

# Wastewater reuse in Pakistan: Highlights of recent literature reviews

## Key messages

- The use of untreated wastewater is a common reality in Pakistan, where wastewater treatment remains rudimentary and water scarcity drives farmers to ignore health risks.
- The reviewed studies collectively paint a concerning picture of heavy metal contamination in crops irrigated with wastewater across Pakistan, overshadowing the number of studies on pathogenic risks.
- Compared to the abundance of detailed risk assessments, recommendations for risk mitigation are few and often limited to calls for increased wastewater treatment and stronger regulations.
- Research on practical strategies for minimizing risks in the short and medium term remain scarce.
- Potential solutions include, for example, leveraging corporate social responsibility (CSR), adopting nature-based solutions and strengthening policy support for the polluter-pays principle.
- There is a strong need for more social, institutional and economic research to address the outlined challenges effectively.

## Context

Globally, the use of untreated, but often diluted or partially treated wastewater in agriculture spans approximately 30 million hectares (ha). This far exceeds the area of planned use of well-treated (reclaimed) wastewater, which is estimated to cover at best 2 million ha (Qadir et al. Forthcoming). This gap has likely widened over the last decade despite significant investments in treatment infrastructure and capacity, due to the rapid population growth and the consequent increase in water consumption and wastewater generation. As a result, millions of small-scale farmers in urban and peri-urban areas of developing countries depend on wastewater or wastewater-polluted water sources to irrigate high-value edible crops for urban markets, often lacking alternative sources of irrigation water (Raschid-Sally and Jayakody 2008; Drechsel et al. 2022; UNEP 2023).

While (undiluted) wastewater can contain high amounts of crop nutrients that farmers value, the water will also contain various chemical, biological and physical pollutants, such as organic and inorganic compounds, pathogens (bacteria, viruses and parasites), heavy metals, hazardous chemicals, emulsions, pharmaceutical residues, nanoparticles, etc. The composition of wastewater can vary widely depending on its source, such as domestic, industrial or agricultural activities, as well as its treatment level and any dilution that occurs if channeled into existing water bodies. In those bodies, the water can cause significant ecological damage and, if reused, public health problems (Qadir et al. 2010; Khalid et al. 2018).



(photo: Venkataramani Govindan; modified).

In Pakistan, freshwater scarcity is a major reason for farmers turning to wastewater for food production, followed by the incentive of reduced production costs. As a typically free and reliable water source, rich in crop nutrients, wastewater is appealing to farmers, even in cases where alternative water sources could still be available, as it lowers their production costs (Mehmood et al. 2022). Ensink et al. (2004a) estimated that approximately 36% of the wastewater generated in Pakistan is used for agriculture, while the remaining 64% is discharged into water bodies or directly into the Arabian Sea. The authors estimated that 80% of all larger communities practice direct wastewater reuse for crop irrigation, covering around 32,500 ha nationwide, a figure likely much higher according to Thebo et al. (2017). As wastewater treatment facilities are very limited (around 1% according to Parveen and Khan 2023; Ishaque et al. 2024), most of the wastewater used is untreated.

Aside from domestic effluent, one in five registered industrial units in Pakistan generates highly contaminated wastewater, particularly from tanneries, petrochemical industries, food processing, the textile industry, refineries, paper and sugar industries, etc. The majority of these industrial units are situated in or near main cities, discharging their waste directly into nearby water bodies or onto cultivated soils (Natasha et al. 2020). Ensink et al. (2004a) estimated that urban wastewater is directly supporting the production of about 26% of all vegetables in Pakistan. This percentage will be larger when areas indirectly irrigated with diluted wastewater are also considered. The livelihood benefits for farmers provided by wastewater use, as well as its associated risks, were studied by the International Water Management Institute (IWMI) between 2001 and 2011, with a focus on chemical and pathogenic risks from both occupational exposure and crop consumption. Epidemiological studies were undertaken in the city of Faisalabad in conjunction with monitoring of soil, groundwater and produce quality, and economic analyses. The overall aim of the research was to develop a set of control measures that would minimize risks while maintaining benefits to farmers (Ensink et al. 2004b).

