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Assessing the community's perception of wastewater irrigation and health impacts

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Abstract

Pakistan is facing water scarcity with a rapid population growth since from past few years. The continuous demand of water, forced the people to use alternative water resources and wastewater has become the best source of alternative water resource. This qualitative approach focusses on the wastewater irrigation in Faisalabad city, Punjab Pakistan. We draw upon community's engagement in wastewater irrigation and health impacts, focusing on community's perception, experiences, and expert's insights. We contended in favor of producing stronger interaction among health impacts of wastewater irrigation in vegetables production and its health risk impacts. Through in-depth interviews with local farmers, health professionals, and environmental experts, this study identifies the benefits, challenges, and health risks associated with wastewater irrigation, offering recommendations for sustainable practices and policy development. Consequently, it deserves vital consideration as part of these aspects.

Keywords: wastewater irrigation, perception, health risk, community, health risks reduction strategies

Introduction

In the world, 80% of wastewater consists of several harmful substances and it cause many poisonous effects on human beings as well as environments. So, the removal of toxic substance before disposal it into landfills is used as a substitute of water which is evolving need (Alhamedi *et al.,* 2023). Water shortage due to drought and over exploitation of groundwater has become a critical challenge for farmers. In developing countries use of untreated wastewater is very

common practice (Maleksaeidi *et al.,* 2018). Wastewater is mostly used to grow food like vegetables. But their intake caused health risks for consumers and farmers. Skin problems are most common health risks associated with wastewater farm works (Woldetsadik *et al.,* 2017). However, Libutti *et al.* (2018) identified reusing wastewater for crop irrigation has the potential to reduce or mitigate water scarcity, boost the agricultural industry, and save groundwater resources. In this instance, Pakistan's 26% of national vegetables are produced by using wastewater (Ensik *et al.,* 2004a) and wastewater vegetables irrigating area is around 32500 hectares and it is expected this area will be increase considerably in future (Saleem, 2005). Significant poverty, inequality, and social fragmentation linked to shifts in access to and rights to land and natural resources as well as exclusionary service delivery are further characteristics of the peri-urban area (Karpouzoglou and Mehta, 2015; Vij and Narain, 2016). While a number of scholars examined the significant reasons of using wastewater such as raising water stress, increased wastewater production, rising food demand, upgrade sewage infrastructure, regularity and reliability of wastewater supplies and its nutritional value for crops (Ashraf *et al.,* 2017; Khan *et al.,* 2013; Singh *et al.* 2021); employment opportunities for local community (Nawaz *et al.,* 2022); better source of fertilizer and gives high yield with less production cost (Khanpae *et al.* 2020). It is commonly known that food made from wastewater may contain bacteria, fungus, nematodes, viruses, and protozoans that can lead to a variety of illnesses in people and other living things (Murtaza *et al.,* 2010; Kausar *et al.,* 2017) because the wastewater's high salt content, harmful metal concentration, and pathogenic levels, irrigation with it raises more questions about crop, animal, and human health (USEPA, 2004; Ashraf *et al.,* 2013; Iqbal *et al.,* 2017). Furthermore, consuming food contaminated with heavy metals can drastically affects body and weakening its immune system and raising the risk of upper gastrointestinal cancer, intrauterine development retardation, and other problems associated with malnutrition (Ullah *et al.,* 2022).

This paper investigates the interplay between wastewater irrigation and its health impacts, with an emphasis on understanding farming community and expert's perspectives. By examining the experiences of those involved in or impacted by wastewater irrigation, The goal of this research is to advance a more accurate understanding of the health implications of this practice and inform policy and public health strategies. Faisalabad city has become a fascinating

subject to investigate why, given the situation, farmers perception about WWI and specifically to find out health impacts of WWI related to the unregulated wastewater use. The structure of this article is as follows; First, we investigate the pertinent literature that helps us conceptualize WWI followed by a section of health risks which draws understandings about community's behavior in wastewater health risks reduction strategies. Next, the methodology and research approach implemented in this paper to analyze our case study are described. This is followed by a short overview of study area, the farmers' perception of wastewater irrigation. Our case study visions are then categorized in three main parts: first, find out the perception of using wastewater, second, showing how it relates to community's uneven exposure to risk from WWI, thirdly, tracing the adaptive behavior of community towards wastewater health risk reduction strategies, and, in conclusion, we summarize the major contributions of the study to policy makers.

