Seasonal variation in occupational health risk for farming families reusing treated wastewater effluent in Kanpur, India.

MSc. Thesis

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MSc Thesis Identifier WSD.23-974682
Updated version, October 2023

कानपुर, भारत में उपचारित अपशिष्ट जल का पुन:
उपयोग करने वाले कृषक परिवारों के लिए व्यावसायिक स्वास्थ्य जोखिम में मौसमी भिन्नता

Seasonal variation in occupational health risk for farming families reusing treated wastewater effluent in Kanpur, India.

Master of Science Thesis
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This research is done for the partial fulfilment of requirements for the Master of Science degree at the IHE Delft Institute for Water Education, Delft, the Netherlands.

Delft
03/10/2023

Abstract

Wastewater effluent reuse is a common agricultural practice in peri-urban and rural India, constituting approximately 30% of irrigation. It addresses water scarcity and supports crop cultivation. However, India faces challenges in effluent treatment and management to ensure farmer health and safety. Effective treatment, quality monitoring, and risk assessments are essential. An exploratory study was conducted with eight farming families actively reusing treated wastewater effluent. The study aimed to describe effluent reuse practices among family members across seasons, assess seasonal effluent quality variation, and evaluate occupational health risks using semi-quantitative risk assessment methods. Farmers in the studied village recognise three seasons: Summer, Monsoon, and Winter. While Summer and Monsoon activities exhibit minimal disparities, Monsoon differs significantly from Winter due to distinct crop cultivation practices. Women engage in irrigated crop farming and household duties, while adolescent boys aged 12-18 participate in fieldwork. Children under 12 are not involved in fieldwork. Farmers perceive effluent quality as poor, especially during the Monsoon, with elevated E. coli concentrations exceeding permissible limits. Occupational risks include exposure to microorganisms, chemicals, and poor postures. Winter entails lower risks due to reduced wastewater exposure. Monsoon season poses higher dirt and disease risks due to rainwater. Animal husbandry significantly exposes individuals to wastewater, and household tasks near animals increase year-round indoor contamination risks for all family members. Additional risks include consuming waterlogged field products and unhygienic milk. Common physical hazards include odours and skin irritants, necessitating proper cleaning and disinfection, given the livestock's contact with effluent channels. Women face higher risks in quantity but similar intensity compared to men based on their activities. Future studies on treated wastewater effluent reuse should consider agricultural and animal husbandry activities, acknowledging their year-round interdependence. A comprehensive occupational risk assessment approach should evaluate gender-based activity differences and recognise that staying at home does not eliminate effluent exposure due to animal-related transport indoors. Future studies on treated wastewater effluent reuse should consider both agricultural and animal husbandry activities, recognizing their year-round interdependence and the necessity for a comprehensive occupational risk assessment approach which evaluate the differences between gender activities.

Keywords: reuse of wastewater effluent in agriculture, gender occupational risk assessment, seasonal agricultural practices, wastewater treatment, irrigation

Acknowledgements

To Leia and my family;

To Marij, Erik, and Ilya, my Dutch family;

To my Mentor, Claire Furlong, and my Supervisor, Tineke Hooijmans, for the opportunity, the patience, and all the support;

To Lena Breitenmoser and Folake Babalola, for their inspirational work, support, and shared information;

To my fellow colleagues Michelle C. Villarreal and Cuthbert Nkhoma for their support and adventures in India;

To IHE Delft for the opportunity, safe and inspirational space of learning, and the active desire to always get better.

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Chapter 1 Introduction

In this chapter an introduction of the general topic of the study is presented. The context is provided for the research problem. Finally, the aims and objectives are listed.

1.1 Background

The Sustainable Development Goal 6 (SDG6) Clean water and sanitation - Ensure availability and sustainable management of water and sanitation for all, shows in its report that more than 733 million people live in countries with high and critical levels of water stress and that 2.8 billion people lack safely managed sanitation (UNEP 2019). The reuse of wastewater treated effluent for irrigation in agriculture is historically a solution to address water scarcity and enhance agricultural productivity in some countries (Jaramillo et al 2017). Specifically, where water resources are limited and agricultural activities are crucial for livelihoods, the practice of using wastewater effluent for irrigation is increasingly common (Jimenez et al 2005; Declercq et al 2015; Jaramillo and Restrepo 2017; Kesari et al 2021; Massoud et al 2022; Neelofar at al 20023; and Garduno-Jimenez et al 2023). However, a critical research gap exists concerning the occupational risks faced by farming family members (women, men and children) who are directly exposed to the effluent during agricultural activities in different seasons.

Wastewater treatment is an essential process to remove contaminants and pollutants from wastewater before it can be reused for various purposes, including agricultural irrigation. The World Health Organization (WHO) highlights the importance of adequate treatment to reduce health risks and safeguard public health when reusing wastewater (WHO, 2006). Treatment processes typically include physical, chemical, and biological processes to remove suspended solids, organic matter, and pathogens, resulting in a treated effluent that meets regulatory standards.

The use of wastewater effluent in irrigation offers several benefits, particularly in water-scarce regions like India. The Food and Agriculture Organization (FAO) emphasizes that wastewater irrigation can provide a valuable alternative water source, improving water availability for agriculture and mitigating water stress (FAO, 2018). Additionally, treated effluent contains essential nutrients, such as nitrogen and phosphorus, which can enhance soil fertility and crop yields (WHO, 2006). Given the high demand for water in agriculture and the potential benefits of wastewater reuse, its use in irrigation has become a common practice in India.

While the reuse of wastewater effluent in agriculture offers potential advantages, it also poses significant risks, particularly to farming family members who come into direct contact with the effluent during irrigation activities. The United Nations Environment Programme (UNEP) highlights concerns related to the presence of pathogens, chemicals, heavy metals, and other contaminants in wastewater effluent (UNEP, 2019). Exposure to these substances can lead to various health issues, including waterborne diseases, skin infections, respiratory problems, and long-term health impacts.

Existing literature on the occupational risks of farming family members using wastewater treated effluent for irrigation in India is limited. However, a study conducted by Babalola (2022) could identify several risks related with the use of wastewater effluent for irrigation in Kanpur, India. Participatory risk assessments can be applied to understand the behaviour and attitudes of farming family members towards occupational risks associated with wastewater reuse. These assessments can explore factors influencing risk perception, knowledge, and adoption of protective measures, providing insights into the decision-making process and the implementation of appropriate interventions.

The lack of information about the occupational risks faced by farming family members (women, men, and children) using wastewater-treated effluent for irrigation in agriculture in India necessitates further research (Babalola 2022; Breitenmoser et al 2022; Kesari et al 2021). The existing literature highlights the importance of wastewater treatment, the rationale for its use in irrigation, and the risks associated with the practice (Ganoulis 2012; Shomar et al 2014; Thebo 2016; Jaramillo and Restepo 2017; Morris et al 2017; Da Silva et al 2020; and Lahlou et al 2021).

1.2 Research problem

As the scarcity of water is a reality in India, the reuse of wastewater treatment effluent is more than a promising alternative but an increasing necessity for farmers in need of water for irrigation (FAO 2023; WHO 2006). The problems related to this fact are the necessity of a strict control on the quality of the effluent distributed to the farmlands, which if not following the standards of quality can be extremely hazardous for the health of the farm families and also for the environment, due to its biological and chemical components (WHO 2006, 2016 and 2022).

There is no much gender information on the occupational risks of farmers using treated effluent for irrigation, some studies just treat the persons working in contact with the effluent as "farmers" (Kesari et al 2021; Massoud 2022). Segregated information on gender and age of the family members and the spread of risk across farming families working in the Indian fields are not usually found. Also, no information about the seasonality of the risk in their labour, as different seasons can change the environment of the farm, potentially creating the necessity of changing their activities or creating new ones, which by itself can generate new potential occupational risks. In general, there is a lack of information on agricultural practices influenced by seasonality which can be potentially hazardous, and also of segregated information related to practices carried out by different genders and children ages.

1.3 Research aims and objectives

Aims

To explore seasonal variation in occupational health risk for farming families reusing the sewage treatment plant treated effluent in Kanpur, India.

Objectives

1. To describe practices related to the reuse of treated wastewater effluent in agriculture carried out by different family members in different seasons.

2. To assess seasonal variation in effluent quality from the sewage and common effluent treatment plants.

3. To assess the seasonal occupational health risk for different farming family members using a semi-quantitative risk assessment.

Chapter 2 Literature review

The relevant literature for this study will be explored in this chapter. The researcher gathered, analysed, summarised, and linked data from peer-reviewed and grey literature, such as conference proceedings and journals. The review began with a broad overview of the significance of wastewater treatment and its impact on health and the environment. Then, it is linked to the reuse of wastewater. Finally, it explores wastewater reuse in farming in India, including the risk related to it and the existent controls for effluent reuse in India.

2.1 Wastewater treatment and reuse

2.1.1 Overview of wastewater and its constituents.

In the UN Sustainable Development Goal 6: Clean Water and Sanitation, the definition of wastewater is "water that has been used in households, commercial establishments, industries, or agriculture and has become contaminated through contact with human, animal, or industrial waste." (UN 2022). The UN Environmental Program addresses that wastewater is "any water that has been adversely affected in quality by anthropogenic influence and comprises liquid waste discharged by domestic residences, commercial properties, industry, or agriculture and can encompass a wide range of potential contaminants and concentrations" (UNEP 2023). The UN Development Program explains that wastewater "incorporates various types of water contaminated with pollutants, including domestic wastewater, industrial effluents, and agricultural runoff" (UNDP 2020). Conversely, "sewage" typically refers to wastewater discharged into a sewer pipe network but can also encompass water contaminated with faces and urine from domestic usage and industrial and municipal liquid waste (UNEP 2023). Therefore, as the terminology indicates that both terms are intrinsically the same, the present study will use the term wastewater while referring to the influent and the effluent from the Sewer Treatment Plant (STP).

Englande et al. (2015) point out that the wastes originating from industry "may be toxic or inhibitory to biological processes, and thus their discharge to a municipal treatment plant must be regulated" (Englande et al. 2015). The same authors address that whereas the characteristics of municipal wastewater are relatively constant, industrial waste characteristics and parameters of concern can change significantly and should be treated accordingly if present in the municipal wastewater collection network.

Untreated wastewater represents a significant global threat to environmental water quality due to its contribution of excess nutrients to rivers, lakes, and aquifers, which can harm ecosystem functioning (UN 2022). Untreated wastewater can consist of water along with various components, including (UNEP 2023):

- Nutrients such as nitrogen and phosphorus.
- Solids, which encompass organic matter.
- Pathogens, which include bacteria, viruses, and protozoa.

- Helminths, which refer to intestinal worms and worm-like parasites.
- Oils and greases.
- Runoff from surfaces like streets, parking lots, and roofs.
- Heavy metals like mercury, cadmium, lead, chromium, and copper.
- Many toxic chemicals include PCBs, PAHs, dioxins, furans, pesticides, phenols, and chlorinated organics.

The wastewater is gathered from various origins via the "sewer" system and subsequently conveyed to the treatment facility. Depending on its source, wastewater can be categorised into distinct groups based on the unique attributes of its components, which in turn determine the appropriate treatment technologies to be employed (Ali et al. 2021). According to the same author, based on its generation source, sewage can have six primary sources (Figure 1):

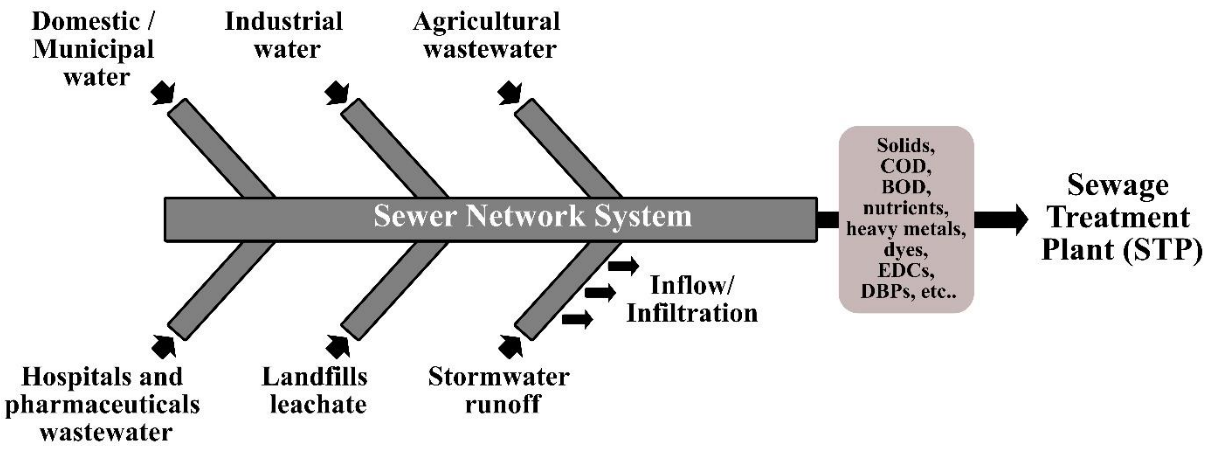

Figure 1 Major sources and generation points of wastewater. Reproduced from Ali et al (2021).

- Domestic/Municipal Sewage: Produced in residential, commercial, institutional/governmental, and recreational areas. It contains human and animal faeces and urine and potential inclusions such as paper, household cleaning chemicals, medications, waste, blood, etc. Domestic sewage poses the most significant health risk due to its high concentration of bacteria, viruses, and other microorganisms that can be pathogenic (Ali et al., 2021).

- Industrial Wastewater: Discharge materials used in various industries and processes into the municipal sewage system. It contains chemicals, paints, acids, alkalis, sand, detergents, and highly toxic materials (Ali et al. 2021).

- Agricultural Wastewater: Generated in agricultural areas due to irrigation combined with fertilizers and pesticides, which are generally toxic chemicals hazardous to human health (Ali et al. 2021).

- Hospitals and Pharmaceutical Facilities Wastewater: Generated in hospitals and pharmaceutical industries, these wastewater sources contain refractory micropollutants and toxic chemicals, which can pose challenges for subsequent sewage treatment if present in the municipal sewage network (Ali et al. 2021).

- Landfill leachate: In general, is defined as any contaminated liquid effluent percolating through a waste deposit and released from a landfill or dump site due to external factors/sources and with unknown constituents and toxicity (Foo and Hameed, 2009).

- <u>Urban Drainage Waters</u>: Many sewage systems are designed to receive both sewage and urban drainage waters. The latter contains significant amounts of sand, various types of gravel, solid materials, and large volumes of water (Ali et al., 2021).
- <u>Groundwater Infiltration</u>: Caused by pipe damage leading to sewage leakage into the groundwater table (Ali et al. 2021).

2.1.2 Significance of treating wastewater.

Until the late 19th century, human waste disposal primarily involved outdoor latrines, with a significant portion of the population practising open defecation (Henze and Harremoes, 1983). The introduction of sewage treatment systems in urban areas followed scientific discoveries by researchers like Louis Pasteur, who demonstrated that sewage-borne bacteria were the cause of numerous infectious diseases (Topare et al., 2011). In the early 1900s, initial wastewater treatment experiments involved spreading the wastewater over extensive farmlands, where microorganisms facilitated its decomposition. However, this approach adversely affected the land's health (Topare et al., 2011). Subsequently, a similar "treatment" method was tested by directly releasing wastewater into rivers and lakes, leading to a notable decline in water quality in those areas (Topare et al., 2011). The primary concept was to depend on the self-purifying abilities of terrestrial and aquatic systems. Still, it became evident that nature couldn't indefinitely absorb the volume and composition of the discharged waste (McGhee, 1991).

