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USING WASTEWATER FOR AGRICULTURE IN FAISALABAD: APPRAISAL OF SOCIO-CULTURAL AND ECONOMIC OUTCOMES

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ABSTRACT

The urban slums deprived of basic human needs like drinking water, and sanitation facilities are spreading in major cities like Faisalabad, Karachi, and Lahore. The wastewater generated in houses and foul water of rain is being thrown away directly into open channels or in covered sewers. The wastewater collected at disposal stations either after treatment or as such is being used for agriculture purpose by farmers placed in surrounding villages. The reuse of wastewater for agriculture is influencing the physical ecosystem as well as cultural and socio-economic situations of the community. The study was carried out to appraise cultural and socio-economic outcomes of using wastewater for agriculture in Department of Sociology, Government College University Faisalabad during January-March 2020. The data were collected both from primary and secondary sources. Certain transact walks in area of the study were made and consultative meetings with key informants were also held. 60 farmers who were using wastewater for agriculture, were selected by simple random sampling techniques. The appraisal of data revealed that reuse of wastewater for agriculture activities had positive impacts on cultural and socio-economic aspects of the rural community. The results indicated that reuse of wastewater for agriculture activities had many positive impacts on cultural and socio- economic aspects of the rural population. Price of agricultural land, rent of land and households' monthly income were increased. Employment opportunities were also generated. The perception of community about most of the environmental improvement was better. However, perception of farmers about impact on public health, soil structure and ground water resources was medium or low. It is also concluded that use of wastewater for agriculture is a beneficial source of plant nutrients and organic matter required for retaining richness and output levels of soil that enhance living standard of inhabitants and lessen poverty.

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INTRODUCTION

Growing universal population has resulted into widening the gap between demand and supply for water uses. This gulf has reached to such an alarming extent that it is posturing a threat to human existence in various parts of the globe. Consequently, sociologists and other scientists throughout the world are working on innovative practices of conserving water. One of the techniques could be to reuse urban wastewater after treatment for agriculture and other productive functions. This exercise could release pressure on clean

water for use in other sectors that need fresh water. Wastewater is a resource for productive uses because wastewater have nutrients that are useful for agriculture purpose. Wastewater has many pathogens that could be dangerous or toxic to people as well as for environment. Water and sanitation agencies in big towns/cities are working on discarding and treatment of urban wastewater to ensure least impact on environment or human health. Wastewater is also a source for productive purposes since wastewater holds nutrients that are valuable for agriculture use and other activities. In both developing and developed countries, the most common practice is the application of both treated and untreated municipal wastewater to land for farming.

REVIEW OF LITERATURE

In Pakistan, a common practice is the application of both treated and untreated municipal wastewater to agricultural land. Untreated wastewater is widely used for aquaculture and agriculture. It has been the practice since centuries in China, India, Mexico and also in some parts of Pakistan (Hussain *et al*., 2002). The main cause of wastewater usage in agricultural system is growing waster stress (Baig *et al*., 2011) and nutritive value (Imran, 2016).

Ashraf *et al. (*2017) revealed that 20 million hectares of land on world-wide level was being irrigated with untreated, partially treated and treated wastewater, which were contributing to food security. Industrial discharges, municipal wastewater, and storm water runoff are the main sources of wastewater. It can be used for various purposes including industrial and urban uses, landscape and crop land irrigation, artificial ground water recharge, aquaculture etc. However, its usage contains potential risks like soil health, environment and detrimental effects on plant growth. It is also supposed to be the carrier of a variety of toxic substances including salts, pesticide residues, heavy metals, poisonous gases and a wide range of pathogens which have harmful effects on soil, crops, groundwater, air, and ultimately on human beings. So, treated wastewater is more useful to get rid of microorganisms and toxic substances before using it for irrigation than untreated or partially treated water but it may cost more for the farmers. However, partially treated wastewater can be efficiently used for agriculture purposes (Weldesilassie *et al*., 2010).