## Materials and methods

This summary builds on three recent literature reviews on wastewater use in agriculture in Pakistan:

- a) In 2022, a literature review was internally commissioned by IWMI to understand the current status and discourse around wastewater irrigation in Pakistan to potentially revive IWMI's wastewater research in the country. The review (Munir 2024) originally covered the period from 2011 to 2021 and was, for this brief, later extended to also include studies between 2022 and October 2024, resulting in a total of 164 reviewed papers.
- b) A comprehensive scoping study on the same topic was conducted and published by Kasi et al. (2022), covering the period from 1996 to 2020. This broader study initially identified approximately 3,000 papers, of which 136 were shortlisted for detailed analysis.
- c) In 2020, another review was published by Natasha et al. based on 144 studies of wastewater use for crop irrigation in Pakistan.

The sources used for paper selection varied to some extent among the reviews. For instance, while Munir (2024) used databases and platforms such as Scopus, Web of Science, ResearchGate and Google Scholar, Kasi et al. (2022) also included platforms such as PubMed and JSTOR. All searches were limited to articles published in English and focused on Pakistan.

**Given the significant overlap in sources and findings among the three studies, this summary focuses on trends and highlights across the three reviews.**

Only papers presenting interesting or unique approaches for follow-up research have been referenced in this brief; for other works, readers are encouraged to see the published reviews.

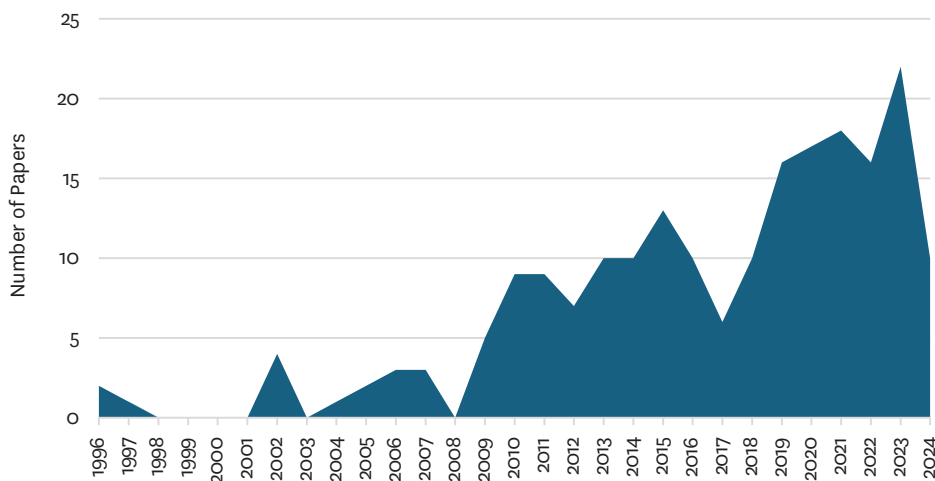


Many farmers in parts of Punjab Province, Pakistan use wastewater for agriculture (photo: IWMI/Pakistan).