What is the rationale behind wastewater treatment before disposal? Wastewater treatment aims to break down the intricate organic compounds found in wastewater into more straightforward and stable forms, achieving a state where they are no longer problematic. This can be achieved through physical or chemical processes, as well as biological treatment utilizing microorganisms (Von Sperling, 2007).

The adverse environmental impact of allowing untreated wastewater to be discharged into groundwater or surface water and/or soil is as follows according to Cheremisinff (2002 and Spellman (2000), both cited by Topare (2011):

- The decomposition of organic matter in wastewater can release significant quantities of foul-smelling gases.
- When untreated wastewater, which carries a substantial organic load, is released into a river or stream, it consumes the dissolved oxygen needed to satisfy the water body's Biochemical Oxygen Demand (BOD). This depletion of dissolved oxygen can lead to adverse effects, including mortality in aquatic life.
- Additionally, wastewater may contain nutrients that promote the growth of aquatic plants and algae, potentially causing eutrophication in lakes and streams.
- Untreated wastewater often harbours pathogenic microorganisms and toxic substances from industrial sources or the human intestinal tract. These contaminants can pollute the land or water bodies where wastewater is disposed.

For these reasons, wastewater treatment and proper disposal are advisable and essential. Effective human waste management brings significant societal benefits in terms of public health and environmental well-being. It's estimated that for every US$1 invested in sanitation, there is a substantial return of approximately (UN Water, 2017).

2.1.3 Wastewater treatment.

According to Von Sperling (2007), wastewater treatment is a process that replicates the self-purification phenomenon that occurs in water bodies, where the organic matter is converted into inert mineralized products (effluent and sludge) by natural mechanisms; the difference is the technology in the treatment plants that makes the purification process under controlled conditions and higher rates. The author also explains that "effluent" refers to the treated wastewater that meets regulatory standards and can be safely discharged into water bodies or reused for various purposes.

Wastewater treatment can be approached through either centralized or decentralized methods. In centralized systems, wastewater is gathered from numerous users, typically in urban areas, and subjected to treatment at one or more centralized treatment facilities (Von Sperling, 2007). It's worth noting that, particularly in communities with low population density, the expenses associated with collecting wastewater make up over 60% of the overall budget for centralized wastewater management (UN Water, 2017). When properly managed, wastewater treatment plants significantly reduce the load of pollution discharged to the environment. However, depending on which types of treatment steps are present and how they are managed, wastewater treatment plants themselves can be a major point source of pollution affecting ambient water quality, because the treated effluents are still highly enriched in nutrients and hazardous substances like micro-pollutants which are not sufficiently removed by conventional treatment processes (UN 2023).

WHO (2006) describes the fundamental steps of wastewater treatment as consisting of physical, chemical, and biological processes. These processes include preliminary treatment, primary treatment (sedimentation), secondary treatment (biological processes), and tertiary treatment (Table 1), where advanced processes such as disinfection can occur. The degree of removal of pollutants in sewage treatment in order to achieve the desired quality is associated with these treatment levels (UFMG 1995). As explained by UFMG (1995), the preliminary treatment only aims to remove coarse solids, while the primary treatment aims to remove sedimentable solids and part of the organic matter. In both, physical mechanisms for removing pollutants predominate. The secondary treatment, in which biological mechanisms predominate, mainly removes organic matter and, eventually, nutrients (nitrogen and phosphorus). The tertiary treatment aims to remove specific pollutants (usually toxic or non-biodegradable compounds) or the complementary removal of contaminants not sufficiently removed in the secondary treatment (UFMG 1995).

Table 1 Application of different levels of treatment. Source: Adapted from UFMG (1995).

Level	Pollutants involved	Removal efficiency	Predominant treatment	Application
Preliminary	Coarse solids	-	Physical	Initial treatment step
Primary	Settleable solids and organic matter	Solids in susp.: 60-70% Organic matter: 30-40% Pathogens: 30-40%	Physical	Partial treatment, the intermediate step of more complete treatment
Secondary	Non-settling solids, non-settling organic matter and eventually nutrients	Organic matter: 60-99% Pathogenic: 60-99% (higher depending on specific removal steps)	Biological	More complete treatment (for organic matter)
Tertiary	Microorganisms	99%	Biological and Chemical	Microbiological inactivation, toxic non-biodegradable compounds

A Sanitation System comprises context-specific technologies and services tailored to waste management, encompassing collection, containment, transportation, transformation, utilisation, or disposal. Additionally, it entails the necessary control, operation, and maintenance for ensuring a safe and sustainable system operation. Contemporary water reclamation technologies and strategies incorporate multiple measures to mitigate health and environmental risks in various reuse applications. This includes source control, advanced treatment schemes, and engineering controls, enabling specific water quality production for diverse purposes (Tilley et al. 2014). Numerous wastewater treatment technologies are available, as can be seen, for instance, in the "Compendium of Sanitation Systems and Technologies" (Tilley et al 2014). They cover infrastructure, methods, and services for containing, transforming, or transporting products within the sanitation chain. These technologies can be tailored to various sanitation chain segments, such as user interface, collection, storage, transportation, centralised or semi-centralized treatment, and reuse or disposal.

2.2 Motivation for wastewater treatment and reuse

2.2.1 Addressing water scarcity and resource limitations.

In regions facing erratic weather patterns and water scarcity, wastewater serves as a consistent water source for farmers (Ensino et al., 2004; Santos et al., 2002). Wastewater contributes water and nutrients to urban and peri-urban agricultural production (Akponikpè et al., 2011; Saldías et al., 2016). Although historical case studies indicate the widespread use of untreated wastewater for irrigation, the full scope of this practice, including its associated risks, costs, and benefits, remains poorly understood (Raschid-Sally & Jayakody 2008; Ensink et al. 2004). Addressing these essential questions regarding untreated wastewater irrigation is crucial for policymakers and sanitation professionals to ensure the appropriate infrastructure, organizational processes, and technical/administrative capabilities are in place, considering downstream water quality and the livelihoods of dependent farmers (Thebo 2016).

Predictions suggest that extractable phosphorus (P) resources will become scarce or exhausted within the next 50 to 100 years (Steen, 1998; Van Vuuren et al., 2010). Consequently, P recovery from wastewater is emerging as a viable alternative. Recycling human urine and faeces globally could potentially meet 22% of the global P demand (Mihelcic et al., 2011). Advanced technologies are needed for N and P recovery from sewage or sewage sludge, and while large-scale applications are still in development, there has been significant progress in recent years (Lahlou 2021).

Recycling nutrients and harnessing energy from wastewater can create new income opportunities and expand resources available to low-income households (Winblad and Simpson-Hébert, 2004). For instance, composting toilets, offering a cost-effective solution, can enhance agricultural productivity, improve nutrition, and mitigate the health and environmental consequences of open defecation (Kvarnström et al., 2014).

2.2.2 Reducing environmental pollution.

Once freshwater serves a beneficial or economic purpose, it is typically discharged as wastewater into natural watercourses, whether treated or untreated (Wilas et al. 2016). In some developing countries, over 95% of all generated wastewater is released without treatment into the environment (UN Water 2017).

Downstream of untreated wastewater discharge, effluent can be extracted and reused, constituting the process of indirect reuse (USEPA 2012). When treated, wastewater can be directly reused for agriculture, landscaping, aquaculture, industry, groundwater recharge, urban use, environmental restoration, or drinking water supply, and it's called reclaimed water. (Da Silva et al 2020).

2.2.3 Sustainable urban and agricultural development.

According to Da Silva et al (2020), in developing countries, wastewater reuse primarily focuses on irrigation, often using untreated wastewater due to challenges like limited legislation, regulatory mechanisms, data, technical issues, and infrastructure investment. Low-cost solutions like SODIS reactors, constructed wetlands, and biofilters combined with SODIS reactors can help meet WHO irrigation quality standards, enabling safe reclaimed water use (Da Silva et al., 2020).

Another way to alleviate the water and energy sector is to reuse wastewater in animal feed cultivation, offering a way to boost food production and enjoy relatively higher public acceptance compared to other uses (Lahlou 2021). More people are willing to use reclaimed water for non-food crops than for food crops or other applications like dishwashing (Lahlou, 2021).

2.3 Health impacts and risks

2.3.1 Potential health hazards associated with wastewater reuse.

According to WHO guidelines (2006), raw or partially treated wastewater contains substantial levels of pathogens linked to human faeces, including viruses, bacteria, protozoa, and helminth eggs. These faecal contaminants lead to diseases such as diarrhoea, dysentery, hepatitis, cholera, and helminth infections (WHO, 2006). Additionally, wastewater may contain various heavy metals and persistent compounds, particularly in tannery and sewage effluents (Qadir et al., 2010). Depending on the specific toxicant, these substances can trigger respiratory, carcinogenic, neurological, immunological, or renal diseases (Qadir et al., 2010).

The use of wastewater in agriculture can be limited due to health risks associated with exposure pathways and wastewater effluents' biological and chemical quality (Jaramillo, 2017). The author emphasises that faecal pathogens pose the most significant health threat to reusing wastewater.

Agricultural laborers face increased risks due to continuous and direct contact with contaminated water and soil and consuming the crops they cultivate (Fuhrimann et al., 2017; Dickin et al., 2016). Consumers of these products can also be exposed to health hazards when consuming fresh produce grown with wastewater containing toxic substances, particularly metals that crops can absorb (Bos et al., 2010; Dickin et al., 2016).

2.3.2 Public health considerations.

Wastewater encompasses diverse biological and chemical elements that may pose public health risks (Bos et al., 2010). According to the World Health Organization (WHO, 2016), substances with the potential to harm human health are classified as risky, including biological components like E. coli, pathogens, viruses, helminths, coliforms, and protozoa; chemical elements such as heavy metals like Cr and Cd; as well as physical elements like malodorous gases, sharp objects, and skin irritants. Also, according to WHO (2016), a hazardous event is any circumstance that creates or worsens a hazard, posing environmental threats and escalating health concerns in affected areas.

Another important consideration related to public health is the fact that for wastewater reuse, treating municipal wastewater through treatment plants is commonly deemed satisfactory for addressing environmental and public health issues. Nonetheless, even with tertiary wastewater treatment, there remains a potential for enteric viruses, toxic chemical contamination, and environmental harm (Ganoulis 2012). The choice between reclaimed wastewater and traditional water sources for agricultural irrigation, for instance, hinges on mitigating public health risks to an acceptable level alongside assessing environmental hazards, and both aspects must be weighed against economic benefits when determining a good and viable solution (Ganoulis 2012).

Technological treatment schemes, as outlined in Section 1.1.1, can help reduce risks. However, achieving absolute public health security may not always be practical or economically feasible, particularly in low-income regions with challenges in maintaining organisational and maintenance standards (Jaramillo, 2017).

2.3.3 Risk assessment.

Health risks, defined by WHO (2015), result from hazards affecting human health; their severity depends on hazard concentration and wastewater exposure (Stenström et al., 2011). While studies often emphasise wastewater contaminants as primary health risks, they may overlook potential exposure risks for farmers with direct wastewater contact in irrigated fields or through consuming contaminated agricultural products (Bos et al., 2010). However, the most significant health risks involve biological and chemical factors in wastewater and related exposure pathways (Bos et al., 2010).

Risk analysis in wastewater reuse involves an integrated framework encompassing risk assessment (considering the physical system, loads, and risk quantification) and risk management (evaluating alternative risks, costs, as well as social and health aspects). The ultimate objective typically involves creating a Decision Support System (DSS) that identifies a compromise solution that optimizes all objective functions. Maximum pollutant concentration data are crucial for designing wastewater reuse systems and managing associated risks, requiring consideration when exploring different recovery and reuse alternatives.

Risk assessment is essential to identify and address health risks in sanitation safety planning, focusing on critical changes for water supply safety (WHO, 2016). Various approaches are available (Babalola, 2022):

Sanitary Inspection: involves on-site visual assessments and standardised checklists to identify potential hazards (WHO, 2016). Questions elicit "yes" or "no" responses, signifying risk factors. WHO (2016) addresses that the number of "yes" responses quantitatively assesses system safety (e.g., low, medium, high, and very high risk) and that this method is valuable for risk ranking (WHO, 2016).

Quantitative Microbial Risk Assessment (QMRA): systematically quantifies risks using pathogen data, exposure pathways, dose-response analysis, and risk characterisation (Petterson and Ashbolt, 2003). QMRA is applied in WHO water-related guidelines (WHO, 2016).

Risk Matrix: The risk matrix combines qualitative hazard occurrence and severity estimates into a risk score (WHO, 2016). According to WHO (2016), expert judgment determines risk levels, and it's used for assessing various hazards.

2.4 Standards and regulations

2.4.1 International guidelines and standards for treated effluent.

The World Health Organization (WHO) provides guidelines for wastewater reuse, which are grounded in policies and institutional frameworks. These standards, as outlined in WHO's 2006 recommendations, are adaptable to different forms of reuse, including groundwater recharge, gardening, agriculture, electricity generation, fishing, and more (WHO 2015). Specific guidelines are necessary to ensure comprehensive protection in each of these reuse scenarios.

WHO (2006) addresses that E. coli is commonly recommended as a reliable indicator for faecal contaminants when assessing wastewater's microbiological quality, as it comprises about 90% of faecal coliforms (FC). WHO recommends an E. coli concentration of 103 CFU (colony forming units) per 100 ml for safe irrigation use, with a target reduction of 4 Log (WHO, 2006). The European Commission provides guidelines (Commission, 2022) for water reuse (including risk assessments) exclusively in agricultural irrigation within its member states, aiming to promote greater water reuse across Europe. These guidelines categorise reused water into various quality levels determined by factors like crop type, irrigation method, and water treatment approach, typically involving secondary treatment combined with filtration and disinfection. Key quality parameters encompass E. coli (Table 2), BOD, TSS, turbidity, and pathogens (Schellenberg et al., 2020). A comparison between them can be seen in Table 2.

Schellenberg et al. (2020) also observed significant disparities in pathogen management strategies among countries and even among different users within the same country. For instance, E. coli restrictions in France range from ≤250 to <100,000 CFU per 100 ml, depending on whether the crops are intended for raw consumption or harvested from drip-irrigated trees.

Table 2 Comparison between WHO wastewater reuse and European Union standards for irrigation. A: for crops eaten uncooked, direct contact; B and C: for crops eaten raw with the edible part above ground, no direct contact with wastewater; D: industrial, energy, a

Guidelines from:	Parameter	E. coli (CFU/100mL)
WHO	Restricted	$<10^4$
	Unrestricted	$<10^3$
EU Commission	A - All irrigation methods	<10 or ND
	B - All irrigation methods	$<10^2$
	C - Drip irrigation	$<10^3$
	D - All irrigation methods	$<10^4$

2.4.2 India's regulatory framework for wastewater reuse.

Schellenberg et al. (2020) note that the Environmental Protection Act of 1986 introduced initial discharge standards for sewage treatment plants (STPs). These standards imposed distinct limitations based on different reuse purposes, including inland surface waters, land irrigation, and marine coastal areas (Schellenberg at al 2020).