The reuse of municipal wastewater in agriculture is increasing high concern with the ever-rising scarcity of fresh water reserves in many regions of the world. Explosion of metropolitans' fast urbanisation and escalating wastewater amounts, wastewater is largely used as a low-cost alternative compared with traditional irrigation water. It supports livelihoods and generates substantial value in urban and per-urban agriculture and property values. However, there are some meagre threats to health and environmental risks related to this practice (Scott, *et al*., 2004).

Furthermore, wastewater is often a reliable water source available round the year. It often contains the nutrients required for quick plant growth. The use of wastewater in agriculture often lessens downstream environmental impact on water and soil resources (WHO, 2006).

It was found in a study by FAO (2012) conducted during 2012 in South Asia that agriculture faced multidimensional challenges between today and 2050 to satisfy an estimated population of 9 billion. However, one assurance was that more water will be needed to produce an estimate of 60% of additional food. 20% of the total cultivated land is reported as irrigated agriculture but it contributes 40% of the total food produced worldwide. FAO estimated that irrigated land in developing countries would increase by 34% by 2030, but the amount of water for agriculture will increase by only 14%. Hence, it would compel to identify innovative resources of water including reuse of municipal wastewater to manage the shortfall of water required for agriculture.

Research was carried out in Yemen conducted by Rageh (2014). It was found that irrigation with treated municipal wastewater was considered an environment friendly wastewater disposal practice as compared to its direct disposal to the surface or ground water bodies.

In addition, it was also revealed in another study conducted by Rusan *et al. (*2007) in a different city of Republic of Yemen that wastewater was a valuable source of organic matter and plant nutrients required for maintaining output levels and richness of the soil.

Studies conducted in Pakistan, Ghana, Mexico and Vietnam by International Water Management Institutions revealed negative as well as positive effects of wastewater reutilization for agriculture (Jimenez, 2006).

Faisalabad is the third largest city of Pakistan having 3.32 million population and second one in the largest

populous province (Punjab) with 53.09% of total population of the country (GoP, 2017). In Faisalabad, ground water is brackish. Due to which canal water is the only feasible and suitable irrigation source. At present, the crop intensity has jumped up from 60% to 130%. Furthermore, lands of some farmers situated at tail end of irrigation channels do not get their allocated share of canal water owing to scarcity of supply of canal water and cracks of canal at different reaches. Consequently, farmers having land near wastewater sources seek for wastewater as alternative source of irrigation.

A sewerage treatment plant under Greater Faisalabad Water Supply, Sewerage and Drainage Project funded by the Asian Development Bank (ADB) was established on western side of the city. The concealed sewerage lines and open foul water channels from almost half of the city are gathered in deep sewage wells constructed near this pumping station. After treatment, this wastewater is being used by surrounding farmers for cultivation. In past, very few investigations have been made on the subject related to use of wastewater and its upshots on consumers. A Ph.D. dissertation on 'Impact Assessment of Greater Faisalabad Water Supply, Sewerage and Drainage Project' was carried out in Department of Sociology, G.C. University, Faisalabad during 2019. This research paper is a part of that dissertation having main focus on appraisal of social, cultural and economic outcomes on users of wastewater for agriculture.

MATERIALS AND METHODS

This study was conducted on sewerage pumping station of wastewater located at Kaleem Shaheed Road (North-West side of Faisalabad city) as main source of wastewater. Later, several transect walks in the catchment site of Chak No. 217-R.B. (Key users of wastewater from this pumping station) were carried out during January-March 2020. Moreover, five meetings with key informants and progressive farmers were organized in this village. Same procedures have been adopted in a study carried out in rainfed area of Chakwal (Nosheen, 2009).

A list of farmers living in Chak No. 217-RB was collected from concerned patwari (local revenue officer) for sampling frame of this study. A list of wastewater users was also collected from Water and Sanitation Agency, Faisalabad (WASA, Faisalabad, 2019). Simple random sampling technique was used for selecting 60 farmers who were using wastewater for agriculture. Data was collected by using a well-conceived interview schedule through a survey. The data were presented with frequency and percentage by using descriptive analysis. The collected data was further analyzed by using inferential statistical techniques which was Z-test.

