefits of wastewater irrigation. According to most of the wastewater users, no problem was raised due to wastewater irrigation in terms of land productivity, yield per acre, labor hiring, health risks etc. it has been seen that most of the farmers were using wastewater, but untreated wastewater was preferred by most of farmers.

They were aware about the limits for use of wastewater religiously but as ever said that they don't have any other choice but use wastewater for Irrigation purposes. According to farmers of wastewater irrigation area, wastewater do not have any kind of effect on human health working in it. According to framers, the constraints were not prohibiting them to use wastewater for irrigation rather it is productive and beneficial for them. So, wastewater irrigation should democratize and popularized so that farmers can get a reliable source of water to irrigate their lands. Under all these circumstances wastewater should not be considered as harmful for the farmers in one form or the other, because farmers seems to be fully satisfied with it. So, it should not be banned and WASA officials should restrain any action on it (Zafar and Akhtar, 2003).

Investigation of food chain contamination

The usage of wastewater to irrigate the crops severely affects the food chain resulting in the promotion of different diseases in the human beings. The farming community is not aware of the harms this contamination may cause. Irrespective of the contamination issues, the farming community think that they are using cheap water to irrigate their crops. The hazardous elements such as lead, arsenic, ammonia, Cadmium, Mercury, Cyanide etc. penetrates into the food chain and affects the human health badly. The people of Pakistan are not much aware from this fact and are continuously using vegetables, fruits, and crops irrigated by wastewater. The farmers only anticipate the economic benefits due to the rich nutrients from wastewater ignoring all the health risks. The soaring urbanization and industrialization are the major source of wastewater. In the developing countries like Pakistan the wastewater produced is not treated and is directly discharged into the water channels contaminating the food chain and in return worsening the health issues (Prince, 2018).

Adverse health impact on human health

Due to the wastewater irrigation, the human health is badly affected. The study conducted by Ragavachari and Durgadas (2014) showed that by fecal coliforms and Giardia cysts as well as other pathogenic bacteria such as Shigella and Salmonella heavy contamination of food occurs. Stool samples were obtained from the occupationally exposed 75 farmers revealed that 45% of them were harboring Giardia Cysts. The contaminated food is highly dangerous for the people who consume it. It can cause giardiasis, amebiasis, and diarrhea. Cd, Cr, Ni and Pb which are toxic metals make the wastewater unsuitable for aquatic life, irrigation and drinking resulting serious consequences for the human as well as aquatic health (Odige, 2014).

Conclusion

Wastewater irrigation though economical for the farming community is highly dangerous for the human health. The hazardous elements which are included in the wastewater by the industries using toxic chemicals poses serious consequences for the human beings. The present study concluded that wastewater irrigation should be avoided if we are unable to treat it at the disposal plants. The people of Pakistan are already combating the health problems due to the poor performance of the health department. So, the government of Pakistan should be aware of this widespread problem of wastewater irrigation and the farming community in particular should be made aware about the safe irrigation practices and the masses in public should be made aware about the consumption of the salads, fruits, and vegetables. The fresh water channels should be saved from the wastewater, so it may not get contaminated.

RECOMMENDATIONS

1. The government of Pakistan should take strict measures against the chemical industries who discharge water into the fresh water channels without treating it.
2. The chemical industries should be bound to transplant water treatment plants to treat the wastewater before discharging into the water channels.
3. The industries which violates the commandments must be heavily fined.
4. An Awareness campaign should be launched with the help of print and electronic media to make the people aware from the hazardous effects of wastewater on the human and aquatic life.
5. Trees must be planted alongside the water channels containing wastewater.
6. The general masses should be careful about the usage of the products produced by the untreated wastewater.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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