After the publication of very stringent draft STP norms in 2015, the standards for discharge were revised a second time in 2017 and published as Environment (Protection) Amendment Rules 2017 (CPCB 2023). According to the Pavitra Ganga project (2020), the 2017 standards represent the currently applicable norm. However, the new standards do not distinguish between different disposal routes, being applicable to all modes of disposal. Nevertheless, the new standards distinguish between locations and have more stringent quality requirements for larger cities. In a case at the National Green Tribunal, the norms were again tightened in 2019 but are not yet put into force (Pavitra Ganga Project 2020). Table 3 presents the prescribed discharge criteria for irrigation reuse in India.

Table 3 India's recommended treated sewage discharge standards for irrigation. These standards encompass various coliforms, including E. coli, Faecal Coliforms (FC), and Total Coliforms (TC). (Schellenberg et al., 2020, CPCB, 2021)

Parameter	**Crop**		
	Non-edible	**Raw-eaten**	**Cooked before eaten**
Turbidity (NTU)	AA	<2	AA
SS (mg/L)	30	nil	30
TDS (mg/L)		2100	
Temperature (ºC)		Ambient	
pH		6.5 – 8.3	
BOD (mg/L)	20	10	20
COD (mg/L)	30	AA	30
Total chromium – Cr (mg/L)		2	
Total Kjeldahl Nitrogen (mg/L)	10	10	10
Nitrate (mg/L)	10	10	10
Diss. PO_4 as P (mg/L)	5	2	5
Faecal Coliform (MPN/100ml)	230	nil	230
Helminth eggs/L	<1	<1	<1
Colour	AA	Colourless	Colourless
Odour		Aseptic (not septic and no foul odour)	

According to the Pavitra Ganga project 2020 Deliverable D3.1 report, at the Jajmau Sewage Treatment Plant (STP) in Kanpur, a 130 MLD (Million Litres per Day) STP employs the conventional activated sludge process to treat wastewater contaminated with industrial effluents. This site faces several significant challenges, which are common issues encountered by urban local bodies. These challenges include a substantial increase in wastewater production, inadequate sewage treatment operations, poor maintenance of existing treatment facilities, insufficient electricity supply for energy-intensive aeration processes, limited options for sludge disposal, treatment systems ill-suited for handling industrial wastewater discharge, and the pollution of rivers due to the release of organics, nutrients, heavy metals, and micropollutants. Additionally, the plant's influent has elevated pollutant concentrations because of the contamination of municipal wastewater with industrial effluents from tanneries, resulting in higher levels of Chemical Oxygen Demand (COD), Chromium (Cr), and salt concentration (Pavitra Ganga Project 2020).

The available water quality data for the Jajmau STP is outlined in Table 4. Generally, the STP Jajmau influent exhibits elevated contaminant concentrations, primarily due to the combination of municipal wastewater with industrial effluents from tanneries. This mixing leads to increased levels of COD, Cr, and salt content (Pavitra Ganga Project 2020). The treatment of Jajmau mixed wastewater using the conventional treatment methods as primary sedimentation, aeration, clarifiers, sludge digestion, and mechanical sludge dewatering, are the inadequate settling of sludge, resulting in higher Total Suspended Solids (TSS) and COD levels in the treated effluent; the nitrification occurs, but denitrification is absent, leading to increased nitrate concentrations in the effluent; the presence of tannery wastewater, which contains leather by-products, hair, chromium, and sulphites; and high salt content, contributing to elevated Total Dissolved Solids (TDS). The removal of salt during treatment is ineffective. Other components that cannot be effectively removed include lime and sodium bisulphite ($NaHSO_4$) (Pavitra Ganga Project 2020).

The study has considered both Indian standards for discharge and European Union (EU) requirements (Table 4), as discussed in the previous section (2.4.1). A comparison between influent and effluent water quality parameters from Jajmau STP and the Indian and EU discharge and irrigation water standards is presented in Table 4.

Table 4 Comparison between influent and effluent water quality parameters from Jajmau STP and the Indian and EU discharge and irrigation water standards. Source: CPCB (2021).

Parameters	**Jajmau STP, Kanpur**		**Indian standards**					**European Union**	
	Influent	**Effluent**	(1) 1986 General discharge in inland surface water.	(1) 1986 General discharge on land for irrigation.	2015 Draft Indian STP discharge.	(2) 2017 Environment (Protection) Amendment Rules STPs.	2019 National Green Tribunal Order.	(3) 1991 Urban Wastewater Treatment Directive (UWWDT 91/271/EEC.	(4) 2019 Regulation on minimum requirements for water reuse: class A water.
pH	-	-	5.5 – 9.0	5.5 – 9.0	6.5 – 9.0	6.5 – 9.0	5.5 – 9.0	-	-
Total Dissolved Solids (ppm)	1716 ± 546	1156 ± 234	2100	2100	-	-	-	-	-
Turbidity (NTU)	-	-	-	-	-	-	-	-	5
BOD (mg/L)	360 ± 89	63 ± 27	30	100	10	30 / 20 (metro cities)	10	25	10
COD (mg/L)	1366 ± 428	143 ± 87	250	-	50	-	50	125	-
P total (mg/L)	-	-	-	-	-	-	-	2 * / 1 **	-
o-Phosphate (mgP/L)	-	-	5	-	-	-	1	-	-
N total (mg/L)	-	-	-	-	10	-	10	15 * / 10 **	-
NO_3-N (mg/L)	-	-	10	-	-	-	-	-	-
NH_4-N (mgN/L)	-	-	50	-	5	-	-	-	-
TSS (mg/L)	1223 ± 454	72 ± 46	100	200	-	100 / 50 (metro cities)	20	35 / 60	10
VSS (mg/L)	604 ± 236	40 ± 24	-	-	-	-	-	-	-
Sulphide (mg/L)	42,0 ± 8,7	-	2	-	-	-	-	-	-
Cr total (mg/L)	10,2 ± 6,1	0,4 ± 0,6	2	-	-	-	-	-	-
Total Coliforms (cfu/100mL)	1,4 E+09	2,7 E+06	-	-	-	-	-	-	-

Faecal Coliforms (cfu/100mL)	1,2 E+08	7,7 E+05	-	-	<100	<1000	<230	-	-

1 Sources: CPCB website, the 1986 standards cover a total number of parameters incl. heavy metals and other pollutants
2 http://www.indiaenvironmentportal.org.in/files/file/Sewage%20Treatment%20Plants_2.pdf
3 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31991L0271&from=EN
4 https://www.consilium.europa.eu/media/41908/st15254-en19.pdf Class A: crops w/ edible part in contact with reclaimed water

2.5 Global perspective on wastewater reuse

2.5.1 Worldwide trends and practices in wastewater reuse

Wastewater treatment plant discharges can impact various water uses: drinking water supply, urban and agricultural irrigation, and livestock watering (Morris et al 2017). The same authors also point out that reuse for recreational activities like swimming, boating, and fishing are also affected, often leading to health issues like infections or gastroenteritis. For the reuse in wildlife habitats, particularly fisheries and fish habitats, risks can encompass both public health concerns and broader ecosystem health threats. Studies show sewage effluents can harm fish physiology and habitat (e.g., Bahamonde et al., 2015; Jasinska et al., 2015).

But one of the activities in which wastewater is most reused is in agriculture. More than 10% of the global population consumes food produced through wastewater irrigation, which is notably higher in low-income countries with arid and semi-arid climates (WHO 2006). Treated and untreated wastewater is used for irrigation in various countries, posing health and environmental risks similar to direct wastewater use in agriculture (WHO, 2006). WHO points out that population growth is the main driver of increased water demand. Recognising the increasing wastewater production resulting from urbanisation highlights the necessity for improved integration between wastewater management and broader water resource management (WHO 2006).

As global agriculture relies heavily on wastewater, securing alternative irrigation sources is crucial for food security and environmental preservation (Jaramillo 2017). Safe wastewater use in agriculture is important worldwide, especially in water-scarce regions, as an efficient strategy to prevent water pollution (Garduno-Jimenez et al. 2023). However, this practice comes with risks that need local assessments, considering soil as a receiving medium and ensuring no pollution transfer occurs. The risks of wastewater use in agriculture are diverse, impacting soil properties and human health (WHO 2015). In economically challenging contexts, the demand for alternative irrigation, including inadequately treated wastewater, can create avoidable risks (Jaramillo 2017). Therefore, it's vital to communicate both the benefits and drawbacks of this practice, along with cost-effective strategies to aid decision-making and encourage responsible wastewater use (Declercq et al 2015). Table 5 shows how water and wastewater are used in different sectors in some countries.

Table 5 Freshwater and treated wastewater utilization status in different countries. Source: Kesari et al (2021).

Country/ Region	Water utilizing sectors		Status of water reuse (major sectors reusing water)	
Europe	Agriculture	44%	Landscape irrigation	20%
			Groundwater recharge	2.2%
			Recreational	6.8%

	Industry and energy production	40%	Non-potable urban uses	8.3%
			Indirect potable uses	2.3%
			Agriculture irrigation	32%
	Public water supply	16%	Industrial	19.3%
			Environmental enhancement	8%
			Other	1.5%
South Africa	Agriculture	60%	Agriculture	43%
	Domestic	27%		
	Industrial	3%	Industry	48%
	Power	4%		
	Mining	3%		
	Other	3%	Landscape and sports field irrigation	9%
USA	Freshwater thermoelectric plants	41%	Geothermal energy	2%
	Agricultural irrigation	37%	Agricultural irrigation	37%
	Industries	6%	Golf course irrigation	7%
	Domestic	14%	Landscape irrigation	17%
	Livestock and aquaculture	3%	Groundwater recharge	12%
			Seawater intrusion barrier	7%
			Recreational impoundment	4%
			Wetlands, wildlife habitat	4%
			Industrial and commercial	8%
			Other	2%
India	Agriculture	87%	Agricultural irrigation	78%
	Industrial	7%	Industrial use	12%
	Domestic	4%	Thermal power plant	4%
	Energy	2%	Groundwater recharge and artificial lakes	6%
Greece	Irrigation	83%	Agricultural irrigation	78%
	Animal husbandry	1.3%	Irrigation of forested land and firefighting	17.7%
	Industry	2.2%	Landscape irrigation	23.92 %
	Public use (potable)	13%		
	Other	1.2%		

2.6 Wastewater reuse in India

2.6.1 Historical context of wastewater management

According to Ali et al (2021), before 1940, municipal wastewater in India primarily originated from domestic sources, however, industrial development post-1940 significantly increased industrial discharges into municipal collection systems. The industrial activities generated higher quantities of heavy metals and synthetic organic compounds, with approximately 10,000 new organic compounds added annually. Many of these compounds are now found in municipal wastewater across most communities (Chang et al., 2011).

Indian state governments are responsible for sewage treatment, and about 33% of households in metropolitan areas are connected to sewage networks linked to state wastewater treatment plants (Breitenmoser et al., 2022). Most sewage treatment plants operate with two-stage treatment, including primary and secondary treatment, with capacities ranging from 0.2 to 800 MLD (CPCB, 2013; Breitenmoser et al., 2019, cited by Babalola, 2022). According to the Central Pollution Control Board (2013), functional sewage treatment plants treat only 37% of generated sewage, which amounts to 72,368 MLD. These facilities often operate inadequately, with 35-50% of their effluents failing to meet discharge regulations (Breitenmoser et al., 2019, cited by Babalola, 2022).

In 2013, the CPCB reported the use of 13 different technologies for sewage treatment in India, with the Up flow Anaerobic Sludge Blanket (UASB) process being the most prominent. However, contemporary innovations like the Activated Sludge Process (ASP), Moving Bed Biofilm Reactor (MBBR), and Sequencing Batch Reactor (SBR) are also employed in current STPs (CPCB, 2013). Due to resource availability, climatic conditions, stakeholder preferences for technological advancements, and government assistance programs, the technological designs and treated sewage volumes in Indian states vary, as shown in Figure 3 (Breitenmoser et al., 2019). The CPCB (2013) conducted performance assessments of various technologies, including Membrane Bioreactor (MBR), UASB-EA, ASP, MBBR, SBR, and Waste Stabilization Pond (WSP) (CPCB, 2013; Babalola, 2022). In the Figure 2 is showed the STP technologies in some states of India.

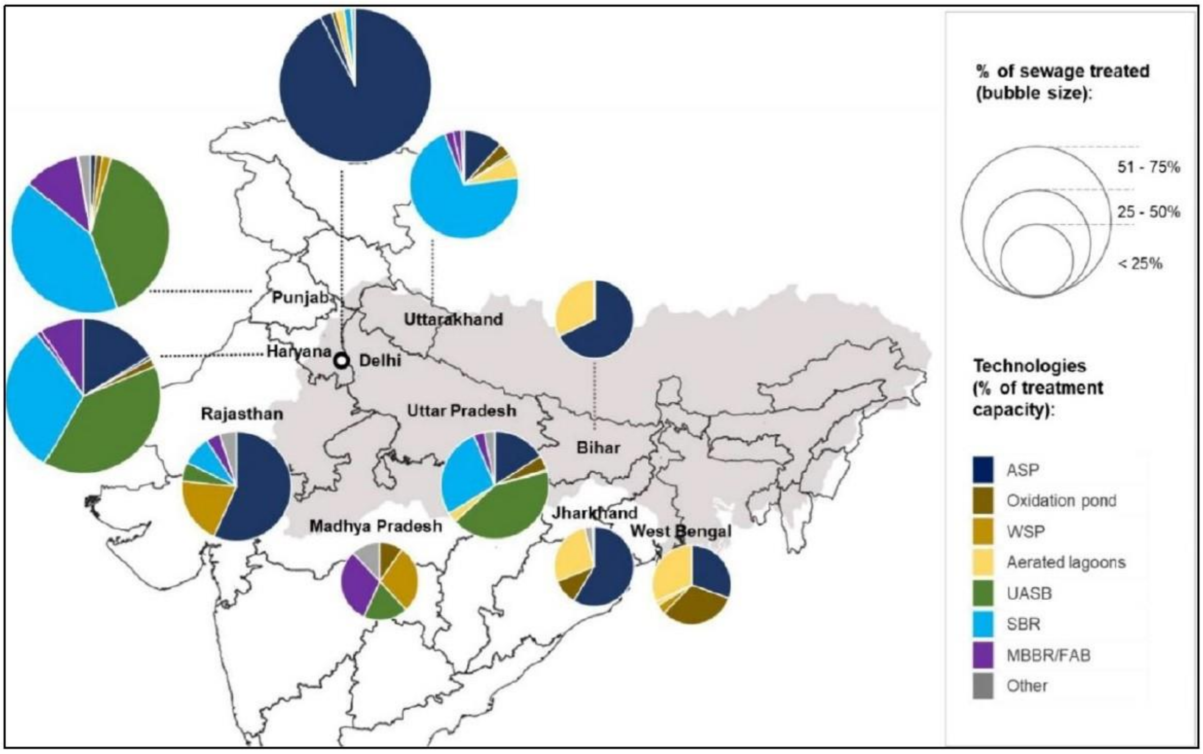

Figure 2 STP technologies and total treatment capacity installed in different states of India (Breitenmoser et al., 2019, cited by Babalola 2022).