Perception of respondents about the overall improvement made in physical and social environment of area after use of wastewater for agriculture purposes was calculated by using following formula of Yeh's Index.

$$\text{YIP} = \frac{B-W}{R}$$

B = Number of persons perceived better about one attribute.

W = Number of persons perceived worse about one attribute

R = Total number of responses

This index ranges from +1 to –1. A positive value designates more respondents who perceived better than those who perceived worse about any aspect. A larger value shows more intensive degree of worse perception or better perception. If value of calculated index was more than 0.5 then perception of residents was better about improvement made. Further, the composite or average index of perception to give an overall picture of various physical and social environmental aspects as perceived by respondents was also calculated on similar pattern.

RESULTS AND DISCUSSION

Effect on socio-cultural aspects of community

Z values of all social aspects showed highly significantly response in all socio-cultural aspects of community after provision of wastewater. 61.67% to 88.33% respondents agreed that use of wastewater for agriculture had improved all socio-cultural aspects of their lives (Table 1). A greater impact was found for decrease in fighting due to water schedule (88.33% respondents) and reduction in water breaching occasion (85% respondents)., while relatively less impact observed for increase in visits paid by relatives and friends (61.67%) and increase in choice of arranging children marriage (65.00%).

Table 1. Changes in socio-cultural aspects of community after using wastewater for agriculture.

Sr. No	Description of Social aspects	Response about changes				Z value (P value)
		Yes		No		
		Frequency	%age	Frequency	%age	
1.	Reduction in community conflicts	44	73.33	16	26.67	3.61 (0.000)
2.	Improvement in food and clothing quality	46	76.67	14	23.33	4.13 (0.000)
3.	Increase in visits paid by relatives and friends	37	61.67	23	38.33	1.81 (0.035)
4.	Increase in choice of arranging children marriage	39	65.00	21	35.00	2.32 (0.010)
5.	Reduction in water breaching occasions	51	85.00	9	15.00	5.42 (0.000)
6.	Decrease in fighting due to water schedule	53	88.33	7	11.67	5.94 (0.000)
7.	Improvement in quality of food serving on marriage and death events	45	75.00	15	25.00	3.87 (0.000)
8.	Increase in celebration of rituals	42	70.00	18	30.00	3.10 (0.000)

Framers' subsistence source solely depends on production from agricultural food stuffs. The social and cultural aspects of rural community like quality of hosing, clothing, food, living style, celebration of rituals and ties of relation with friends, relatives and neighborers as well as local community bonding and conflicts are largely based on main sources of income of an individual household. The land-owning and sources of irrigating it and agriculture produces are the major ingredients for strengthening and improving all such social and cultural aspects of rural life. In our study, majority of respondents agreed on positive change in socio-cultural aspects after using wastewater for agriculture. On the contrary, Rageh, *et al. (*2017) considered a wasta water unsuitable for irrigation purpose owing to have high risk on environment in the surrounding. He further added that wastewater after treatment could be useful in terms of adding organic matter and nutrients in the soil.

Changes in Productivity of Agriculture Land

Z values showed highly significantly increase in yield of wheat, vegetable and fodder after provision of wastewater (Table 1). A huge majority of farmers (81.67% for wheat, 88.33% for fodder and 91.67% for vegetables) obtained a rise in production of the crops under study per unit area after availability of wastewater used for irrigation purpose (Table 1). These results establish a fact that wastewater is very much nutritious for agriculture purpose and ultimately have positive impact on farmers economics.

Table 2. Changes in produce of different crops after provision of wastewater for Agriculture.