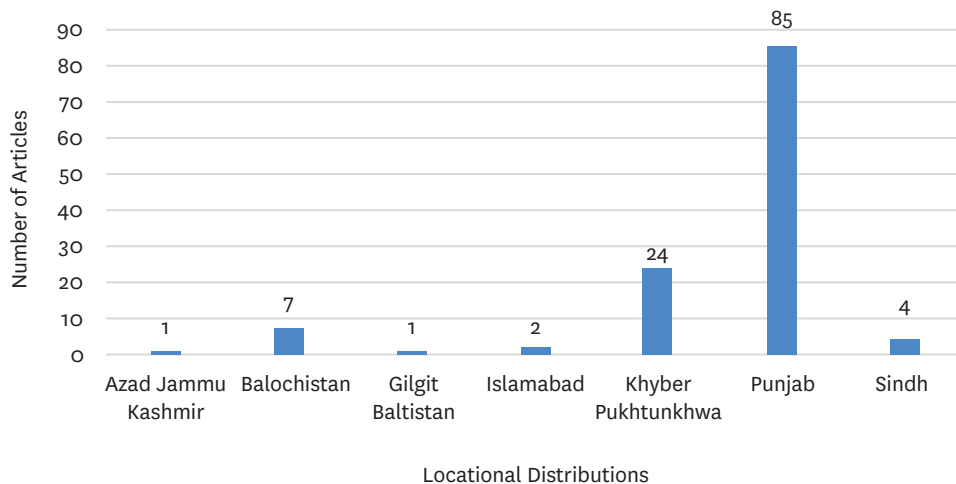
## Summary of review results

This section presents trends and highlights from the three literature reviews in bullet form:

1. The number of published research papers on wastewater use in agriculture has increased steadily over time (Figure 1).
2. A geographical analysis showed that most studies were conducted in Punjab, particularly in Faisalabad (Kasi et al. 2022; Figure 2), although Munir (2024) took into account studies conducted in or around at least 28 cities.
3. Among the over 40 crops mentioned across all papers, the large majority focused on different vegetables, followed by wheat and fodder crops. About 80% of the most recent studies since 2021 have concentrated on vegetables.
4. While earlier studies emphasized the benefits and livelihood support wastewater use offers farmers, recent studies focus more on associated risks. However, according to a meta-analysis of literature data by Natasha et al. (2020), there is an average increase of 75% in the nutrient content (nitrogen [N], phosphorus [P], potassium [K]) in vegetables/crops irrigated with wastewater compared to freshwater. One key reason cited is that the nutrient use efficiency for wastewater-irrigated crops is almost 100%, which is much higher than what an industrial (non-liquid) fertilizer can achieve.
5. Over 90% of the studies focus on heavy metals (Table 1) and possible risks to soils, crops and consumers of those crops, while a few studies (5%) examine fodder quality and risks to animal health. Pathogenic risks to humans or livestock, as well as risks associated with (organic) emerging contaminants, are seldom analyzed, compared to earlier IWMI studies before 2010, which had a strong co-focus on pathogenic health risks, particularly helminths.
6. Most assessments of chemical risks analyzed water, soil and plant samples. Studies on livestock health also sampled animal blood, hair and feces (e.g., for iron analysis). Human health impacts were studied through household surveys (recall period for disease symptoms), with stool sampling conducted in a few cases (e.g., van der Hoek et al. 2002).



**Figure 1.** Increase in studies on wastewater use in Pakistan between 1996 and 2024 (Kasi et al. 2022, updated by IWMI till October 2024).



**Figure 2.** Locations of studies reviewed by Kasi et al. (2022).

7. The majority of studies (80%) focus on untreated urban wastewater, while about 20% of the studies address industrial wastewater streams. Papers on groundwater pollution are rare (e.g., Ghaffar and Iqbal 2021). Groundwater is often mentioned but typically as a control for comparison with polluted canal or wastewater.

**Table 1.** Priority list of analyzed contaminants in wastewater studies from 2011–2022.

Parameters analyzed	Number of papers reviewed
Cr, Ni, Cd, Pb	>30
Cu, Fe, Zn, Mn, Co	20–30
As	10–19
N, P, K, Ca, Mg, Na, EC, pH, SAR, Mo, Se	3–9
BOD, COD, Dissolved Organic Carbon, TDS, TSS, RSC, Carbonates, Chloride, Amino Acid Chelate, Fe chelated with lysine, Sulphide, Phenol, Methylene blue active substances, Dichlorodiphenyltrichloroethane (DDT), Dichlorodiphenyl-dichloroethylene (DDE), Dichlorophenol (DCP), Trichlorophenol (TCP), Endrin, Dieldrin, Petroleum Hydrocarbons, Glutathione (GSH), Zn-lysine	1–2

Source: Munir (2024).