Kaur et al. (2012) identified significant challenges facing the sewage treatment plants in India, primarily driven by a rapid increase in wastewater production. These challenges include technology overcapacity due to insufficient maintenance of existing treatment facilities, inconsistent electricity supply for energy-intensive aeration processes, inadequate sludge disposal options, treatment systems ill-suited for the illegal mixing of industrial wastewater, and inappropriate sludge disposal choices (Kaur et al., 2012; Schellenberg et al., 2020). Schellenberg et al. (2020) also highlight India's substantial challenges in safeguarding the environment and public health, driven by a growing population and inadequate sanitation infrastructure. Recent developments in Indian wastewater standards and global approaches have led to confusion and hindered sectoral progress. These issues stem from limited institutional capacity, inadequate risk assessment, and an exclusionary standards-setting process. The absence of uniform discharge and wastewater reuse standards can exacerbate pollution and public health concerns in underserved areas, failing to effectively address pollution risks and water insecurity in most Indian cities (Schellenberg, 2020).

2.7 Summary of key findings from the literature.

The literature review provides a comprehensive understanding of the state of wastewater effluent reuse, both globally and in the Indian context while highlighting the significance, challenges, and potential benefits of this sustainable practice.

Emerging trends and concerns in wastewater treatment encompass several specific areas which can result in problems with reusing the wastewater-treated effluent. These include the dynamic nature of wastewater, emerging environmental and health issues, challenges related to industrial waste, and the influence of evolving regulations. Key concerns also encompass:

- Treatment plant performance and reliability.
- Aging and poorly maintained infrastructure.
- Wastewater disinfection methods.
- Adoption of new process analysis and control techniques.
- Mitigation of impacts from stormwater, sanitary overflows, and diffuse pollution sources.
- Effective odour control strategies.
- Modernization of wastewater treatment facilities.
- Organizational management and quality procedures for treatment plants.
- Ensuring the safety of farmers in direct contact with wastewater effluents.
- Safety of farmers in direct contact with wastewater effluent.

Ultimately, alongside public awareness campaigns to educate users, it is also crucial to carry out wastewater reuse demonstration projects for various reuse options, including agriculture (Massoud 2022).

Chapter 3 Research methodology

3.1 Introduction

This study was conducted as a component of the Pavitra Ganga project, which received support from the Indian government and the European Union under the Horizon 2020 research and innovation program. The objective of the project is to advance Sustainable Development Goal 6 (SDG6) by "harnessing the environmental and economic benefits of wastewater treatment and reuse solutions in urban and peri-urban regions of India".

3.2 Case study area

3.2.1 Study region and city

The city of Kanpur, where this study took place is located in the state of Uttar Pradesh ("State of the North" literally), often abbreviated as UP, stands as the fourth-largest state in India (Figure 3) and is renowned for its exceptional population density (Kanpur City Development Plan 2006). Located in the northern central region of the country, this area holds a significant position in the Indo-Gangetic Basin (IGB) alluvial aquifer system, renowned as one of the world's most crucial and extensively tapped sources of freshwater (MacDonald et al 2015). This area has garnered recognition for its agricultural significance, with its fertile lands playing a pivotal role in sustaining centuries of food production, as highlighted by Taneja et al. (2014).

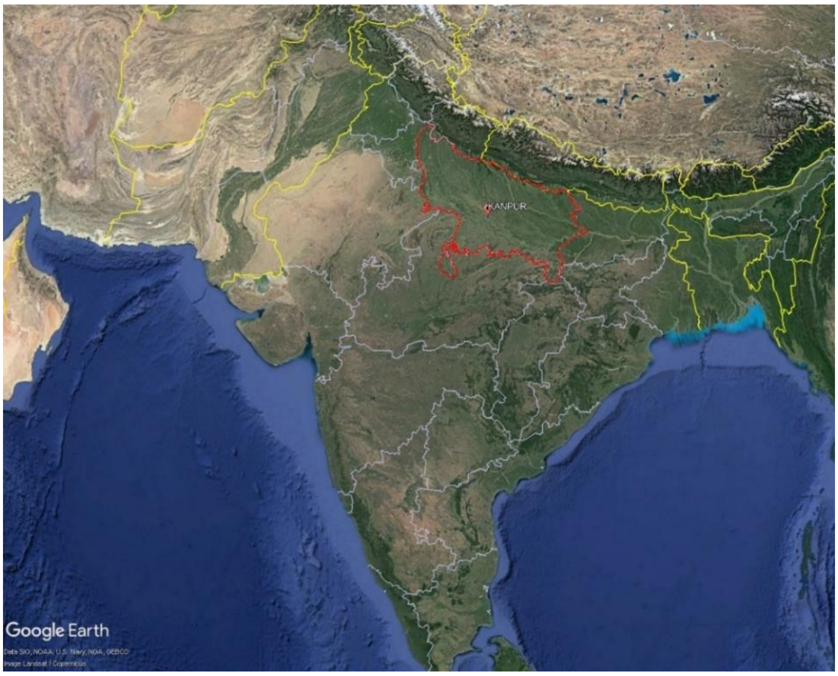

Figure 3 Satellite image showing India and the state of Uttar Pradesh in red. Source: Google Earth (2023).

The state's economy is substantially reliant on agriculture, with key crops including rice, wheat, and sugar cane (Indiacensus.net 2023). In the 1960s, the introduction of more productive rice and wheat varieties, coupled with increased fertilizer availability and enhanced irrigation practices, propelled Uttar Pradesh to become the leading grain producer in the country. Additionally, animal husbandry and milk production contribute significantly to the income of small-scale farmers in the region (Indiacensus.net 2023).

The city of Kanpur (Figure 4), is situated in the central-western part of the state, positioned at 26.44° North latitude and 80.33° East longitude on the right bank of the Ganges River (Indiacensus.net 2023). Kanpur is a significant urban center in India with an area of jurisdiction of 260 km^2 (SUSANA 2020a). The estimated population of Kanpur is 3.2 million urban and 4 million rural (indiacensus.net, 2023). Decadal growth rate of the city is 8.9%. Household size is 6 people per household. The average density of the city is 1,158,343 persons/km^2 (SUSANA 2020a).

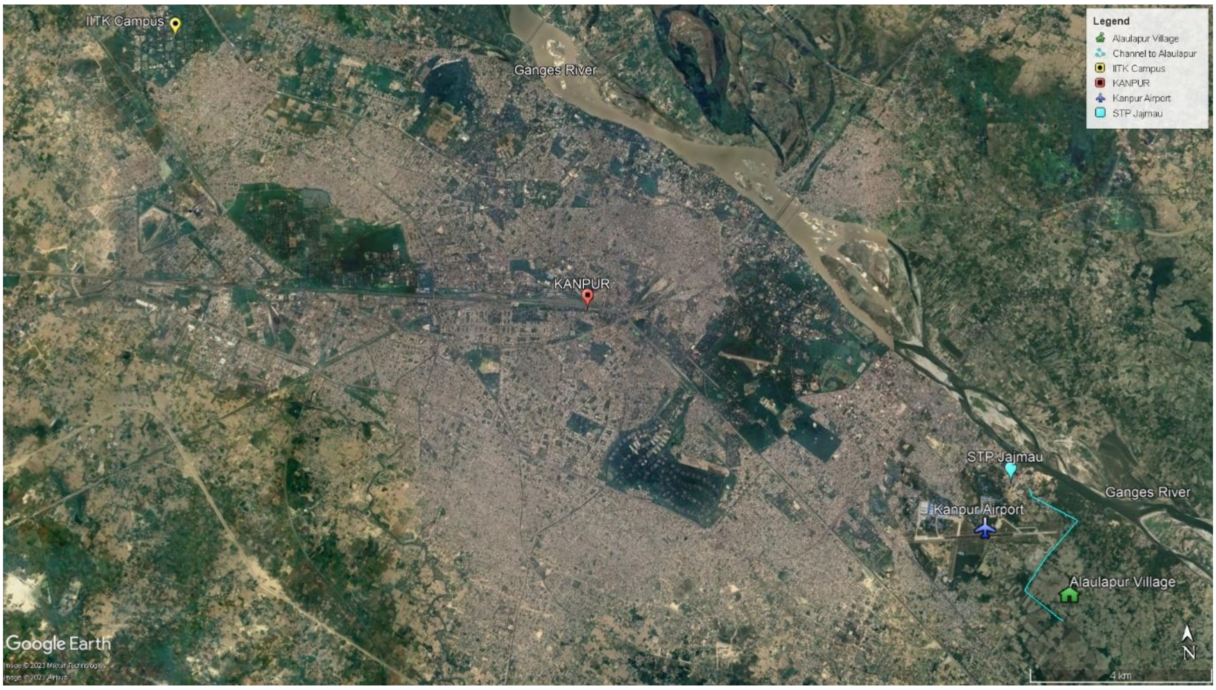

Figure 4 Satellite image of Kanpur city, peripherical rural areas, and the Ganges River. On the up-left the India Institute of Technology Kanpur (IITK), on the low-right, the airport, above it the Jajmau STP, and the village of Alaulapur. Source: Google Earth (2

Kanpur experiences a subtropical climate, characterized by three distinct seasons (Table 6): the monsoon (wet/rainy season) from mid-June to early October, the winter season (cold season) from mid-November to late-February or early-March, and the summer (hot season) from mid-March to mid-June (Babalola 2022).

Table 6 Three recognized seasons in the region of Kanpur. Source: Babalola (2022).

Season	Months	Temperature (ºC)	Average Humidity (%)
Summer (hot season)	Mid-March to Mid-June	41	<30
Monsoon (Wet season)	Mid-June to early-October	27-35	90 (700mm)
Winter (Cold season)	Mid-November to late-February	4-8	58

Kanpur's industrial zones play a key role in cotton and wool production, tanning and leather manufacturing, fertilizer production, and arms manufacturing (Kanpur City Development Plan 2006). Unfortunately, these industries contribute significantly to the pollution of the Ganges River, leading to Kanpur being identified as the most polluted stretch of the river (Tare et al., 2003, as cited by Vidyarthi et al., 2020). According to the same authors, urban-industrial drainage is a major source of pollution in the Ganges River, resulting from the discharge of inorganic and organic compounds, as well as heavy metals, by various industries in the city.

According to the Kanpur City Development Plan (2006), the primary water sources in the city are the Ganga and Pandu rivers. The city's water demand amounts to approximately 600 Million Liters per Day (MLD), with around 80% of it becoming wastewater. SUSANA (2020b) in Kanpur's Shit Flow Diagram (SFD) the majority of the population in Kanpur (52%) uses onsite sanitation systems. 1% of the residents are practicing open defecation. Only 39% of the excreta in Kanpur is safely managed, leaving 61% unsafely managed (Figure 5).

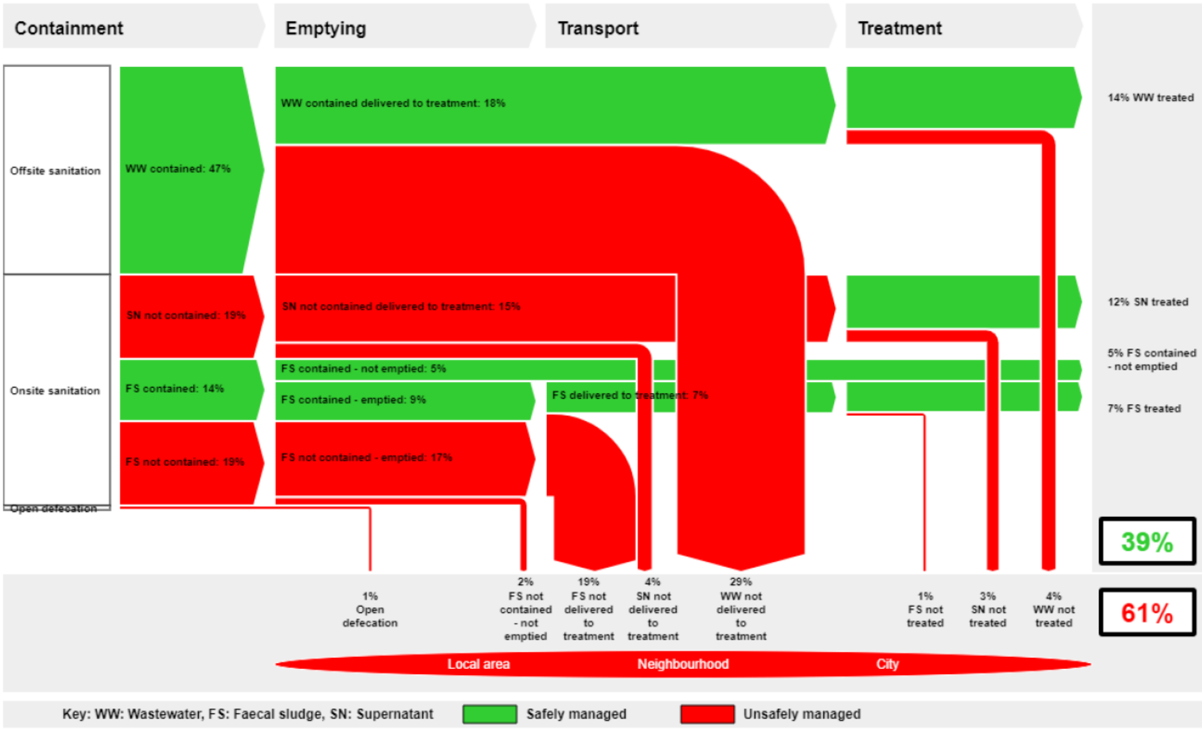

Figure 5 SFD graphic of Kanpur. Source: SUSANA (2020b).

3.2.2 Study focus location

Alaulapur (Figure 6) is a village in the Ghatampur Block, Kanpur Nagar district, situated at approximately 26°23'26.9772" N latitude and 80°26'2.4788" E longitude. It is about 30 kilometres southeast of IIT Kanpur, 7 kilometres from Kanpur's airport, and located on the right bank of the Ganges River, about 3.5 kilometres away from the river itself.

According to the Pavitra Ganga Project (N.D.), the village comprises 180 households. Most residents collect drinking water from local sources and store it in containers at home. Approximately 70% use public handpumps as their primary source of drinking water, while 18% rely on private handpumps. Notably, 48% of households consume untreated water.

Regarding sanitation infrastructure, 41% of households have toilets, and 91% have proper sludge disposal. However, 52% of residents practice open defecation outside their homes.

In Alaulapur, farmers use concrete channels to irrigate their fields (Figure 7 and 8), mainly for paddy and wheat cultivation (Breitenmoser et al 2022). About 61% of households in Alaulapur use treated wastewater for daily irrigation, while 39% resort to it when no alternative source is available. Flood irrigation is practiced by all resident farmers, and the rice and wheat they produce are both sold and consumed locally.

Farmers in this village frequently report health issues such as fever, diarrhoea, joint pain, and skin diseases, which they attribute to exposure to inadequately treated effluents used for irrigation (Babalola, 2022; Breitenmoser et al., 2022).

Figure 6 Satellite image of the village of Alaulapur. Source: Google Earth (2023).

