Title	**ASSESSMENT OF WASTEWATER PRODUCTION AND REUSE IN THE PERI-URBAN AREAS OF FAISALABAD, PAKISTAN**
Keywords	Municipal, Industrial Wastewater, Reuse, Recycling, quantity, Flows, Faisalabad, Peri-urban agriculture,
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Short CV for Introduction Purposes (100 words max)	
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1. Introduction

The global water shortages and food security issues related to population explosion necessitate shifting fresh water away from agriculture to more pressing uses. Therefore, search for new water resources for irrigation is required, among which is the re-use of wastewater for agricultural purposes. Wastewater irrigation has long been adopted in the developing and developed countries, due to its high fertility, as well as due to lack of infrastructure and facilities for disposal of wastewater effluent.

The use of wastewater effluent for irrigation has many-fold benefits for farmers; on one hand the availability of excess amount of nutrient rich water; and on the other hand prevention from environmental pollution caused by disposing wastewater off into drainage and irrigation networks. Wastewater irrigation also serves as a "natural" treatment method. The wastewater is also considered the best substitute of the freshwater shortages. Together with these benefits, wastewater irrigation also has some potential hazard such as health risks for the irrigators, groundwater and soil contamination by NO_3 leaching and heavy metals accumulation. The heavy metal accumulation is much serious environmental concern, which causes the toxicity to the plants and the animals.

The application of domestic sewage to agricultural lands or use of the soil mantle as a wastewater treatment system has been practiced since antiquity. Sewage farming, or the transportation of wastewater to rural areas for irrigation and disposal, was practiced in the sub-continent as early as 1877. Although the reuse of wastewater has been practiced for many years, particularly in agriculture, it has been given increased importance in recent years, both as a mean to dispose off the disposal water and irrigation the agricultural areas. It is possible to further increase benefits of urban wastewater in small towns even when treatment is not feasible option (Ensink, 2002).

1.1. Problem Statement

Water has become a limiting factor for agricultural and industrial development. Governments are continuously searching for unexploited sources of water, which can be economically and effectively used to supplement the scarce water resources available. The problem is two fold; on one side, more water is required in cities due to expansion of both population and industries, and on the other, there is pressure on the agriculture sector to meet the food needs for increasing population. Therefore, the only solution to the problem is better utilization of limited water resources and search for other unexploited water resources.

1.2 Objectives

In view of the above stated problems the objectives of the study were formulated as

1. To estimate the total municipal and industrial wastewater production from the Faisalabad city.
2. To quantify the reuse of wastewater and the area under wastewater irrigation.

2. Methodology

2.1 Study Area

Faisalabad is a big industrialized city, with a population about 2.00 million. It is located at a latitude 31-25^{o}N and Longitude 73-06^{o} E with an altitude of 214 meters. The average annual rainfall is about 550 mm with average maximum and minimum temperatures 45^{o}C and 2^{o}C respectively.

2.2 Faisalabad Sewage System

Faisalabad is situated in Center of the Punjab Province with the total population around 2.0 million. The total water supply to the city is 310,500 m^{3}/day, The groundwater of Faisalabad is saline so the seepage water from Chenab Well Field near Channiot about 25 km from Faisalabad is supplied for domestic uses. The existing sewerage system of this city is divided into two distinct zones formed by the Rakh Branch canal and the railway line passing through the middle of the city. Each zone has independent sewage collection and disposal systems. Sewage from the existing collection systems is discharged untreated into Maduana drain and treated/untreated in Paharang Drain in the east and west respectively.