Sr. No	Crops	Response on crop production per acre				Z value (P value)
		Increase		Decrease		
		Frequency	%age	Frequency	%age	
1.	Wheat	49	81.67	11	18.33	4.91 (0.000)
2.	Vegetables	55	91.67	5	8.33	6.45 (0.000)
3.	Fodder	53	88.33	7	11.67	5.94 (0.000)

Wheat, fodder and vegetable are major crops in Chak No. 217/RB. Vegetables and wheat are consumed by urban inhabitants. Fodder and wheat straw are consumed by drought animals like donkeys & horses as well as by milch cattle like buffaloes & cows present in urban areas. Our results showed positive monetary effect of wastewater used for agriculture purposes on the living of farmers of this locality. A similar study was conducted by Younas (2004). She concluded that since both social and natural circumstances were changing and subject to extensive uncertainty, it was indispensable to use alternate supply of irrigation like wastewater in order to alleviate poverty in countryside areas. Further, it was also discovered in another study done in Republic of Yemen by Rusan *et al. (*2007) that wastewater was a valuable source of organic matter and plant nutrients required for maintaining fertility as well as productivity of soil. However, in another study done in Yemen by Rageh (2014), it was found that irrigation with treated municipal wastewater was an environment friendly wastewater disposal exercise as compared to its direct disposal to the surface or ground water bodies. In Pakistan, wastewater discharges are also growing rapidly, particularly in big cities which are mostly used to raise vegetables and fodders in the vicinity of urban areas (Ashraf *et al*., 2017).

The area under study is situated adjacent to Faisalabad city, and land is good enough for growing seasonal and non-seasonal vegetables. Thus, several landowners have given their agricultural land on rent to landless contractors. Maximum number of the farmers responded that rent of cultivated land has risen up unexpectedly. This sudden increase in rent of agricultural land was from Rs. 25,000 acre^{-1} before availability of wastewater to Rs. 100,000 acre^{-1} after availability of wastewater for irrigation. This indicated that consuming wastewater for agriculture had a positive impact on unexpected mounting rent of agricultural land and contributed to increase in income of households.

Change in employment generation and monthly income

86.67% farmers responded that new employment opportunities had been generated after using wastewater for agriculture purposes while only few (13.33%) responded that no change occurred in employment (Table 3). Likewise, a huge majority (95%) of respondents agreed that their monthly households' income was increased after availability of wastewater for agriculture, while a meager number (5%) of respondents replied that they got no change in their monthly households' income (Table 3). It may be the fact that they are not progressive farmers, or they could not afford price of wastewater.

Table: 3. Effect on households' monthly income and generation of new employment opportunities after availability of wastewater for Agriculture

Sr. No	Description	Response about Income and Employment				Z value (P value)
		Frequency	%age	Frequency	%age	
1.	Household Monthly Income	Income increase		No change		
		57	95.00	03.00	05.00	6.97 (0.000)
2.	New Employment Opportunities	Employment generated		No change		
		52	86.67	8	13.33	5.68 (0.000)

Small canal water irrigation channel (Sir Wala Rajbah) meant for irrigating agriculture land of this village is passing through Faisalabad city centre, which has been blocked due to rapid sprawl of this textile industrial city, encroachments and due to full of municipal solid waste and sludge. It needs regular, quick, and repeated cleaning and even then, it usually breaches from various reaches and quantity of canal water is very scanty. Resultantly, the agriculture land of this village due to short supply or stoppage of canal water for irrigation did not remain productive and consequently, salinity also prevailed in the area. Therefore, land of this village was not considered useful for agriculture, residential or industrial purposes. Data collected from the office of District Land Revenue Officer Faisalabad (secondary sources) depicted that average value of agricultural land

was Rs. 400,000 acre^{-1} before availability of wastewater for irrigation purposes. Similarly, data collected through survey from the respondents (farmers) disclosed that the price of agricultural land per acre was about Rs. 500,000 to Rs. 600,000 acre^{-1} before availability of wastewater for agriculture purpose. Now, the land price per acre after availability of wastewater for irrigation is around Rs. 6,000,000 to Rs. 8,000,000 acre^{-1}. This is a massive rise in value of agricultural land because of availability of wastewater for irrigation purpose. This has resulted into encouraging impact on economic features for this whole locality. Hussain *et al*. (2002) also reported in a similar study that after Chenab River. wastewater was the only key source of irrigation for Faisalabad area, and it had significant positive effect on rent and price of agricultural land.