Fig 1. Wastewater flow from industries to homes and potential health risk

2. Theoretical framework: Theory of Planned Behavior

Two strands of debate enlighten the investigation and conceptualization the behavior of farming community in WWI. The first is the debate on perception towards WWI and the second is attitude towards using wastewater in vegetables production and its health impacts. Thus far, these two arguments have been proceeding concurrently, but there hasn't been much idea sharing between them. However, since these two discussions have different strengths in conceptualizing community behavior, there is considerable value in encouraging stronger interaction between them. In WWI debate, which we turn to first, we draw on a long history of research on wastewater irrigation and from this debate, we distil the concepts of popularity of wastewater use in vegetables production and its health impacts.

The theory of planned behavior (TPB), which theorizes the behavior, that is determined by intention, which in line is prejudiced by three important factors: attitudes towards the behavior, subjective norms, and perceived behavioral control. This model is adapted to understand farmers' behaviors regarding wastewater irrigation. Mostly farmers in the history of wastewater use highlight that their peer groups or neighbor farmers were using wastewater and they were getting good crops that’s why they had started using it and few of them said they had no specific reason behind its use only because their grandfather or father were using it. As the theory of planned behavior highlight the subjective norms effects on the behavior.

To involve our research with both irregularities about WWI and the way risk from WWI and health risks reduction strategies. The focus group discussion, offers significant insights to understand reasons of using wastewater in vegetables production. Through making this theoretical interaction among both discussions, we come at a more inclusive understanding of behavior towards WWI.

3. Methods and research approach

3.1. Study area

The research was conducted in the adjacent villages of wastewater collecting drains Madhuana and Paharang drains of Faisalabad in the state of Punjab (Figure 2). Wastewater using villages were selected purposively. Faisalabad accounts for almost 20% of Pakistan's GDP, making it the

country's largest contributor. In essence, it is the hub of Pakistan's textile sector, accounting for almost 65% of the country's export market. Since all of these production facilities generate enormous amounts of wastewater, one of the main environmental problems facing Faisalabad is wastewater management, and industrial effluent in particular. Between 1998 and 2017, the population of Faisalabad grew from 2.0 million to 3.2 million. By 2030, it is predicted to double. Faisalabad generates over 1,100 million cubic meters of wastewater annually (MCM/year), of which only 20% is thought to be processed at Uchkera Wastewater Treatment Ponds before being dumped into the Chenab River and Ravi River, two natural water bodies (Sheer, 2019). It's a best location to investigate the behavior of community towards wastewater irrigation's health impacts. The Paharang drain in Faisalabad, that was used for carrying storm but currently it's become highly polluted by industrial wastes (Rashid et al., 2018). In these sites vegetables cultivation has becoming the main livelihood for farmers (Abedullah et al., 2011). At Paharang drain, farmers had small landholdings and they are supported by labor work and agriculture work. Wastewater exposure has been linked to viral, bacterial, and protozoan diseases and other diarrheal diseases (Bos et al., 2009; Qadir et al., 2007; WHO, 2006; Wang et al., 2013).