Figure 7 Satellite image of the area around Alaulapur. The airport is on the left. The blue line shows the canal transporting wastewater treated effluent from the Sewage Treatment Plant (STP) of Jajmau, located in the upper part. Source: Google Earth (2023).

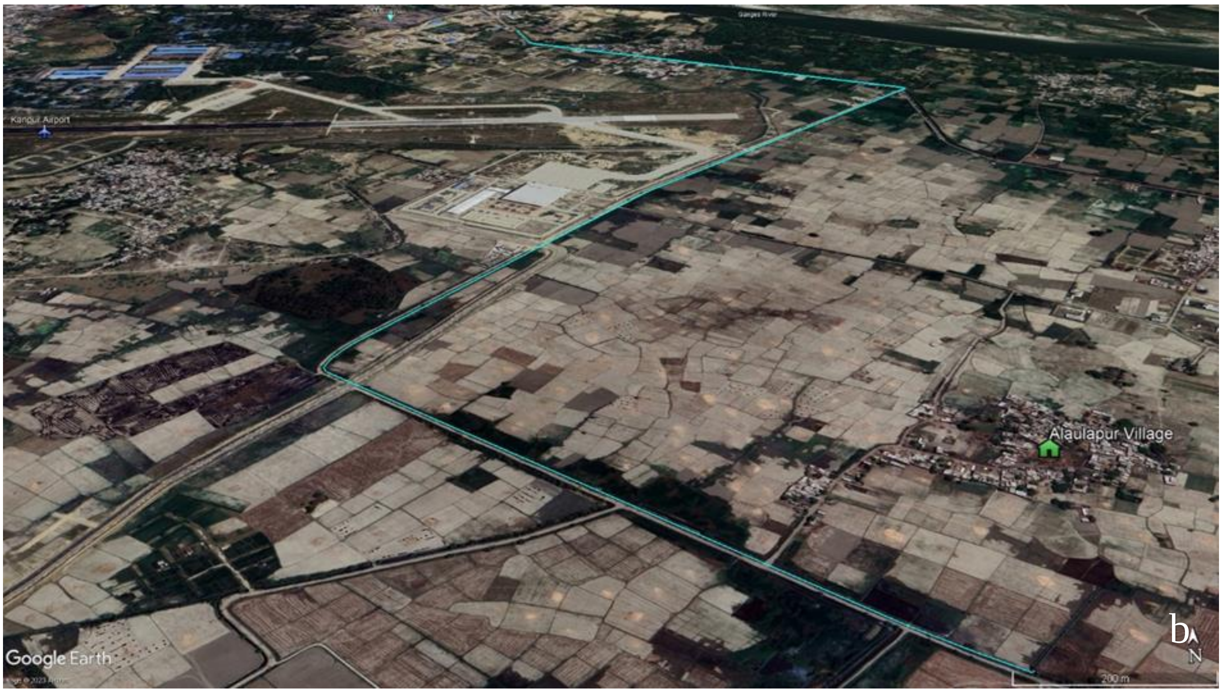

Figure 8 The effluent concrete canal (blue line) and some sub canals passing in front of the village. Source: Google Earth (2023).

3.2 Study design

This research employed a mixed-methods case study approach to investigate agricultural practices. Utilizing two participatory methods (daily schedules and seasonal calendar), a key informant interview, field observations, and secondary data, was deemed appropriate for exploring the activities of farmers (men, women, and children) closely intertwined with their environment. This interconnectedness made it challenging to isolate specific contextual factors (Leedy and Ormrod, 2005, as cited in Tembo, 2022).

The study focused on participants who are farmers engaged in cultivating crop fields irrigated with treated wastewater effluent. Selection criteria were based on collaboration with the NGO Solidaridad and the village leader, aiming to include families with at least one male, one female, one boy, and one girl actively involved in agricultural activities.

This research conducted a risk assessment by combining data obtained from two participatory methods, secondary data, and field observations. It received support from two main entities: the Indian Institute of Technology Kanpur (IITK) and the NGO Solidaridad. Solidaridad, with its well-established collaboration with Alaulapur farmers, provided a field assistant/translator to facilitate the research process. A pilot interview was conducted to train, evaluate, and refine participatory methods and interviews. The translator/field assistant received training in research methods. When necessary, his actions were corrected and improved.

3.3 Methods

3.3.1 Primary data collection - Daily schedule

A daily schedule (Chambers 1994a and 1994b; Narayanasamy 1994) is related to objective 1, and was developed through visits in 8 households, where it was done by a woman and by a man, for each family. Additionally, a schedule outlining a typical day for children (considering gender and age) was made with the support of the women. The objective was to identify the specific activities/practices related to irrigation carried out by family members throughout a 24-hour period on the farm, including exposure to effluent or contaminated materials during irrigation, harvesting, and processing, considering different seasons. Variations between weekday and weekend schedules were examined and documented. Following the completion of schedules for the current season (monsoon), a discussion was conducted to identify potential differences across seasons in daily practices, and when was the case, a separate daily schedule was developed for each season.

A 24-hour clock, or wheel diagram was created for analysis and comparison of the roles of men, women, and children in farm work. This analysis aims to understand the specific tasks undertaken by women and men, examine the involvement of children in farm activities, identify seasonal variations in workload for women, men, and children, and pinpoint potentially hazardous practices during daily activities.

A comparative gender analysis was conducted to examine the activities and workload differences between women and men, as well as the nature of the practices they engage in different seasons.

The daily schedule method was originally intended to be performed by all family members, including men, women, and children. However, the male head of the family was interviewed first, and his permission determined whether other family members would participate in the activity. Consequently, in three out of the eight families interviewed, it was not feasible to conduct the method with female family members or children. Additionally, most families did not permit the use of photographs during the process.

3.3.2 Primary data collection - Seasonal calendar

The seasonal calendar (Chambers 1994a and 1994b; Narayanasamy 1994) is related with the objective 1, and was developed using a key informant interview with the head of the village. The objective was to identify seasonal variations in practices amongst genders and children with different ages, particularly those related to irrigation and effluent reuse, and identify potentially hazardous events.

A matrix was constructed for each family member women, men, girls and boys, to document the characteristics of each personal routine for each season as defined by the participants. Was provided detailed information on the necessary practices for each month, enabling discussions on workload (who does what) variations and seasonal differences. Moreover, the analysis was able to assess the conditions of effluent exposure during irrigation work, as well as other related practices such as fertilizing, pest control, harvesting, and processing. Factors including quantity, quality, timing, location in the farm, and intensity will be considered for each month/season.

Initially conceived to be conducted with focus groups, this method encountered obstacles due to residents' disinterest in participation. Consequently, the village head emerged as a suitable informant to undertake this task, given his comprehensive knowledge of all village families and active involvement in the irrigated planting fields.

3.3.3 Primary data collection - Observation

This approach facilitated the acquisition, evidence, and assessment of pertinent data during 11 field visits to Alaulapur village from July 11th to August 14th. It was crucial for understanding the agricultural activities within the village and gauging the distances that families needed to cover from their homes to the crop fields. Moreover, it encompassed the identification of hazards, such as hazardous events, exposure pathways, exposure groups, and existing control measures pertaining to irrigation on the farmlands. The observation is related to all objectives in this study.

3.3.4 Secondary data collection – E. coli concentration

Related to objective 2, the secondary data about the quality of the effluent treated by the Jajmau Sewage Treatment Plant (STP) and conveyed through the concrete channel to Alaulapur village were utilized. Specifically, this involved the analysis results for Escherichia coli (E. coli). These data were sourced from an unpublished original dataset acquired from FHNW, IHE & AKVO (2022), gathered during the period from September to October 2022, and done for the Pavitra Ganga project (Task 2.4 in Work package 2). In the study was assessed the microbial health risks from exposure to multiple water sources in selected peri-urban communities alongside the irrigation channels downstream of Jajmau STP in the city of Kanpur. Additionally, the average E. coli concentration results studied in the MSc Thesis of Babalola (2022) were incorporated, which were also obtained from irrigation channels within Alaulapur village and from its irrigated crop fields.

3.3.5 Community engagement and participant identification

During the initial visit to Alaulapur, the researcher and the translator were introduced to the village head by two Solidaridad employees. Subsequently, a group comprising the researcher, translator, village head, and two Solidaridad employees identified and visited ten families. The selection criteria for these families included active involvement in the work at the irrigated crop fields and the presence of at least one man, one woman, and ideally, also one boy and one girl within the family. Following these visits, a list of ten participating families was compiled. All ten families were informed about the research and expressed willingness to participate in the study.

3.3.6 Occupational risk analysis

Initially, for objective 3, the intention was to conduct separate focus group activities with men and women to collaboratively develop an occupational risk analysis. However, due to a lack of interest among Alaulapur village residents, this activity could not be carried out. Consequently, the occupational risk analysis relied on the risk matrix established by Babalola (2022), which already included a list of activities identified in the village of Alaulapur, and the field work done during this study. From this existing list, a new matrix was created, incorporating the information gathered in the current study. This updated matrix was utilized by the author to assess and score the risks associated with various activities. The ultimate aim was to identify activities performed by each family member during different seasons of the year and conduct an analysis of the results. This analysis would lead to safety recommendations in case any significant differences were identified between seasons.

During this phase of the study, a comparison and triangulation were carried out with information obtained from previous methods. It also provided an opportunity to address and discuss any errors or misunderstandings identified during the field activities. The risk matrix created assess various exposure scenarios during different seasons for different family members (men, women, and children). The health risk assessments for each exposure scenario was compared based on the number of hazardous events and the corresponding health risk scores per event in each season. The classification scoring method outlined in WHO's Sanitation Safety Planning Manual (2022) was employed to assess the severity and likelihood of identified hazards. Based on the risk scores, the hazards will be categorised as low (L), medium (M), or high (H) according to the guidelines provided in the manual (Table 7).

Table 7 Suggested risk category descriptions for team-based descriptive risk assessment. Source: WHO (2022).

Risk Descriptor	Notes
High	The event could result in injuries, acute and/or chronic illness or loss of life. Actions need to be taken to minimize the risk.
Medium	The event could result in moderate health effects (e.g. fever, headache, diarrhoea, small injuries) or discomfort (e.g. noise, malodours). Once the high-priority risks are controlled, actions need to be taken to minimize the risk.
Low	No health effects are anticipated. No action is needed at this time. The risk should be revisited in the future as part of the review process.

Was used a semi-quantitative risk assessment tool to explore how the activities of the farmers impacts the health risks associated with the reuse of treated wastewater effluent for irrigation in their crop fields. This tool assessed and prioritized the exposure risks identified from the interaction of the farmers with wastewater effluent in the fields and other non-direct contacts on the farmlands, in front of their houses and inside their houses. Both qualitative and quantitative data from primary and secondary sources, interviews and results of E. coli concentrations were used to achieve its aim. A framework illustrating this method can be seen in Figure 9.

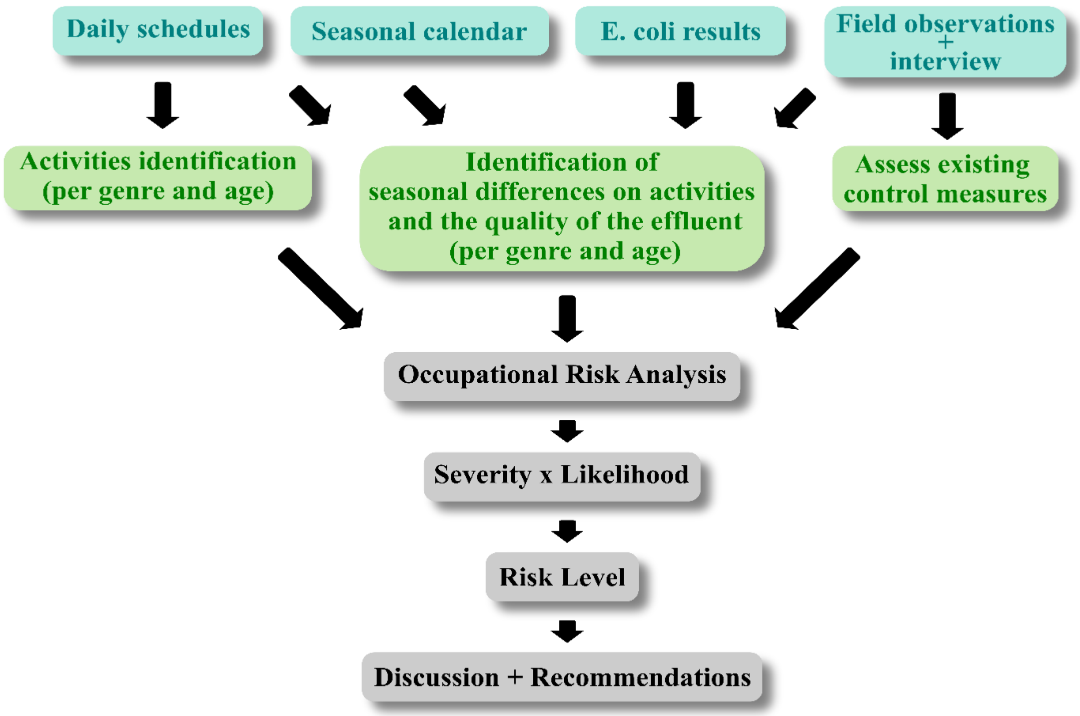

Figure 9 Occupational risk analysis process flowchart.

A matrix used for definition of the risk score can be seen in the Table 8, and a description of each classes is shown on Table 9. To assess the severity and likelihood used for scoring the risks, the WHO guidelines (2015) were used as shown in the Table 8, which explains how the low, medium and high risks were prioritized depending on the likelihood and severity of the exposure.

Table 8 Matrix for definition of Likelihood and Severity of risks, to be used in the semi-quantitative risk assessment (WHO 2022).

			Severity (S)				
			Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
			1	**2**	**4**	**8**	**16**
Likelihood (L)	**Very unlikely**	**1**	1	2	4	8	16
	Unlikely	**2**	2	4	8	16	32
	Possible	**3**	3	6	12	24	48
	Likely	**4**	4	8	16	32	64
	Almost certain	**5**	5	10	20	40	80
Risk Score R = (L) x (S)			**<6**	**7-12**		**13-32**	**>32**
Risk Level			**Low Risk**	**Medium Risk**		**High Risk**	**Very High Risk**

Table 9 Description of the classes of likelihood and severity in risk assessment. Source: WHO, 2016.

Descriptor		Description
Likelihood (L)		
1	Very unlikely	Has not happened in the past and it is **highly improbable** it will happen in the next 12 months (or another reasonable period).
2	Unlikely	Has not happened in the past but **may occur in exceptional circumstances** in the next 12 months (or another reasonable period).
3	Possible	It May have happened in the past and/or **may occur under regular circumstances** in the next 12 months (or another reasonable period)
4	Likely	Has been observed in the past and/or **is likely to occur** in the next 12 months (or another reasonable period)
5	Almost certain	Has been observed in the past and/or **will almost certainly occur** in the next 12 months (or another reasonable period)
Severity (S)		
1	Insignificant	Hazard or hazardous event resulting in **no or negligible health effects** compared to background levels.
2	Minor	Hazard or hazardous event potentially resulting in **minor health effects** (e.g. temporary symptoms like irritation, nausea, headache)
4	Moderate	Hazard or hazardous event potentially resulting in **self-limiting health effects or minor illness** (e.g. acute diarrhoea, vomiting, upper respiratory tract infection, minor trauma).
8	Major	Hazard or hazardous event potentially resulting in **illness or injury** (e.g. malaria, schistosomiasis, food-borne trematodiasis, chronic diarrhoea, chronic respiratory problems, neurological disorders, bone fracture); and/or may lead to a legal complaint; and or major regulatory non-compliance
16	Catastrophic	Hazard or hazardous event potentially resulting in **serious illness or injury, or even loss of life** (e.g. severe poisoning, loss of extremities, severe burns, drowning); and/or will lead to a major investigation by a regulator with prosecution likely.