8. Risks to humans, crops and soils were assessed using various indices and factors, including the health risk index, daily intake, bioconcentration potential, pollution load index, metal transfer factor, potential ecological risk, enrichment factor, translocation factor, degree of contamination, etc. Only the initial IWMI studies applied epidemiological

approaches to assess health risks directly via the affected population (e.g., Ensink and van der Hoek 2009).

9. Studies focusing on ecological risk assessments, aquaculture or salinity were rare, except for soil contamination through wastewater irrigation. This paucity is even more pronounced for studies conducted at larger scales, such as watersheds. Although some studies have mapped the spatial distribution of contaminants, which could support activities such as zoning (Noreen and Younes 2023), such efforts remain limited.

10. In general, most studies were very descriptive, presenting laboratory data and comparing them with various standards extracted from over ten national and international agencies, verifying or reconfirming risks (Table 2). Only one in twenty studies concluded that risks were acceptable (for example, such as those of zinc or iron accumulation in wheat seeds). Results varied across studies, locations, crops, soils and contaminants, making it difficult to identify a chemical risk pattern.

11. A few papers compared soils and crop yields between wastewater- and freshwater-irrigated sites, including costs and benefits. However, some of these comparisons have been questioned for their validity (Drechsel et al. 2015).

12. The comparison of health risks from different hazards, such as acute health symptoms caused by pesticides or wastewater use (Abedullah et al. 2016), can help understand priority risks. This has also been tried in other regions, comparing, for example, exposure to pesticides and wastewater-borne pathogens (Amoah et al. 2006). The results will, however, always be location-specific, depending on factors such as the type of hazard and the way and frequency of human exposure.

**Table 2.** Percentage of observations with levels of toxic metals in wastewater, soils and plants higher than their respective limit values proposed by various organizations.

Organization	Pb	Cu	Zn	Cd	Cr	Mn
<i>Water (mean 37% for all metals)</i>						
USEPA (2010)	80	25	0	89	56	63
WHO/FAO (2007)	10	50	0	89	71	63
NEQS-Pak	30	25	0	44	14	38
<i>Soil (mean 17% for all metals)</i>						
USEPA (2010)	0	13	-	67	-	38
European Union Standards (EU 2002)	0	0	0	-	14	-
NEQS-Pak	0	-	-	-	-	-
USA	-	100	-	11	0	-
<i>Plants (mean 42% for all metals)</i>						
USEPA (2010)	-	-	0	-	-	-
WHO/FAO (2007)	70	25	17	78	43	12.5
European Union Standards (EU 2002)	90	25	17	78	-	-
NEQS-Pak	50	-	-	-	-	-

Source: Natasha et al. (2020).

Note: For sources cited in the table, see Natasha et al. (2020).

13. The guidelines of the World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO) are only cited in view of **risk assessments**, i.e., their suggested thresholds to achieve water quality targets. However, these guidelines are hardly referenced in terms of recommended **risk mitigation** measures, such as employing multiple risk barriers and health-based targets (WHO 2006), at least for pathogens, given the absence of treatment. An exception is the work of Ensink and van der Hoek (2009).

14. In general, recommendations for risk mitigation are often limited to one sentence, such as calls for increased wastewater treatment, enforcement of regulations or banning vegetable irrigation with unsafe water. Few studies have explored how to achieve risk mitigation or have experimented, for example, with methods such as phytoremediation, metal immobilization or mixing wastewater with canal water to reduce contamination levels. Socioeconomic studies or research addressing the political economy of wastewater use or institutional roles and capacities are rare.

## Conclusions

The reviewed papers collectively present a concerning picture of heavy metal contamination in wastewater-irrigated crops across Pakistan. The consistently high levels of various toxic metals across diverse regions highlight the urgent need for interventions to mitigate the potential health risks posed to the population. There is, however, a paucity of studies that go beyond risk assessment to explore feasible options for minimizing or avoiding the observed risks.