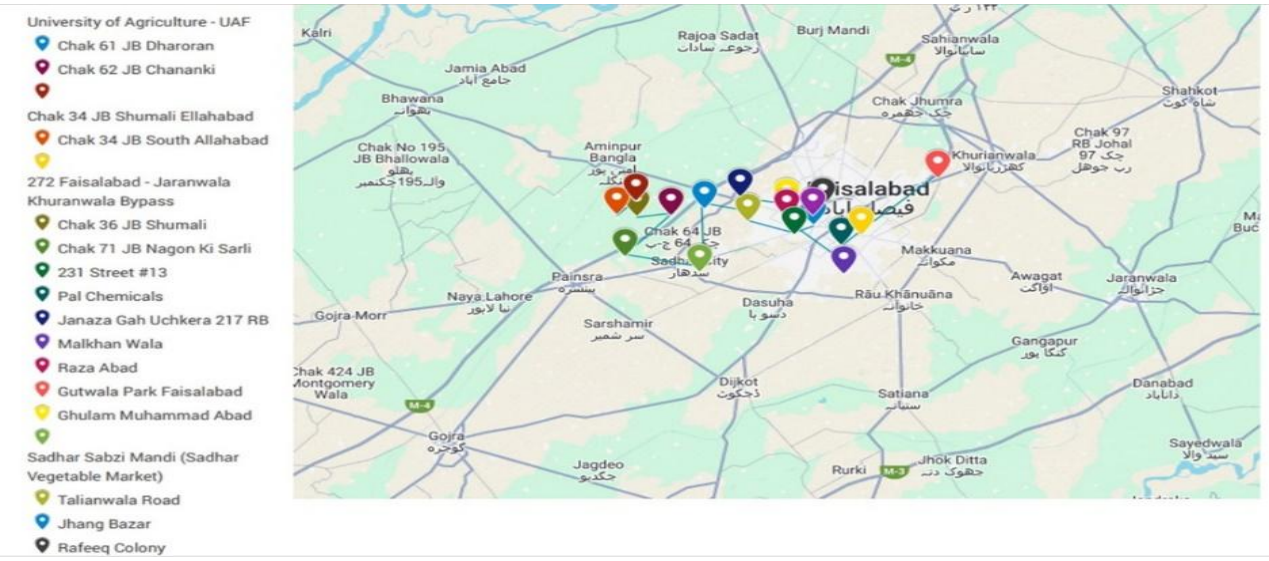

Fig 2. Sites of data collection

3.2 Methodology

Data was prompted through qualitative methodologies such as key informant interviews as well as focus group discussion (Bousetto *et al.*, 2020). Focus groups were comprised on wastewater vegetable growers and their selection was made by purposive sampling technique. Key informants were community's leaders and few irrigation and food department officers and their selection was purely made by purposive sampling technique. Data was collected in winter and summer throughout the year from April 2023 to February 2024. In the initial stage, wastewater using villages from two main wastewater sites-here referred to as C1 Paharang, C2 Madhuana drains where wastewater is using as a source of irrigation water. In the first phase focus group discussion with wastewater using farmers of adjacent villages of two main sites (C1 and C2) were carried out in order to gather more detailed information into wastewater irrigation's health impacts and community's behavior towards health risk reduction strategies. Focus group discussion were conducted and estimated time of each group discussion was comprised on 40 to 60 minutes. We positioned our enquiries in villages near to Faisalabad's main drains where wastewater irrigation is practiced where informal conversations and 16 FGDs with wastewater using farmers occurred in the research region. This included interviews with farmers and local village leaders in households, local community's doctor, and the district's gastro specialist doctor, wastewater handling and dealing institutions as well as food authority department. Open-ended questions were used for investigation. We inquired participants to explain about WWI, and to investigate on how this problem was shifted over time. In addition, we compared participants' statements with institutional bodies. The goal was to gather information about WWI not firmly following the scientific idea of 'water quality' but conclude to the less observable depictions of WWI that was main interest of the research participants. Through the 'outward layering' of data sets, a learning process was accomplished that enabled the study to uncover the political aspects of WWI. All questions were asked in native language Punjabi with the assistance of two enumerators, trained for few days former to data collection.