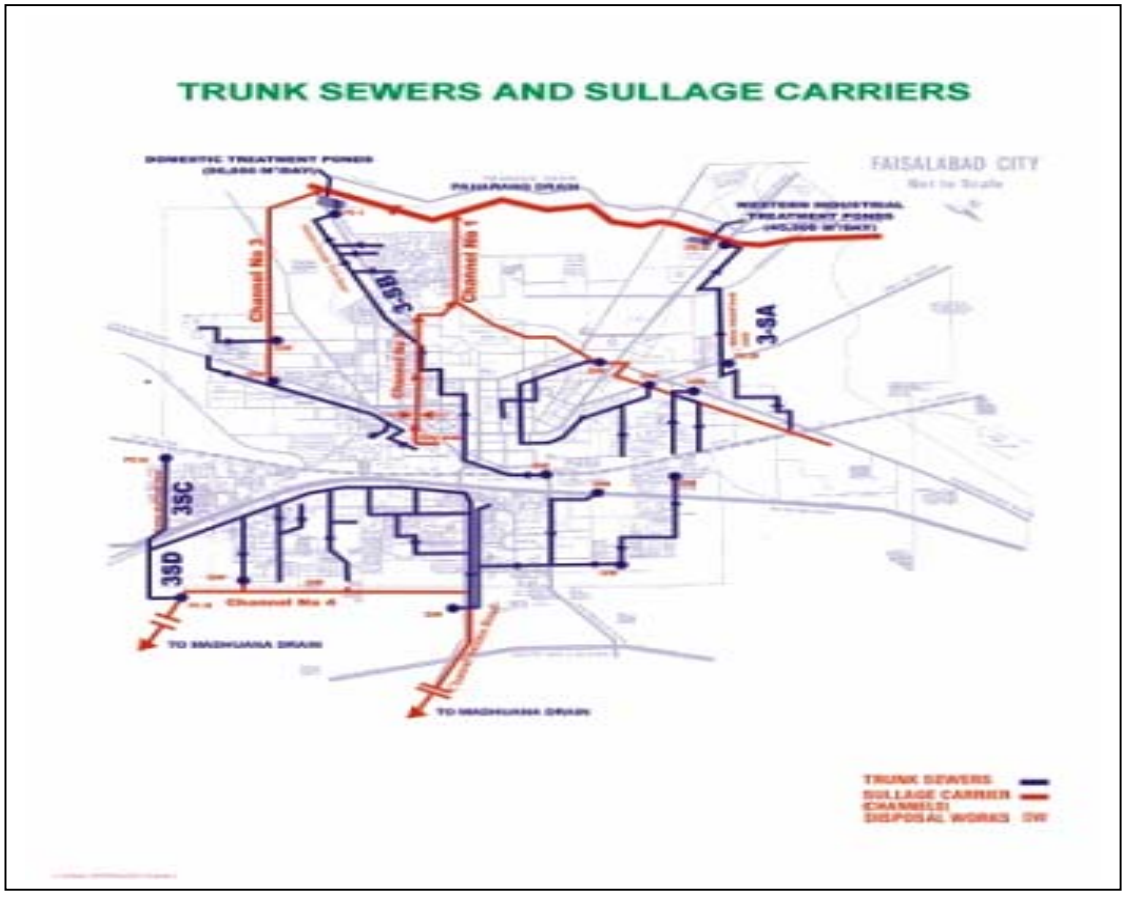

Figure1: Layout of Faisalabad Sewage System

2.3 Reconnaissance and Walkthrough surveys

In order to find out the wastewater irrigation sites around the city and to estimate the areas irrigated with wastewater about four surveys were conducted. Every wastewater disposal station was visited and interviewed by the local farmers or the WASA personnel detained at the disposal site. Two surveys were conducted in Rabi season and Two surveys in *Kharif* season in order to know any difference between wastewater use with seasonal cropping patterns.

2.4 Wastewater Measurements

2.4.1 City's Total Wastewater Production

For measuring the city's total wastewater production, the whole sewage system was measured at the same time. There were about five points which pass whole of the city's effluent, three on western side and two on eastern side. In first exercise the discharges were measured on the same, same time on one side, but different from the other side whereas in second exercise discharges were measured at two consecutive days but at the same time. First exercise was conducted in December 2001 and second was conducted in June 2002. The measurements were done with Large and pigmy current meters according to the size of the channel.