Investments in wastewater treatment remain the best long-term solution. However, for short- and medium-term needs, research should shift its focus from mere risk assessments to risk mitigation. This includes exploring how best to incentivize and implement (stricter regulations on) wastewater treatment, as well as improving reuse monitoring, optimizing crop selection

and promoting safer irrigation practices, with attention to both chemical and pathogenic risk factors.

There is a pressing need for more social, institutional and economic analyses to better understand stakeholder perceptions, alternative livelihood options and possible pathways for solutions. Economic assessments of wastewater irrigation consistently highlight its financial cost advantages compared to other water sources, which remain a key factor in farmers' decision-making despite perceived health risks (e.g., Baig et al. 2019). To design strategies and campaigns for on-farm risk reduction, it is mandatory to understand farmers' reasoning for increased wastewater use, their perceptions of risks and benefits, and ways of assessing water quality (Weckenbrock et al. 2011; Butt et al. 2022; Mehmood et al. 2022).

Risk mitigation could benefit from more research on topics such as nature-based solutions for wastewater treatment (e.g., UNEP 2021), the impact of biochar on crop yields and nutrient and heavy metal uptake (e.g., Hameeda et al. 2019), the facilitation of behavior change of stakeholders (e.g., Galibourg et al. 2024) and options for implementing and enforcing the polluter-pays principle and other (water) policies to address pollution and improve wastewater management and governance across scales (Luken 2009; Weckenbrock et al. 2011). The polluter-pays principle is strongly supported by, for instance, the National Hazardous Waste Management Policy (Government of Pakistan 2022).

Among other interesting opportunities flagged in the reviewed papers is the role of the private sector, such as the strong interest of the textile industry in (co)investing in wastewater treatment, driven by the increasing need for corporate social responsibility (CSR) in the sector (Shaikh 2013; Drechsel 2018). Another area to explore is how far wastewater auctioning could serve as a vehicle for increasing reuse safety (Hanjra et al. 2018).

Finally, water management and sustainable development must go beyond wastewater treatment and use to address the multidimensional water security issues Pakistan is facing as the country strives to achieve the water-related United Nations Sustainable Development Goals by 2030 (Ishaque et al. 2024).



Wastewater being channelled for crop irrigation in parts of Punjab Province, Pakistan (photo: IWMI/Pakistan).