During the second phase, key informant interviews were directed including government officials from irrigation and drainage department, water and sanitation agency and health department. Respondents were categorized in two age groups like young age group and old age groups and prior consent was taken from respondents to participate in the study and it was ensured to keep confidential their personal information. Interviews were lasted between 60 and 90 minutes at the

at pre fixed place, in Urdu. They were directed by interview guide that focused on the knowledge attitude and practices in wastewater irrigation, health risks, health risks reduction strategies.

Table 1. Characteristics of wastewater using communities

Characteristics of Farming communities	**C1**	**C2**
Locations	Paharang Drain	Madhuana Drain
Native language	Punjabi	Punjabi
History of wastewater usage	In the last 2 decades	More than 2 decades
Land ownership	Majority has land ownership	Mostly were tenants
Land holding size	1-5 acres	5-10 acres

Finally, data was collected from sixteen focus group discussions and community leaders was very helpful in selection of participants, at first phase. Focus group participants yield by purposive sampling technique. The focus group consisted of wastewater vegetable growers and groups are formed on the base age like old and young and education. The groups were homogeneous inside but heterogenous when compared group to group. As per culture of the city, male was belonged to agriculture so focus groups were consisted on male participants. Questions were asked by researcher own self but notes taking were made by researcher. All conversations were recorded through audio recorder and consent from participants were taken prior to start interview. Finding themes and sub-themes, translating and transcribing field notes and audio recordings, and rigorously coding with key questions were all part of the analysis of the

qualitative data produced by the focus groups and key informant interviews (Braun and Clark, 2006; Greg et al., 2019) using Alas. ti version 8.4.15.

4. Results and Discussion

In the context of perception about using wastewater and irrigation's impact on health, we begin with an account of the perspective of community on using wastewater in vegetables production (objective no.1). We then describe, how health risks caused directly with wastewater irrigation and indirectly linked with wastewater irrigated vegetables consumption (objective no.2). Next, this is tracked by an inspection of adoption of health risk reduction strategies and its barriers (objective no.3).

4.1. Use of wastewater in vegetables production

Faisalabad is an industrial city as well as agricultural city too. The decline of canal water and direct dumping of household and industrial wastes into canals and clean water ditches is a reason behind wastewater irrigation. Key informants highlighted that negligence of community is the reason of wastewater irrigation. Though few institutional bodies blame each other for this negligence behavior. The environment protection agency (EPA) seniors criticized the water and sanitation agency (WASA).

The illegal operation of an increasing number of "hazardous waste disposal" businesses over time has resulted in the direct disposal of industrial waste into waterways, endangering agriculture. However, a lack of freshwater has forced many farmers to use wastewater irrigation for heavy metal-containing food crops including vegetables and cereals (Marshall et al., 2017). The railway line that runs through the city of Faisalabad divides the city's current sewer system into two distinct zones. Sewage collection and disposal systems are self-governing in each zone. The majority of untreated sewage and industrial effluents are dumped straight into the Madhuana drain to the east of the city and the Paharang drain to the west (Munir and Mukhtar, 2005). Information that was collected through focus group discussion, in which farmers highlighted the use of wastewater in vegetables production. Overtime, after the decline of canal water, the issues of clean water for irrigation has been raised. The statement of the participants highlights several key points regarding the use of wastewater for irrigation in agriculture, particularly vegetables'

production. They illustrate that during the water-scarce seasons, they were relying on wastewater for irrigation over a prolonged period underscores the necessity of this practice for sustaining vegetables production. While this approach addresses immediate agricultural need, it also raises important questions regarding the long-term sustainability and safety of using wastewater in food production.