2.4.2 Detailed Flow monitoring of Sample site

For detailed monitoring of wastewater flows, wastewater irrigated site, Narwala Road Site, was selected. WASA has its disposal station here which is called PS-3 Chakera. This site was quite interesting because WASA has treatment pond here and also supplies wastewater to farmers for irrigation purposes on payment. This site was examined for one complete year on fortnightly basis. In addition to this three 24-hr monitoring exercises were also conducted.

3 Results and Discussions

3.1 Flows at Narwala Road Site (Sample Site)

Among different wastewater irrigated sites, the Narwala wastewater irrigated site was selected for detailed monitoring because this was the most important site from wastewater irrigation perspective. This was the only site where proper arrangements were made for delivering wastewater for irrigation purposes. Figure 2 shows the wastewater results for almost a complete year. The measurements were taken on fortnightly basis. Results show that wastewater production almost remained same. The average flow during the study period was about 913 liter/sec. The maximum flows were observed during month of August 01.

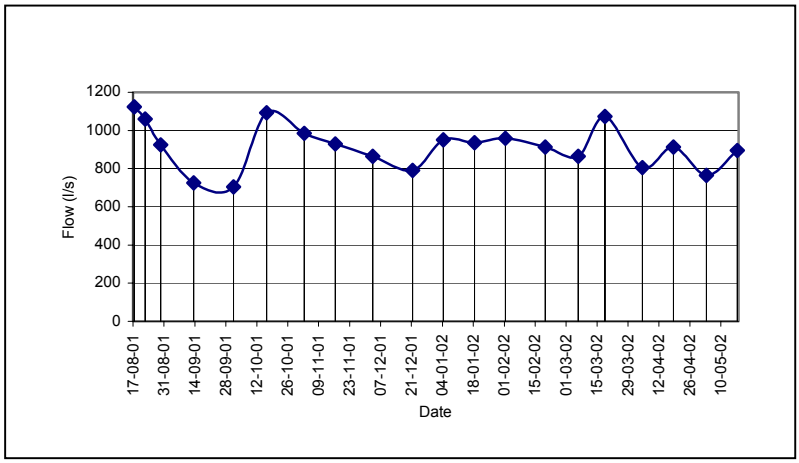

Figure 2: Wastewater flows at the Narwala Road site for 2001-02

3.2 Faisalabad City Wastewater Production

As mentioned earlier the city of Faisalabad has been divided into two zones, divided by Rakh Branch Canal and the Railway line passing through the center of the city. The two sides are the Eastern and Western sides of the city and the sewage generated at eastern side drains towards into Madhuanan Drain and western sides wastewater flow dumped into the Paharang Drain. Table 1 gives results of wastewater flows from the city. The measured city wastewater flows were about 4.72 cumecs in December 2001 and 5.63 cumecs in June 2002. The city's wastewater effluent was measured at the same time on each side in order to get the actual discharge from the city. Paharang Drain's discharge includes water from Channel 1, Channel 2 and PS-13 Sargodha Road, excluding Channel 3 and PS-30.

Table 1: Faisalabad city's wastewater production.

Date	Time	Western Side Flow (m3/sec)	Eastern Side Flow (m3/sec)	City Total (m3/sec)
22-12-2001	10:00	2.73	1.97	4.70
27-06-2002	10:30	3.20	2.49	5.69
Average		2.97	2.23	5.19

3.3 Wastewater Production (vol./day)

The average daily wastewater production is about 0.45 MCM (million cubic meter) from which the average western side production is about 0.26 MCM and eastern side wastewater production is about 0.19 MCM. Western side wastewater is almost from household sources whereas eastern side wastewater production is from industrial sources and very small contributions from households.