## References

- Abedullah, A.; Kouser, S.; Ali, H. 2016. Pesticide or wastewater: Which one is a bigger culprit for acute health symptoms among vegetable growers in Pakistan's Punjab? *Human and Ecological Risk Assessment* 22(4): 941–957. <https://doi.org/10.1080/10807039.2015.1121375>
- Amoah, P.; Drechsel, P.; Abaidoo, R.C.; Ntow, W.J. 2006. Pesticide and pathogen contamination of vegetables in Ghana's urban markets. *Archives of Environmental Contamination and Toxicology* 50: 1–6. <https://doi.org/10.1007/s00244-004-0054-8>
- Baig, I.A.; Ashfaq, M.; Hassan, I.; Javed, M.I.; Khurshid, W.; Ali, A. 2011. Economic impacts of wastewater irrigation in Punjab, Pakistan. *Journal of Agricultural Research* 49(2): 5–14. Available at <https://api.semanticscholar.org/CorpusID:130038688> (accessed on November 21, 2024).
- Butt, T.M.; Azra; Luqman, M.; Farah, N.; Yaseen, M. 2022. Exploring the rewards and consequences of wastewater irrigation in vegetables: Case study of central Punjab, Pakistan. *Sarhad Journal of Agriculture* 38(2): 585–594. <https://dx.doi.org/10.17582/journal.sja/2022/38.2.585.594>
- Drechsel, P. 2018. Corporate social responsibility (CSR) as driver of change - Business Model 22. In: Otoo, M.; Drechsel, P. (eds.) *Resource recovery from waste: Business models for energy, nutrient and water reuse in low- and middle-income countries*. Oxon, UK: Routledge - Earthscan. pp.733–744. <https://hdl.handle.net/10568/93272>
- Drechsel, P.; Danso, G.; Qadir, M. 2015. Wastewater use in agriculture: Challenges in assessing costs and benefits. In: Drechsel, P.; Qadir, M.; Wichelns, D. (eds.) *Wastewater: Economic asset in an urbanizing world*. Dordrecht, Netherlands: Springer. pp.139–152. <https://hdl.handle.net/10568/71179>
- Drechsel, P.; Qadir, M.; Galibourg, D. 2022. The WHO guidelines for safe wastewater use in agriculture: A review of implementation challenges and possible solutions in the Global South. *Water* 2022 14(6): 864. <https://doi.org/10.3390/w14060864>
- Ensink, J.H.J.; Mahmood, T.; van der Hoek, W.; Raschid-Sally, L.; Amerasinghe, F.P. 2004a. A nationwide assessment of wastewater use in Pakistan: An obscure activity or a vitally important one? *Water Policy* 6(3): 197–206. <https://doi.org/10.2166/wp.2004.0013>
- Ensink, J.H.J.; Simmons, R.W.; van der Hoek, W. 2004b. Wastewater use in Pakistan: The cases of Haroonabad and Faisalabad. In: Scott, C.A.; Faruqui, N.I.; Raschid-Sally, L. (eds.) *Wastewater use in irrigated agriculture: Confronting the livelihood and environmental realities*. Wallingford, UK: CABI Publishing. pp.91–99. <https://doi.org/10.1079/9780851998237.0091>
- Ensink, J.H.J.; van der Hoek, W. 2009. Implementation of the WHO guidelines for the safe use of wastewater in Pakistan: Balancing risks and benefits. *Journal of Water & Health* 7(3): 464–468. <https://doi.org/10.2166/wh.2009.061>
- Galibourg, D.; Scott, R.E.; Gough, K.V.; Drechsel, P.; Evans, B.E. 2024. Effectiveness of behaviour change interventions to reduce the risk of faecal contamination in urban irrigated vegetable value chains - applying the COM-B behavioural framework. *Journal of Water, Sanitation and Hygiene for Development* 14(8): 654–669. <http://doi.org/10.2166/washdev.2024.014>
- Ghaffar, A.; Iqbal, N. 2021. Impact of wastewater irrigation on groundwater in the Lahore region and contamination source identification. *Water Supply* 21(4): 1834–1842. <https://doi.org/10.2166/ws.2020.340>
- Government of Pakistan. 2022. *National Hazardous Waste Management Policy, 2022*. Islamabad, Pakistan: Ministry of Climate Change, Government of Pakistan. Available at <https://www.dra.gov.pk/wp-content/uploads/2023/10/Annex-IV-National-Hazardous-Waste-Management-Policy-2022.pdf> (accessed on November 21, 2024).
- Hameeda; Gul, S.; Bano, G.; Manzoor, M.; Chandio, T.A.; Awan, A.A. 2019. Biochar and manure influences tomato fruit yield, heavy metal accumulation and concentration of soil nutrients under wastewater irrigation in arid climatic conditions. *Cogent Food & Agriculture* 5(1): 1576406. <https://doi.org/10.1080/23311932.2019.1576406>
- Hanjra, M.A.; Rao, K.C.; Danso, G.K.; Amerasinghe, P.; Drechsel, P. 2018. Wastewater as a commodity driving change - Business Model 23. In: Otoo, M.; Drechsel, P. (eds.) *Resource recovery from waste: Business models for energy, nutrient and water reuse in low- and middle-income countries*. Oxon, UK: Routledge - Earthscan. pp.745–759.
- Ishaque, W.; Sultan, K.; ur Rehman, Z. 2024. Water management and sustainable development in Pakistan: Environmental and health impacts of water quality on achieving the UNSDGs by 2030. *Frontiers in Water* 6. <https://doi.org/10.3389/frwa.2024.1267164>
- Kasi, W.A.; Panezai, S.; Saqib, S.E. 2022. Wastewater irrigation and associated health and environmental factors in Pakistan: A scoping review. *Resources and Environment* 12(3): 76–87.
- Khalid, S.; Shahid, M.; Natasha; Bibi, I.; Sarwar, T.; Shah, A.H.; Niazi, N.K. 2018. A review of environmental contamination and health risk assessment of wastewater use for crop irrigation with a focus on low and high-income countries. *International Journal of Environmental Research and Public Health* 15(5): 895. <https://doi.org/10.3390/ijerph15050895>
- Luken, R.A. 2009. Equivocating on the polluter-pays principle: The consequences for Pakistan. *Journal of Environmental Management* 90(11): 3479–3484. <https://doi.org/10.1016/j.jenvman.2009.05.033>