Their statement reflects a complex interplay of environmental, social, and economic factors affecting agricultural practices, particularly in clean canal water scarce regions. The respondents illustrates the magnifying environmental issue like mismanagement of water resources or increased demand due to population growth. This water scarcity forced the farmers to adapt such practices like wastewater irrgation to ensure food sustainability. This show the adaptability and resilience behavior among farmers. They stated "sometimes happily" suggests a nuanced view of wastewater use. There may be cultural acceptance of wastewater irrigation as an alternative or viable option. It is also highlight a shifting in social norms. Farmers may also find it a more cost-effective solution instead of using alternative irrigation methods or technologies. This highlight the socio-economic challenges faced by farmers particularly in low income countries. The focus group participant from the young age group may represent a generational shift in attitudes towards agriculture and resource use. Younger farmers might be more open to innovative practices, including the use of wastewater, as they seek to optimize production and ensure food security. As participant's statement reflects a positive attitude towards wastewater irrigation as a "best opportunity" despite its challenges. As theory of planned behavior affected by its component like subjective norms in this statement participants refer collective experience such as "we are using it happily or sometime forcefully" indicates a shared norm that legtimizes the use of wastewater. This perceived control can motivate continued use of wastewater irrigation, as they believe they can manage the risks and benefits associated with it. Majority of the focus group participants at both drains stated that;

"Due to scarcity and unavailability of canal water, we are forced or happily shifted to wastewater irrigation since from 30 years. Vegetables categorized in such type of crops that need excessive water most specifically in summer. Mostly in a year, canals remains dried and we couldn't get full fledge benefits from it. In such circumstances, wastewater is a best opportunity for vegetables production (Focus group participant_Young age group)".

In Faisalabad, drain water is being pumped illegally to irrigate the fields. Farmers mix their household water into ditches made for canal water. The thematic analysis showed the significant infrastructural gap or the absence of a proper drainage system are key factors behind its initial use. The reliance on crop fields for dumping wastewater can have several adverse effects, including potential contamination of soil and crops, risk to public health, and decreased agricultural productivity. In the selected wastewater using communities, inadequate infrastructure of the housing societies shows the challenges that they are facing. This mismanagement of government and rural planners that caused wide-range governance challenges like lack of maintenance, insufficient planning and inadequate investment in infrastructure. The community is relaying on crop fields for wastewater disposal that poses environmental risks, which can lead to broader implications, such as poor agricultural productivity and health issues arising from contaminated crops. Community's head or leader as a key informant in the study stated that;

"Due to absence of the well-planned drainage system, we have no alternative way other than crop fields to dump the household used water. These limited infrastructural resources forced us to do so. There is also some mistake of housing societies that they mismanaged the infrastructure of the community and we are also involved into it (local leader_ Key informant)".

4.2 Farmers' perceptions about wastewater health risk

As above illustrates the start of wastewater irrigation according to farmers through focus group discussion and key informant interviews. We investigate the wastewater's health impacts. Wastewater irrigation with its potential benefits has numerous adverse health impacts including occupational and consumption related health risk.

The participants at the study sites acknowledges that wastewater has numerous benefits, likely referring to its role in providing water for irrigation and possibly enhancing soil fertility. But the mostly young community members have awareness that it has adverse health impacts such as skin irritation (itching). This dual awareness influences the participant's overall attitude toward engaging in the behavior. The respondents weigh the benefits against the risks. Skin irritation is a common experience among individuals in similar situations. There is a shared understanding or norm within the community about the impacts of wastewater irrigation. There may be societal or

cultural pressures to engage in wastewater irrigation as a necessary practice for agriculture, despite the known risks. The participant may feel compelled to continue participating in wastewater irrigation due to perceived social norms and communal practices, even in the face of health challenges. The participants experienced the lack of control over their exposure the inability to wear protective gear ("not possible to wear the feet") while irrigating with wastewater. The community stated that they feel helplessness regarding avoiding health affects because due to the nature of agricultural work reduces opportunities to mitigate risks. The participant feels that they lack options to protect themselves effectively. This perceived low control the negative impacts of wastewater irrigation. Moreover, consumption related health risk was not clearly depicted.