3.3.7 Gender comparison

Gender analysis, as defined by Narayanasamy (2009), involves a systematic effort to document and comprehend the roles of women and men within a specific context. The author suggests that this analysis should encompass three primary categories of activities: productive work, reproductive work, and community work.

In the context of comparing gender roles in agriculture and animal husbandry within the village of Alaulapur, this study employed the daily routine method. The initial focus was on identifying the physical locations where these activities occurred, which included the following:

1. Planting Fields: Utilized for cultivation, featuring irrigation utilizing treated effluent.
2. Front of Houses: Housing area for livestock, including buffaloes, cows, and goats.
3. Inside Residences: Domestic interiors where various tasks take place.

Subsequently, the study aimed to categorise and analyse the activities performed by each gender within these distinct locations, classifying them into the respective categories of productive work, reproductive work, and community work.

Narayanasamy (2009) defines gender analysis as "a systematic effort to document and understand the roles of women and men within a given context." To conduct this type of analysis effectively, the author recommends categorizing activities into three primary groups: productive work, reproductive work, and community work.

In the context of studying gender differences in agriculture and animal husbandry in Alaulapur village, utilizing the daily schedule method, the initial focus was to pinpoint the specific environments where these activities transpired. These environments included the planting fields (utilizing treated effluent for irrigation), the front of houses (front garden or courtyard) where livestock (buffaloes, cows, goats) were tended, and the interior of residences. Subsequently, we proceeded to identify and classify the activities undertaken by each gender within these locations, categorizing them into the respective working groups, which can be characterized as follows (Narayanasamy 2009):

Productive Work: This category primarily encompasses paid activities directly associated with production. It includes income-generating tasks in agriculture, such as ploughing, sowing, planting, fertilization, harvesting, processing, and transportation. Additionally, it extends to other salaried employment opportunities unrelated to agriculture.

Reproductive Work: Reproductive work is not inherently linked to production but can exert an indirect influence on it. Activities falling within this category encompass domestic responsibilities such as housekeeping, home maintenance, cooking, childcare, eldercare, animal care, firewood collection for kitchen use, and laundry.

Community Work: Community work encompasses various tasks oriented towards collective well-being. These activities involve cleaning communal areas, maintaining street drainage and public spaces, active participation in village events and celebrations, and engagement in religious services.

Each of these work groups entails distinct activities and responsibilities, shaped by societal and cultural expectations regarding the roles of each gender within a given community.

3.5 Data management

The research activities, including interviews and other data collection methods, were conducted in Hindi and were facilitated by a translator. Before any data recording, the researcher sought and obtained consent from the participants. Audio recordings were occasionally made, and photographs were taken, alongside note-taking, during the research process. These audio recordings were subsequently reviewed and aided in the comprehensive written description of the activities, in conjunction with the notes taken during the research activities. We were asked not to photograph women in the houses, which was respected.

To ensure the confidentiality and anonymity of participants, each family was assigned a unique code. The individuals involved in the study were referred to as "man," "woman," "boy," and "girl" to protect their identities. All materials generated throughout the study, encompassing photographs, audio files, and sensitive information, have been securely stored on a password-protected external hard drive.

3.6 Ethical considerations

3.6.1 Ethical review board (ERB)

The research protocols, guides, and interview documents used to obtain informed consent were submitted to and approved by the IHE Delft Research Ethics Committee (RECO). The approval document is included in Appendix A.

3.6.2 Informed consent process

The consent forms, both in English and Hindi, providing an overview of the research process, participant activities, confidentiality, and contact information, can be found in Appendix C. The document emphasizes voluntary participation and the option to withdraw at any time. Consent was always obtained from participants prior to taking photos, recordings, or notes.

Chapter 4 Results and discussion

4.1 Practices related to reuse

4.1.1 Daily schedules results

The study was conducted in eight households in Alaulapur village (Table 10), home of approximately 650 individuals residing in 120 households (personal information from the head of the village). Residents were asked about their daily schedules and clocks were made afterward. Initially, the researcher, aided by a translator, introduced themselves and elucidated the study's objectives. After addressing the residents' inquiries, a consensus document was presented. Initial discussions and interviews in each household primarily involved the male members. Subsequent interviews with women and children were contingent upon the men's consent. In one household, a woman chose not to participate, while in two other households, women and children were not granted permission by their husbands to partake in the study.

Table 10 Number of daily schedules done per family in the village of Alaulapur.

Family code	Man (age)	Woman (age)	Boys (age)	Girls (age)
F01	40	35	7	10
F02	48	45	18	9, 11, 14
F03	40	35	10, 12, 16	-
F04	57	35	-	-
F05	45	20	17	-
F06	32	-	10	-
F07	55	-	-	-
F08	25	-	-	-
Total interviewed	**8**	**5**	**7**	**4**

For this study, due to the objective of occupational risk analysis, the work groups and their identified activities were separated into eight groups shown in Figure 10.

Figure 10 Groups of activities (with colour codes) identified with the daily schedule method in Alaulapur.

The identification of work groups emerged following initial interviews, with a focus on the productive and reproductive work groups (Narayanasamy 2009). Notably, the activities associated with the community work group did not surface in any of the conducted interviews. Nevertheless, the activities within the productive and reproductive work groups proved sufficient for discerning gender differences in Alaulapur.

In Alaulapur, the agricultural and animal husbandry contexts served as pivotal elements in defining the essential tasks for family members. Table 11 itemizes the identified activities categorized by gender and classes of work.

Table 11 Activities for genders and classes of work identified in the village of Alaulapur.

Gender	**Class of work**	
	Productive	**Reproductive**
All	- general work in the crop fields comprising: - seeding; - planting seedlings; - pest controlling (insect, fungus, weed); - fertilizing (manure and chemical); - harvesting; - transporting to the household and; - processing. - milking buffaloes, cows and goats; - working in commerce shops inside the village.	- bathing animals; - cleaning the animal area; - feeding the animals.
Women	- general work in the crop fields; - milking animals.	- cooking breakfast, lunch and dinner; - cleaning dishes and cookware; - sweeping the floor and cleaning the house; - preparing the children to go to school; - packaging food for the husband; - prepares the work uniform for the husband; - teaches children; - filling the water tank; - laundry; - preparing the table for all the meals.
Men	- general work in the crop fields; - collecting grass for fodder; - transporting collected grass; - shredding grass for fodder; - taking animals for grazing in the fields; - working outside the village.	- selling the milk; - storing the milk; - helping in the kitchen (1 man);

The data were recorded and systematically arranged, as illustrated in Table 12. For enhanced visualization and following the recommendation of Narayanasamy (2009), the data were further represented in the form of a clock, as depicted in Figure 11.

Table 12 Example of how data was collected during the interviews for the daily schedule.

Time	Activities Monsoon/Summer
04:00 - 05:00	Wakes up. Feeds, milks and baths the animals
05:00 - 05:30	Toilet, tooth brushing, baths
05:30 - 06:30	Breakfast
06:30 - 08:00	Goes to the field to collect green fodder
08:00 - 08:30	Sells milk
08:30 - 09:30	Takes a bath, washes his cloths
09:30 - 10:30	Lunch
10:30 - 13:30	Rest
13:30 - 14:30	Feeds the buffalos
14:30 - 15:30	Bathes the buffalos
15:30 - 16:30	Cleans buffalo's area
16:30 - 17:45	Milks the buffalos
17:45 - 18:30	Collects green fodder and shreds it for the animals
18:30 - 19:30	Sells milk
19:30 - 19:45	Takes a bath
19:45 - 20:00	Takes a nap, watches TV
20:00 - 20:30	Dinner
20:30 - 21:30	Chats with family
21:30	Sleep time

Respondents were prompted to recall the duration of each activity, including fundamental actions like bathroom visits or showering. Questions were posed following each recounted activity. Respecting participants' preferences, any inquiries deemed too personal, such as specifics about bathroom usage, were optional to answer.

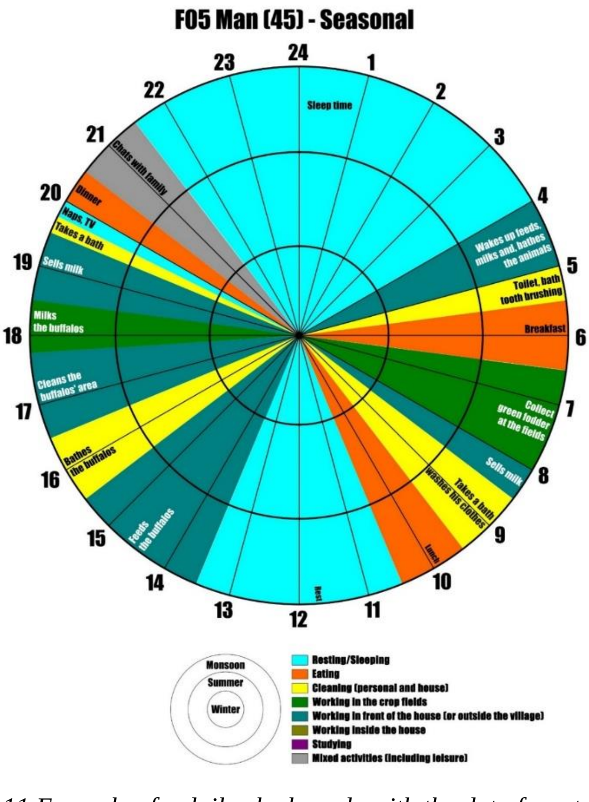

Figure 11 Example of a daily clock made with the data from table 12.

A total of 24 daily schedules were documented (Figure 12), encompassing 8 men, 5 women, 7 boys, and 4 girls. Data on children was sourced from five out of the eight households. In three households, mothers provided the information; in one, the father did, and in another, both parents contributed.

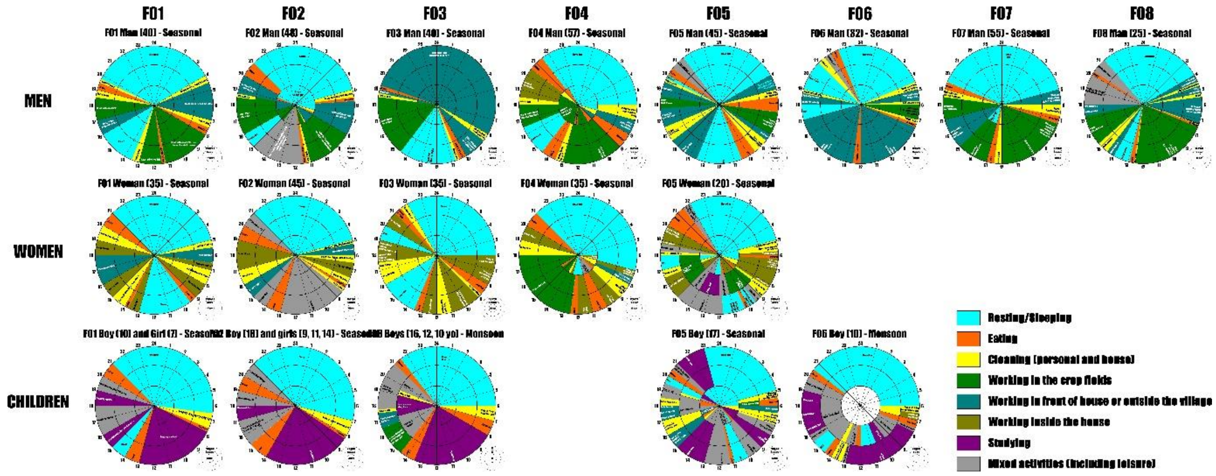

Figure 12 All the daily clocks made in the village of Alaulapur.

To evaluate the farmers' daily schedules, particularly with an eye toward understanding occupational risks associated with wastewater-treated effluent exposure, it's vital to discern the intricacies of their activities. This includes actions preceding and succeeding contact with the effluent and the inherent risks of these actions. Such detailed analysis allows for pinpointing activities where contamination may occur, at the crop fields or at the household area, and understanding their specific execution. This, in turn, facilitates future recommendations for safer practices, if applicable.

While a comprehensive examination of animals' situation wasn't the study's primary focus, understanding the dynamics between farmers and their animals emerged as significant. Both typically encounter the effluent and often share environments, including household spaces.

4.1.2 Women’s daily schedules

In Figure 13, which illustrates the daily schedules of the women, it is possible to observe that the initial activity for three of the five women (F01, F02, and F05) is using the bathroom. For another three (F03, F04, and F05), the day begins with household tasks such as sweeping, washing dishes from the previous night, preparing breakfast, and assisting children in getting ready for school. Notably, two interviewees (F03 and F04) indicated that they prioritize these domestic chores even before attending to personal hygiene or bathroom use.

Three women (F01, F02, and F04) noted that their initial outdoor activities of the day involve tending to animals such as buffaloes, cows, and goats. These chores, performed in front of their homes, encompass cleaning the animals' area, feeding, bathing, and also milking them. Subsequently, these women often engage in indoor tasks, predominantly in the kitchen, such as preparing breakfast and also going to the toilet. In three instances (F01, F04, and F05), breakfast is consumed immediately post-preparation, whereas in two instances (F01 nd F03), household chores or assisting children precede breakfast consumption.

Interestingly, of the interviewees, only two (F04 and F05) reported working in the planting fields, while one (F01) mentioned visiting the fields solely to deliver her husband's lunch. Meanwhile, two respondents (F02 and F03) stated they never frequent the planting fields.

The timeframe between breakfast and lunch is predominantly dedicated to cleaning and meal preparation. Only one participant (F01) referred to this interval as a "rest period," though it was discerned that this "rest" also encompasses lunch preparations.

Three participants (F01, F02, and F03) reported taking a post-lunch rest, ranging from one to two and a half hours. Post-lunch activities among the women included kitchen cleaning and dishwashing (F01, F02, F03), conducting tutorial sessions for village children (F01 and F05), tending to animals near their homes (F01 and F02), laundering (F03), preparing uniforms for a night-working husband (F03), and cooking dinner (all participants). Interestingly, only two out of the five women explicitly mentioned personal hygiene practices in the afternoon: F04 takes a complete shower, while F05 restricts cleaning to her arms, legs, and face.

Dinner typically occurs between 7:00 and 9:30 pm. Following dinner, two participants (F01 and F04) retire immediately, while another (F02) engages in an hour of family conversation. One respondent (F03) dedicates around 30 minutes to washing dishes, noting she doesn't defer this task to the next day. Another, F05, due to stomach ailments, takes her medication and spends about 15 minutes walking outside her home to aid digestion before bedtime. The women generally rest between 9:00 pm and 10:00 pm, and this schedule remains consistent throughout the year according to the respondents.