3.4 Amount of Wastewater used for Irrigation

Wastewater is used for irrigation purposes almost at every wastewater disposal site. Even in the eastern side, where industrial wastewater prevails, was also used for irrigation purposes. Figure 3 shows the amount of wastewater used for irrigation purposes.

3.4.1 Wastewater Use at Sample Site (Narwala Road)

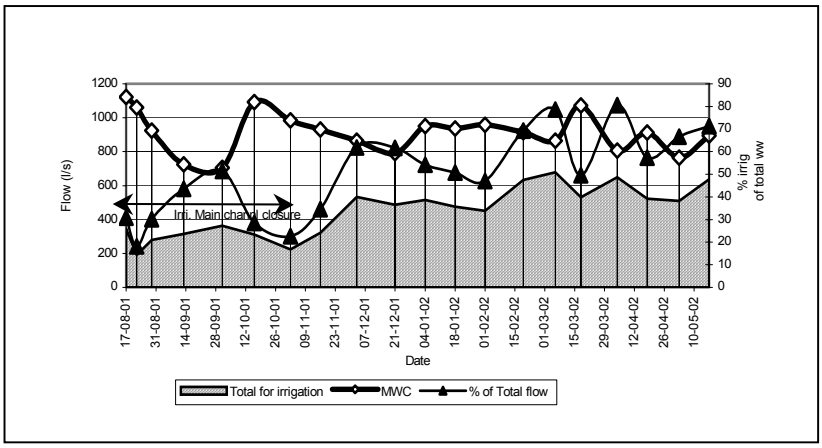

Figure 3: Wastewater used for irrigation purposes at Narwala Road Site.

Figure 3 shows that overall 50% of the total wastewater was used for irrigation purposes throughout the year whereas wastewater use from November to April/May is higher than the other months. It is because of vegetable sowing in these days. Cauliflower, spinach and other winter vegetables are sown in these months. On an average about 440 liter/sec wastewater was used for irrigation purposes at this site.

3.4.2 Wastewater Irrigated Sites in Peri-urban Areas of Faisalabad

The major wastewater irrigated sites have been given below. Besides these there are many small pockets around Faisalabad which are being irrigated with wastewater.

Table 2: List of wastewater irrigated sites around the city

Site	WW Avaialable (l/s)	WW Use (l/s)	Area irrigated (ha)	WW Type	Location	Crops Irrigated
Narwala Road	850	400	250	Municipal	PS-3 Chakera	***Rabi*** season cauliflower, spinach, wheat, s.cane, fodder. ***Kharif*** season fodder (maize, millet, sorghum), rice
Chohar Majra	40-50	70-80	75	Municipal	PS-3 Chakera	-do-
Chak No. 279/RB	300	75	125	Industrial	Channel-3	
Sidhu Pura	70	70	50	Hospital waste	Allied Hospital WW	Wheat, fodder, rice
Islam pura	25	25	15	Municipal	Narwala	Like Narwala Road site

					Road	
Gaoo Shala (marzipura)	25	28	15	Municipal	Narwala Road	Like Narwala Road site
Satiana Road	1400	250	200	Industrial	Satiana Road	Wheat, Rice, s.cane, Fodder
Channel-4	1000	700	900	Industrial	Channel-4	Wheat, Rice, Spinach, Fodder (sorghum)

4. Conclusions

- A total of 0.45 MCM wastewater is produced from the city from which 0.26 MCM is produced on western side (mostly domestic wastewater) and about 0.19 MCM is produced on eastern side (mostly industrial wastewater).
- About 1623 liters/sec of wastewater is used for irrigation purposes from which 950 l/s is used on eastern side and 673 l/s is used on western side.
- At Narwala Road site daily average wastewater flows were 913 liters/sec from which 50% wastewater is used for irrigation purposes.
- By farmers interviews and reconnaissance surveys it was estimated that about 1380 hectares were under wastewater irrigation.

5. References

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