> *"Although wastewater has numerous benefits but it consists of harmful substances. Therefore, during wastewater irrigation most of us experience skin irritation like itching". Same as another one stated that, "Wastewater comes directly in touch to our feet and body because during irrigation, its not possible to wear the feet and I mostly experience itching on legs and feet (focus group participant)".*

Using the Theory of Planned Behavior, the focus group participant's statements demonstrate a complex interplay of beliefs that influence their behavior regarding wastewater irrigation. Behavioral beliefs highlight the weighing of benefits against the health risks. Normative beliefs suggest that social and community influences play a significant role in continuing the behavior despite the known irritations and concerns. Control beliefs indicate that practical barriers inhibit the ability to avoid negative health impacts, potentially leading to a sustained cycle of behavior despite its adverse effects.

The results opposed to a study that due to wastewater irrigation farmers and consumers are gradually exposed to the abdominal sickness, infections (Ensik *et al.,* 2005).

4.3. Behavior towards wastewater health risk reduction strategies

Despite various benefits, wastewater irrigation has different health impacts. It is major carrier of pollutants from plant to human body. At study area, most of the participants are not well aware about harmful effects of it on humans and crops but only few. The study resulted that the farmers were not using health risk reduction strategies while irrigating with wastewater due to low level of education and lack of awareness of health risk of wastewater and health risks reduction

strategies. Wastewater users have cognitive dissonance and belief of safety in which they stated that being in contact with wastewater is "completely safe" and "has no side effects". They had lack of awareness and less understanding of the long-term health implications of exposure. One of the respondents stated that;

"I don't think wastewater irrigation and its grown vegetables could be risky for our health because we never perceived severity of harmful affects and never felt need to use the wastewtaer health risk preventive measures".

The participant may feel societal pressure to conform to local practices, even when recognizing the health impacts. They are relying on simple measures like covering their face with cloth due to the "bad smell" of wastewater. This may suggest a lack of more effective protection or alternatives for irrigation practices, which can limit perceived control over health outcomes. By stating that they are "standing in wastewater in front of you," the participants may be demonstrating resignation or acceptance of their circumstances, suggesting that there is little perceived ability to change the situation or seek safer alternatives. Farmers show collective acceptance of risky practices. Socio-economic factors often shape farmers' decisions. One another respondent stated that;

"Mostly farmers are suffering with itching by using wastewater. Due to its bad odor, I have to cover the face with a small piece of cloth or a handkerchief. Few of them stated that wastewater irrigation is completely safe as I am standing in wastewater ditches in front of you. It has no side effects. Even if a person is suffering with the skin problems, he should take bath with the wastewater".

5. Discussion

This study highlights the farmers' behavior about wastewater irrigation and perception about its health impacts and risk reduction strategies of wastewater irrigation in Faisalabad, Pakistan. By focusing on one single objective like what they think about wastewater, farmers perceived wastewater is a good source of irrigation for vegetables production. We have demonstrated that perception is impacted by a variety of individual characteristics that impact how one comprehends and responds to problems. Our study is illustrating perception of wastewater irrigation in vegetables production can indeed heighten the health risks. Study concluded that consumption of wastewater irrigated vegetables exerts adverse health impacts like diarrhea or

gastroenteritis same was stated by Srikanth and Naik, (2013) and causing severe health risks (Ensik et al., 2005;Gashaye and Yildiz, 2020). Many farmers reported that they were experiencing skin irritation and allergic reactions by using wastewater. Most of wastewater using farmers face skin diseases in rice cultivation (Trang et al., 2007). Farmers mostly experienced health risks because lack of awareness about wastewater irrigated vegetables consumption may cause health risks and low level of education are key factors behind wastewater health risks and similar reults have been shown in an alternate study that lack of awareness of health risks in using low quality water in irrigation among farmers is associated with wastewater health risks (Mayilla *et al.,* 2016). Direct exposure means they work in fields and directly deal with wastewater. Although in Pakistan, wastewater irrigation has been banned but farmers are still using it. It's threatened the participants' health of our study area, also identified by others (Natasha et al., 2020; Iqbal et al., 2021; Zafar et al., 2021). Further, we had demonstrated how wastewater reuse has negative effects on the health of the wastewater using communities? The farmers who have direct exposure with wastewater like workers at farms. They grow crops by using wastewater and had more chance to get health risk as compared to other community members (Weldesilassie et al., 2011; Busgang et al., 2015; Yakamercan et al., 2021).