- Mehmood, Y.; Arshad, M.; Kächele, H. 2022. Effects of wastewater reuse on perceived health risks of farmers in Pakistan: Application of the Zero-Inflated Poisson regression model. *Journal of Cleaner Production* 369: 133430. <https://doi.org/10.1016/j.jclepro.2022.133430>
- Munir, S. 2024. *Wastewater reuse in Pakistan – a literature review*. Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Initiative on Resilient Cities. Unpublished.
- Natasha; Shahid, M.; Khalid, S.; Murtaza, B.; Anwar, H.; Shah, A.H.;...Niazi, N.K. 2020. A critical analysis of wastewater use in agriculture and associated health risks in Pakistan. *Environmental Geochemistry and Health* 45: 5599–5618. <https://doi.org/10.1007/s10653-020-00702-3>
- Noreen, M.; Younes, I. 2023. Wastewater irrigation and its impact on crops in major cultivated belt of Rechna Doab, Pakistan. *Kuwait Journal of Science* 50(4): 783–789. <https://doi.org/10.1016/j.kjs.2023.08.003>
- Parveen, F.; Khan, S.J. 2023. Wastewater treatment in Pakistan: Issues, challenges and solutions. In: Ahmad, M. (ed.) *Water Policy in Pakistan*. Global Issues in Water Policy 30. Cham, Switzerland: Springer. [https://doi.org/10.1007/978-3-031-36131-9\\_12](https://doi.org/10.1007/978-3-031-36131-9_12)
- Qadir, M.; Wichelns, D.; Raschid-Sally, L.; McCornick, P.G.; Drechsel, P.; Bahri, A.; Minhas, P.S. 2010. The challenges of wastewater irrigation in developing countries. *Agricultural Water Management* 97(4): 561–568. <https://doi.org/10.1016/j.agwat.2008.11.004>
- Qadir, M.; Drechsel, P.; Jones, E.R. Forthcoming. Domestic wastewater treatment and agricultural reuse: SDG progress and reporting challenges. *Discover Water* (final review).
- Raschid-Sally, L.; Jayakody, P. 2008. *Drivers and characteristics of wastewater agriculture in developing countries: Results from a global assessment*. Colombo, Sri Lanka: International Water Management Institute (IWMI). 29p. (IWMI Research Report 127).
- Shaikh, A.F. 2013. *Pakistan textile industry*. Keynote address at the First International Textile and Clothing (ITC) Conference, December 9, 2013, Lahore, Pakistan.
- Thebo, A.L.; Drechsel, P.; Lambin, E.F.; Nelson, K.L. 2017. A global, spatially-explicit assessment of irrigated croplands influenced by urban wastewater flows. *Environmental Research Letters* 12: 074008. <https://doi.org/10.1088/1748-9326/aa75d1>
- UNEP (United Nations Environment Programme). 2021. *Nature-based solutions for wastewater management: Barriers and opportunities in the Caribbean*. Kingston, Jamaica: Cartagena Convention Secretariat, United Nations Environment Programme. Available at <https://www.unep.org/cep/resources/report/nature-based-solutions-wastewater-management> (accessed on November 21, 2024).
- UNEP. 2023. *Wastewater – Turning problem to solution*. A UNEP Rapid Response Assessment. Nairobi, Kenya: United Nations Environment Programme. <https://doi.org/10.59117/20.500.11822/43142>
- van der Hoek, W.; Ul Hassan, M.; Ensink, J.H.J.; Feenstra, S.; Raschid-Sally, L.; Munir, S.;...Matsuno, Y. 2002. *Urban wastewater: A valuable resource for agriculture – A case study from Haroonabad, Pakistan*. Colombo, Sri Lanka: International Water Management Institute (IWMI). 20p. (IWMI Research Report 63).
- Weckenbrock, P.; Evans, A.; Majeed, M.Q.; Ahmad, W.; Bashir, N.; Drescher, A. 2011. Fighting for the right to use wastewater: What drives the use of untreated wastewater in a peri-urban village of Faisalabad, Pakistan? *Water International* 36(4): 522–534. <https://doi.org/10.1080/02508060.2011.596323>
- WHO (World Health Organization). 2006. *WHO guidelines for the safe use of wastewater, excreta and greywater - Volume II: Wastewater use in agriculture*. Geneva, Switzerland: World Health Organization. 222p. Available at [www.who.int/publications/i/item/9241546832](http://www.who.int/publications/i/item/9241546832) (accessed on November 21, 2024).