Three respondents (F02, F04, and F05) indicated they engage in leisure activities such as watching TV and conversing with friends and family. Specifically, F04 finds free time only during the winter, which she spends sitting in her residence's courtyard. In contrast, F02 mentioned that her leisure time often involves staying at home without any specific activities.

Only one respondent (F05) reported engaging in religious activities, specifically three times daily. The interviews did not identify any collective or community-centered activities among the women. The tutorial sessions conducted at home for community children by F01 and F05 led these women to spend more time within their residences. These activities are more related to production work than to community work.

There were no seasonal variations in the routines of women who primarily stayed at home (F01, F02, and F03). Such variations seem to emerge when women actively participate in fieldwork (beyond merely delivering lunch to spouses) or engage in studies (F04 and F05).

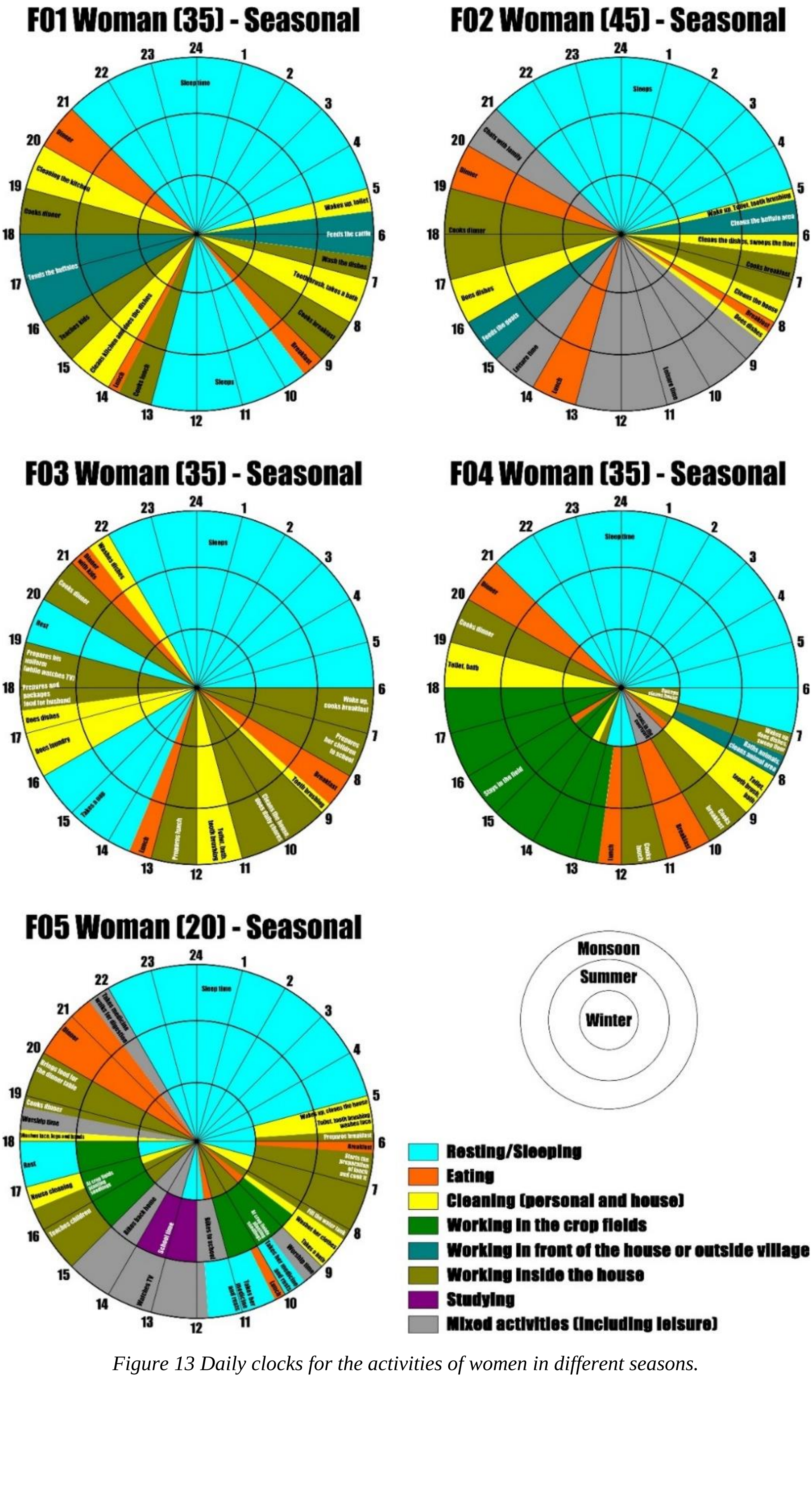

Figure 13 Daily clocks for the activities of women in different seasons.

4.1.3 Men's daily schedules

Eight men from Alaulapur village participated in the study, as depicted in Figure 14. Four of them (F01, F04, F07, and F08) were actively involved in farming and contributed to the cultivation of various crops throughout the year. The study also included interviews with two other individuals, F03 and F06, who had occupations outside the village. F03 worked as a night security personnel while F06 was employed in a factory. However, they also participated in village activities by taking care of buffaloes for grazing and collecting fodder for the animals in the fields.

Men typically commence their day earlier than women, with an average start time of 4:30 am. Among the surveyed men, four individuals (F01, F02, F04, and F06) promptly visit the bathroom upon waking, using this time for toiletry and toothbrushing. Notably, one participant, F04, mentioned incorporating a shower into this morning routine.

Conversely, three other men (F05, F07, and F08) engage in animal care activities immediately upon waking. These activities are carried out in the "animal area", akin to corral areas in Western cultures. Their morning tasks encompass feeding the animals, cleaning the animal area floor, milking the animals, and bathing the animals.

Subsequently, four out of the eight respondents (F01, F05, F06, and F08) reported taking a shower before their morning meal. Further inquiries were made regarding the bathing and personal hygiene practices, leading to the identification of two distinct bathing approaches:

1. **Complete Bath:** This involves using soap and typically lasts between 5 to 15 minutes. It may take place either inside a bathroom or elsewhere.
2. **Foot and Hand Cleaning:** This shorter process, taking approximately 5 minutes, primarily involves cleaning the feet and hands. Soap may or may not be used. This type of cleaning is commonly performed in proximity to the animal areas.

In seven interviews (F01, F02, F03, F05, F06, F07, and F08), it was mentioned that individuals take a complete bath upon returning from their agricultural activities. In contrast, F04 exclusively washes their feet and hands in front of their house.

All interviewees have breakfast at home, except in one case (F02), where the interviewee has breakfast at his neighbor's house, who happens to be his brother. Subsequently, after breakfast, five interviewees (F01, F04, F05, F07, and F08) proceed directly to the cultivation fields. Among them, four (F01, F04, F07, and F08) remain in the fields throughout the morning and return home between 11:00 am and 1:00 pm for lunch. Notably, one interviewee (F01) mentioned having lunch in the fields, with his wife delivering his daily meals.

In another scenario (F02), the interviewee transitions from the cultivation fields to his home, takes a shower, and then proceeds to a small shop co-owned by his father within the community, where he has lunch daily. Additionally, one interviewee (F03) opts to take a shower after lunch, while four others (F02, F05, F07, and F08) indicated that they shower immediately before lunch after returning from the cultivation fields. In contrast, one interviewee (F04) mentioned only briefly cleaning his feet and hands before lunch. Lastly, one interviewee (F06) has lunch at the factory where he is employed, located outside the village.

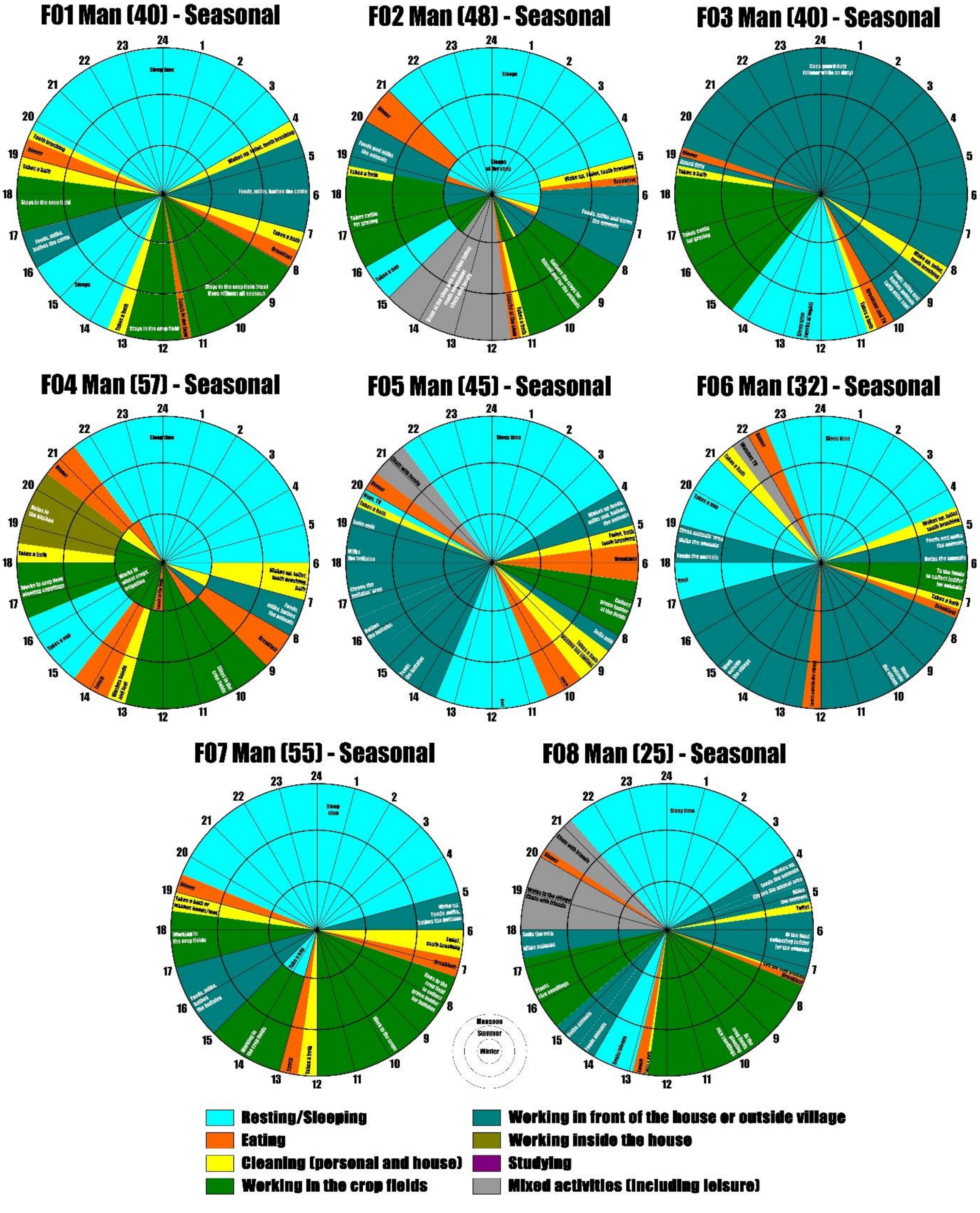

Figure 14 Daily clocks for the activities of men in different seasons.

Post-lunch activities exhibit a dichotomy, encompassing a return to the planting fields or a period of rest, including siestas. This divergence in routines manifests as follows: some individuals engage in fieldwork immediately after lunch (F01 and F07), while others opt for rest post-lunch (F02, F03, F04, F05, and F08). In one instance (F06), an immediate return to work is necessitated due to employment at a factory during this time, and in another case (F02), the individual is engaged in small-scale businesses within the village.

During the afternoon, animal care duties are interspersed with visits to the planting fields (F01, F02, F07, and F08). Conversely, some individuals are exclusively involved in animal care (F05), while others engage in activities beyond the planting fields (F02 in small trade, F06 in a company located outside the village). Both planting field activities and animal care typically conclude around 6:00 pm, although they may extend until 7:30 pm.

Upon returning to their homes at the conclusion of their respective activities, the interviewees' evening routines unfold as follows: Six respondents (F01, F02 just during the monsoon, F03, F04, F05, and F07) reported immediately taking a shower, while one (F08) socializes with friends within the community. Three individuals (F02, F05, and F06) engage in animal care and milk sales. Following their showers, one interviewee (F04) assists his wife in the kitchen, marking the sole instance of domestic responsibilities among the men surveyed.

Dinner is typically served between 7:00 pm and 9:00 pm for most interviewees, with the exception of one (F06), who, due to his daytime work outside the community, has dinner at 10:00 pm.

Bedtimes exhibit variation based on the monsoon and summer seasons, ranging from 7:30 pm to 10:30 pm. Notably, two interviewees alter their sleep schedules during the winter season: one (F02) retires earlier at 7:30 pm (compared to 9:00 pm in the monsoon/summer), while another (F04) goes to bed later, at 10:00 pm.

Only two of the eight interviewees (F02 and F04) exhibited variations in their daily routines across seasons. These differences primarily revolved around waking up later during the winter months, with no alterations in the nature of their activities - just a delay of one to two hours.

Conversely, the remaining interviewees emphasized the consistency of their routines, asserting that the demands of their work, both in the planting fields and, particularly, in animal husbandry, necessitated the perpetual performance of the same tasks. This uniformity extended to their weekend routines, with no discernible differences reported.

Regarding leisure activities within the village, half of the interviewees (F02, F05, F06, and F08) mentioned engaging in activities such as watching TV, reading newspapers, and conversing with friends and family. None of the respondents indicated involvement in religious, community, or collective activities within the village.

Figure 15 displays combined timelines depicting the activities of women, men, and children during the Monsoon season. The graphic illustrates variations in activities, their absence, or altered nature when children are attending school outside the village. Furthermore, it highlights that the duration of work in the crop fields is similar for both men and women. Additionally, it underscores that women who remain at home may still have contact with effluents, as they engage in activities involving animals near their houses.