Monthly income of the households is one of the most significant predictors for appraising poverty level and preparing wealth ranking map of any social and economic setting. With provision of wastewater for agriculture, many hectares of land become productive. This also provides employment like casual labour and tenants. Unemployed family members are also engaged. They contribute to monthly income of households by incomes from extra food production and dropping cost of food stuffs. Vegetable growing in the area owing to wastewater availability for agriculture purposes also creates numerous employment opportunities for the landless individuals. Lot of manpower for growing of vegetables crops right from land preparation to seedling, irrigation, plucking, loading, transporting, unloading, and again marketing to retailers and to consumers is also needed. Likewise, fodder and wheat crops also need more manpower for land preparation, budding, irrigation, harvesting, threshing and storage activities. Usage of wastewater has not only created several employment opportunities in agriculture sector but also generated some new businesses. Although agricultural share in the economy of our country is slowly declining yet it is still backbone of the economy, contributing 18.5% to country's Gross Domestic Productivity and providing 38.5% employment to National Labour Force (GoP, 2020). In nutshell, use of wastewater for agriculture has good effect to enhance the financial features (monthly household's income) of the farmers and producing new employment opportunities. This alleviates the poverty and bring the prosperity in this locality.

Perception of Respondents about Physical and Social Environmental Improvement

A large majority of farmers perceived about improvement made through using wastewater for agriculture that present situations (physical, social and environmental) in the area were better than those conditions which were before using wastewater for agriculture purposes (Table 4). However, it was worth to note that perception of farmers about impact on public health (0.336), soil structure (0.240) and ground water resources (0.366) was medium or low.

Table 4. Perception of respondents about environmental and social improvement (Indices of Perception).

Sr. No	Environmental and Social Aspects	Index of Improvement
1.	Impact on public health (40-20)	0.336
2.	Effect on crops productivity (55-5)	0.833
3.	Upshot on soil structure (42-18)	0.240
4.	Impact on groundwater resources (41-19)	0.366
5.	Effect on property values (56-4)	0.866
6.	Ecological impacts (52-8)	0.733
7.	Social Impacts (54-6)	0.800
8.	Change in access to irrigation facility (55-5)	0.833
9.	Reduction in fertilizers and pesticides use (53-7)	0.766
10.	Spreading of odor, nuisance and pests (49-11)	0.633
Overall Index of Perception		0.687

Overall index value of perception index (0.687) demonstrated that respondents had overall better perception about improvement made due to using wastewater for agriculture in this village. This showed that perceived improvement by farmers of the study area was better with a positive impact of using wastewater for agriculture purposes on social aspects of farmers. However, low index of improvement of public health, soil structure and ground water resources indicated some bad impact on environmental aspects as well. Scott, *et al. (*2004) also reported some meagre threats to health and environmental risks associated with this practice. Similarly, Rageh (2014) pointed out that these soils were highly saline. He argued that this might be due to over quantity of wastewater used for irrigation, exceeding the irrigation requirements. So, wastewater treatment is needed to get rid of harmful substances and microorganisms before using it for irrigation (Ashraf *et al*., 2017).

CONCLUSION

Using wastewater as a resource for agriculture has benefits that would otherwise be discarded and wasted. Use of wastewater enhances the fertility and productivity of agriculture land, as well as increases property values (land pricing and land rent) which boosts monthly households' income of farmers and alleviate poverty. Use of wastewater for agriculture also decreases pressures on environment by reducing the use of environmental waters. However, some issues need to be addressed like presence of pathogens and chemical contaminants as well as impacts on health, soil structure and groundwater resources. These all can be controlled through treatment and effective farm management practices.

AUTHORS' CONTRIBUTION

Dr. Muhammad Musa analyzed data and wrote the manuscript. Waseem Nawaz designed and conducted the research study. Zahira Batool supervised the research and edited the manuscript. Sadaf Mahmood and Dr. Falak Sher helped in collecting and analyzing data. All authors read and approved the final draft for publication.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

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