## Authors

**Sarfraz Munir**, International Water Management Institute (IWMI), Lahore, Pakistan

**Pay Drechsel**, IWMI, Colombo, Sri Lanka

**Thakshila Dharmapriya**, IWMI, Colombo, Sri Lanka

## Acknowledgements

This work was carried out under the CGIAR Initiatives on Resilient Cities and Nature-Positive Solutions. We would like to thank all funders (<https://www.cgiar.org/funders>) who supported these initiatives through their contributions to the CGIAR Trust Fund.



## Disclaimer

This publication has not been independently peer reviewed. Responsibility for opinions expressed and any possible errors lie with the authors and not the institutions involved.

### For more information, contact:

**Sarfraz Munir** ([s.munir@cgiar.org](mailto:s.munir@cgiar.org))

**International Water Management Institute**

12Km Multan Road, Thokar Niaz Baig, Lahore, Pakistan

## Citation

Munir, S.; Drechsel, P.; Dharmapriya, T. 2024. *Wastewater reuse in Pakistan: highlights of recent literature reviews*. Colombo, Sri Lanka: International Water Management Institute (IWMI). 8p. (IWMI Water Issue Brief 33). doi: <https://doi.org/10.5337/2024.236>

/ wastewater irrigation / water reuse / heavy metals / contamination / pathogens / risk assessment / risk reduction / health hazards / regulations / wastewater treatment / policies / polluter pays principle / nature-based solutions / water scarcity / farmers / literature reviews / Pakistan /

Copyright © 2024, by IWMI. All rights reserved. IWMI encourages the use of its material provided that the organization is acknowledged and kept informed in all such instances.

Please send inquiries and comments to [IWMI-Publications@cgiar.org](mailto:IWMI-Publications@cgiar.org)

For access to all IWMI publications, visit [www.iwmi.org/publications/](http://www.iwmi.org/publications/)

**IWMI**  
International Water  
Management Institute



IWMI is a CGIAR Research Center

The International Water Management Institute (IWMI) is an international, research-for-development organization that works with governments, civil society and the private sector to solve water problems in developing countries and scale up solutions. Through partnership, IWMI combines research on the sustainable use of water and land resources, knowledge services and products with capacity strengthening, dialogue and policy analysis to support implementation of water management solutions for agriculture, ecosystems, climate change and inclusive economic growth. Headquartered in Colombo, Sri Lanka, IWMI is a CGIAR Research Center with offices in 15 countries and a global network of scientists operating in more than 55 countries.

**International Water  
Management Institute (IWMI)**

### Headquarters

127 Sunil Mawatha, Pelawatte,  
Battaramulla, Sri Lanka

### Mailing address:

P. O. Box 2075, Colombo, Sri Lanka

Tel: +94 11 2880000

Fax: +94 11 2786854

Email: [iwmi@cgiar.org](mailto:iwmi@cgiar.org)

[www.iwmi.org](http://www.iwmi.org)