As other studies, have shown farmers who work at farms without wearing shoes they are more likely to experience hookworm infections. Our study showed most of the wastewater users had experienced skin irritation or itching. The thematic analysis in our study showed that younger age farmers are more interested to use wastewater as compare to older age farming groups. In young age groups highly educated group of young people are not interested to use it as compared to less educated or illiterates. Farmers with poor drainage are highly associated with wastewater reuse and they have less awareness level to its health impacts. The farmers living in cities have high knowledge of wastewater health risks and they are more likely to use health risks reduction strategies (Deepnarain et al., 2020).

Our findings are helping for related policy makers in generating up-to-dated decisions to minimize the negative health impacts that are linked with the use of wastewater and helpful for starting knowledge-based training programs for farmers. Punjab's urban and peri-urban areas require systematic and enhanced extension services programs since farmers' access to extension services and their limited adoption of health risk reduction techniques have failed to reduce the

health risks associated with wastewater reuse. Farmers may also benefit from additional interventions that offer health and environmental safety information, such as farmer awareness campaigns and field seminars held at the union council level. By educating farmers on the health hazards of wastewater and the proper use of primary protective equipment, dealers and distributors of agricultural products can also be helpful. There are a number of noteworthy limitations to this study. The production costs, yield per acre, and profit margins of farmers using freshwater and wastewater for vegetable production were not examined and compared separately in the study. The farmers' medical expenses were not calculated. The disease symptoms essentially reflected farmers' perceptions of the health hazards associated with reusing wastewater, which could arise from other factors, such as inadequate sanitation or hygiene practices, and these should be quantified. These elements might be the subject of future studies.

5.1. Conclusion

This study examines the interplay between farmers' perception of wastewater irrigation and its health impacts. Demographic data based on two age groups like older and young age, were collected from adjacent villages of wastewater collecting drains of Faisalabad, Pakistan. These drains contain heavy metals and microbes or pathogens that caused potential health risk. At selected sites the majority of participants have less knowledge of its negative health impacts. The study uses thematic analysis to investigate the perception of farmers about wastewater health effects. It has severed negative health impacts rather than fresh water users. It resulted in increased occupational health risks among farmers as well as environmental and alkaline soil just because of heavy metals accumulation.

Awareness level about wastewater health impacts is high in young age groups as compared to old age groups. Increasing knowledge and awareness of the health hazards associated with wastewater is a major priority in terms of policy consequences. Concerns about water shortages at the district level seem to be better addressed by policy initiatives that involve local actors and government organizations. Examples of these initiatives include the development of wastewater treatment facilities and the appropriate usage of personal protective equipment (PPE). Risks to human health can be decreased with the support of appropriate instruction, regular visits by

agricultural field workers, and control monitoring to guarantee PPE use. Safety certificates ought to be given to farmers that implement good agricultural practices (GAP) on their farms. Farmers with limited credit might also benefit from other initiatives, such as a formal credit program with discounted interest rates, which could enable them to buy freshwater or install tube wells. The potential negative impact on crops and overall health may not be fully considered by the community, indicating a need to raise awareness about environmental sustainability and the long-term consequences of their actions. This situation highlights an urgent need for intervention and improved awareness of sustainable practices.

Credit author statement

Each author made a contribution to the design and conceptualization of the study. The questionnaire design, data collection, data analysis, and paper writing were all within the purview of Maria Khalid, a Ph.D. scholar. Prof. Izhar Ahmad Khan and Dr. Naveed Farah and Dr. Fahd Rasul were involved in face and content validity of the study's layout, questionnaire design, methodology, data analysis, interpretation of results and manuscript reviewing.

Declaration of competing interest

The authors have no competing interests that can influence to the work in this paper.

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