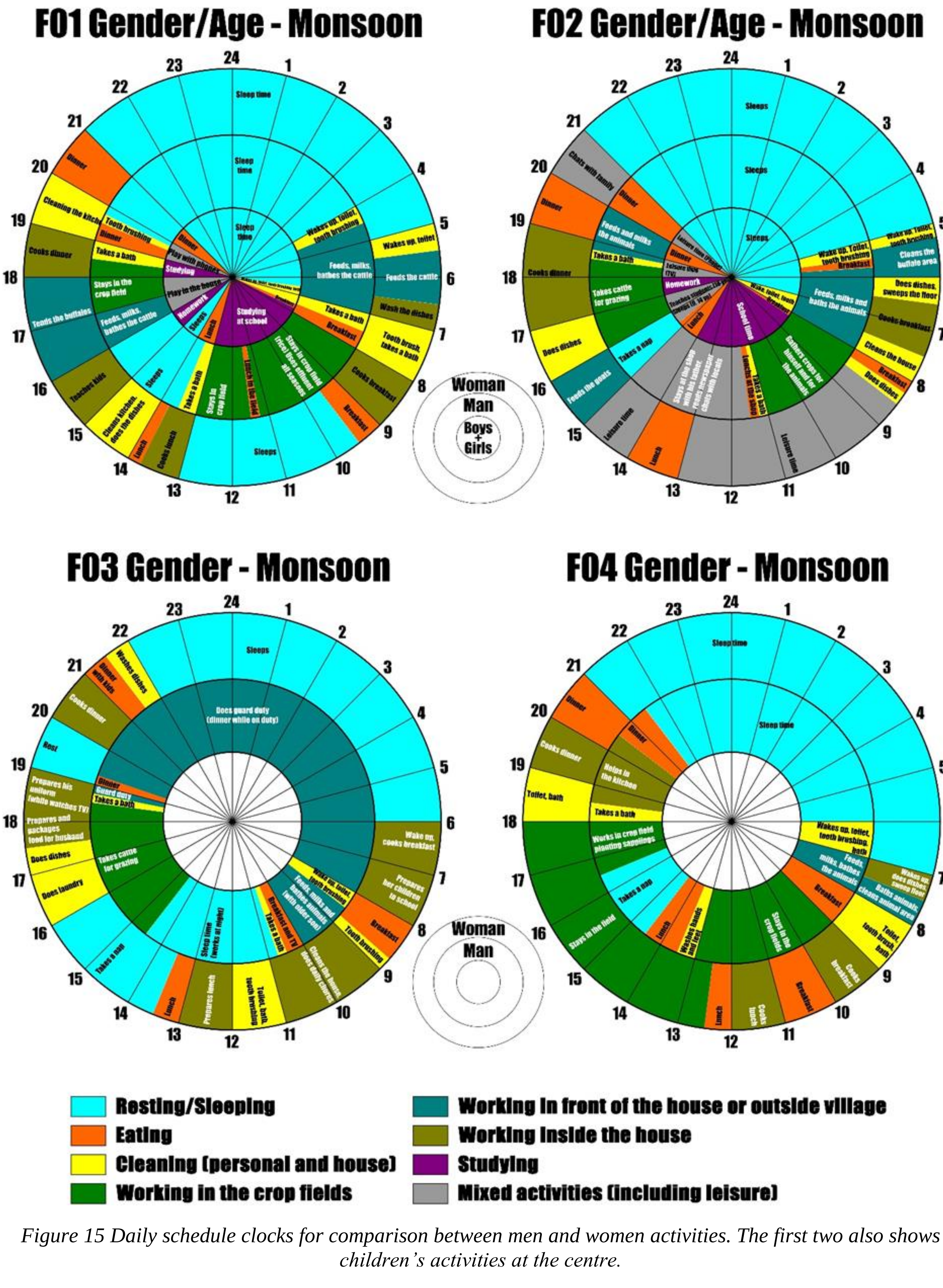

Figure 15 Daily schedule clocks for comparison between men and women activities. The first two also shows children's activities at the centre.

4.1.4 Children's daily schedules

In this study, children were categorized into two age groups: those aged from 0 to 11 years and those aged from 12 to 18 years. Interviews were conducted with mothers (F01, F02, and F03), the father (F05), and directly with a 17-year-old boy (F05).

Typically, children wake up between 6:00 am and 7:00 am, initiating their day with personal hygiene and using the toilet. They then proceed to have breakfast, prepare for school, and travel to the school, which is situated outside the village. The journey to school is made either on foot or by bicycle, involving passage through dirt roads traversing the irrigated crop fields. Classes commence at 8:00 am and extend through the morning, with return times to residences fluctuating between 1:00 pm and 2:00 pm.

Upon returning home, F01, F02, and F03 immediately have lunch. In the case of F06, he washes his hands and feet, and depending on the prevailing temperature, may take a complete shower before lunch. Subsequently, both F01 and F06 engage in a one-hour rest period following lunch.

In the afternoon, children allocate their time to various activities, which encompass indoor play, completing homework, and engaging in study sessions often facilitated by their mothers or village tutors. Indoor play encompasses activities such as watching television, playing with siblings or friends, and utilizing cell phones for entertainment. Notably, during school holidays, which span from May 25th to June 25th, F01 reported that children, aged 7 and 10 years, predominantly engage in indoor play activities at the household.

The daily routines of children aged 0-11 years appear to exhibit minimal gender-related variations, as evidenced by the experiences of F01, F02, and F03. For this age group, the most notable divergence occurs during school holidays when their study time decreases.

In contrast, children aged 12-18 years not only engage in academic pursuits but also contribute to agricultural and animal husbandry activities, as reported by F03 and F05. Activities identified in these cases involve grass harvesting for animal feed (F03) and operating a shredding machine within the residence (F05). Notably, F05's engagement in these activities exhibits seasonal fluctuations, with more active involvement in planting field tasks occurring during the summer, while during the monsoon and winter, the focus shifts primarily to academic studies and animal-related activities.

Regarding variations in activities between weekdays and weekends, the only information available pertains to F06, who enjoys more leisure time throughout the day on Sundays, although it is predominantly spent indoors at home.

Dinner times for the families studied range from 7:00 pm to 9:00 pm. Following dinner, children aged 0-11 typically retire to bed. In contrast, children aged 12-18 engage in activities such as conversing with friends from the village, using cell phones, and/or studying before going to sleep. Notably, F05 exhibits a seasonal variation in his daily routine, with a later wake-up time and an earlier bedtime during the winter season. This adjustment corresponds to his shift from agricultural work to focusing solely on animal-related tasks during this period.

Seasonal differences in daily routines were observed exclusively within the 12 to 18 age group, where children are more actively involved in both agricultural and animal-related activities. In contrast, no evidence was found to suggest the involvement of children aged 0-11 in planting field activities. This observation was consistent across all families interviewed. For a visual representation, refer to Figure 16, which depicts the daily schedules of boys and girls based on interviews with mothers and fathers of children from five different families.

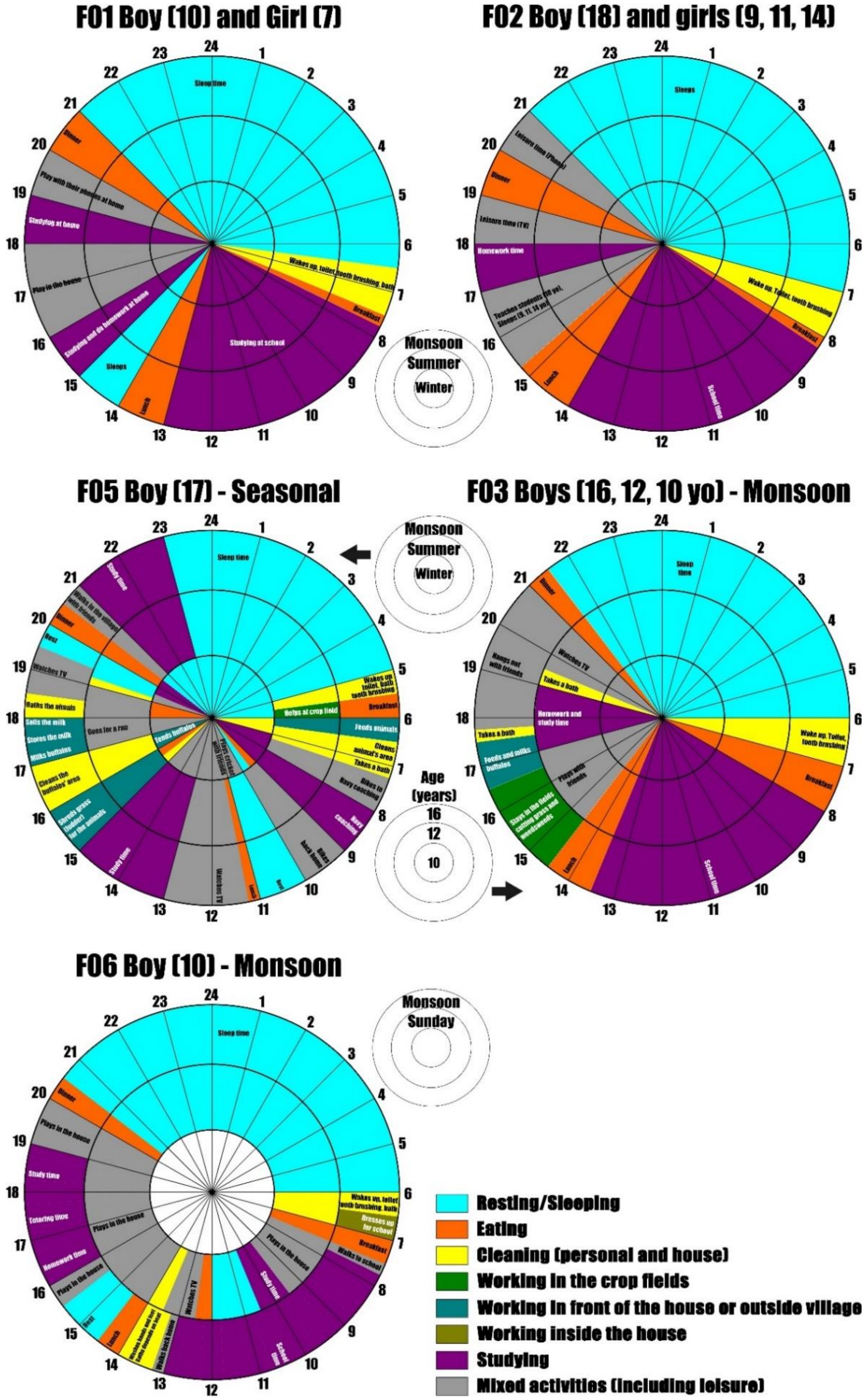

Figure 16 Daily clocks for the activities of children (boys and girls).

4.1.5 Daily schedules discussion

During our field visits to the village, we observed many women actively engaged in fieldwork. The village leader further emphasized that most if not all family members typically contribute to these agricultural tasks. Yet, some women, especially during the monsoon season, seem to primarily focus on domestic responsibilities or childcare, as informed during the visits. Notably, one respondent (F05), who is childless, revealed that she is a student. Upon completing her exams, she not only partakes in field activities but also offers tutorial lessons to village children at her residence.

While observing the groups of women in the crop fields, moments of reprieve were evident, characterized by active conversations. However, it remains unclear if these women regard such moments as leisure since they were not directly interviewed on this topic.

The most notable instance of communal collaboration observed was groups of women working in tandem in the fields. Regrettably, these women were not interviewed, which would have provided richer insights into their group dynamics and domestic roles.

It was possible to understand, with the daily schedule method, that seasonal variations in men's activities primarily revolve around the timing of their tasks, as during Summer and Monsoon, they wake up earlier than in Winter, although this fact do not change the nature of the activities. Work activities in the plantation fields clearly appear to shift based on the crop type; for instance, rice cultivation occurs within flooded fields, while wheat is planted in the soil after the flooded fields have dried.

Regarding animal care, the primary seasonal change revolves around forage procurement. During winter, when grass growth is limited, dry fodder is acquired for animal feed, eliminating the necessity of gathering forage from the fields. Apart from this adjustment in food sourcing, it seems that animal care activities maintain a consistent pattern throughout the year.

Productive work in the crop fields

Productive work in the crop fields involves a range of activities. Information gathered from interviews with eight families revealed that men primarily engage in the cultivation of crop fields. However, in only two families, women also participate in various activities within flooded or floodable fields. These activities encompass:

- Seeding;
- Planting seedlings;
- Fertilization using manure and chemical fertilizers;
- Pest control through the application of herbicides, fungicides, and insecticides;
- Harvesting;
- Transporting harvested products (either by carrying them on one's back or by bicycle);
- Processing.

Notably, the village head (HV1), during an interview aimed at constructing the seasonal calendar, asserted that all family members are involved in crop field work. This assertion was substantiated by observations made during 11 visits to Alaulapur village between July 11th and August 14th. During these visits, groups of women were actively engaged in flooded rice field activities.

Furthermore, the same interviewee emphasized that these activities in addition to being undertaken by all family members consistently throughout the year, are carried out without seasonal variations in family direct involvement in crop fields, in agriculture-related tasks, or in animal husbandry responsibilities.

Working conditions in the crop fields appear to be similar for both men and women, although a more comprehensive investigation and activity monitoring are needed to identify potential differences. Preliminary observations indicate that men tend to work individually, while women often work in groups. It was also observed that both men and women consume meals and attend to their physiological needs while in the fields.

Based on information collected during home visits, discussions with the village head, and observations, it is evident that two distinct groups of women exist in Alaulapur, although further research is necessary to explore the factors contributing to these differing roles and preferences among women in the community.:

1. **Field-Engaged Women:** This group of women predominantly spends their time working in the crop fields alongside men, but also have their responsibilities on reproductive work in the household.
2. **House-Centric Women:** Conversely, another group of women concentrates their efforts more intensively indoors and in front of their houses. Some women in this category assert that they do not participate in planting field activities at any time.

Productive work in front of the houses (animal area)

Activities related to animal husbandry primarily encompass tasks such as feeding, cleaning the animals' living area, milking, and bathing the animals, with a particular focus on buffaloes and cows. For the purposes of this study, only milk production activities (i.e., milking, storage, and sale) are categorized as productive work within animal husbandry.

Milking of buffaloes, cows, and goats in front of residences occurs twice daily and involves the participation of all family members old enough to contribute, typically from adolescence onward. It is noteworthy that this activity is distributed throughout the day among men, women, and teenage children, as both observation and interviewee comments have indicated.

The milk extracted is stored within the residences, with a portion consumed by the families and the surplus sold daily at roadside stalls in front of the houses. Residents from neighboring communities visit Alaulapur twice a day, in the morning and late afternoon, to purchase milk. Apparently, individuals responsible for milk storage and sales, based on information from interviews, consist of men and their male children aged 12 and older. However, further research is needed to delve deeper into this aspect in future studies on the subject.

Reproductive work in the crop fields

Reproductive work activities in the crop fields primarily involve planting and harvesting forage intended for animal feed. Information obtained from both residences and the village head indicates that this activity is typically performed by men and/or adolescent boys. Harvesting commonly occurs in the morning, with occasional instances observed in the late morning. The harvested grass is carried on the backs of farmers from the fields to the road, and then typically secured to a bicycle to facilitate the transportation of larger quantities back to the residence. It is noteworthy that those involved in harvesting have continuous direct contact with the grass, and this is done without any protective measures. Further research may be needed to explore the potential health and safety implications of this practice.

Reproductive work in front of the residences (animal area)

Concerning animal care, the sequence and performers of these activities exhibit variability. In one interview (F01), a woman carried out milking (categorized as productive work), bathing, feeding, and cleaning of the animal area. In another family (F03), older children were responsible for cleaning the animal area. In a specific case (F01), the woman undertook these tasks in the afternoon, while the man handled them in the morning. Thus, it appears that the specific responsibilities within families regarding animal care in front of their houses can vary considerably. Additionally, all family members have contact with this area as it serves as an entryway to the houses.

Upon the arrival of grass for animal feed at the residence, it is typically stored on a sort of "balcony" situated between the animal area and the entrance to the residences. Some visited homes featured a crushing machine on this "balcony." Interviews (F03 and F05) indicated that men and/or teenage boys operated this machine. Unfortunately, it was not possible to confirm whether any cleaning or washing of the grass occurred before shredding, or if a designated individual was responsible for such procedures.

Subsequent to the grass being shredded, it is transported to the food-containing structures at the animal area for feeding buffaloes, cows, and goats. Notably, the feeding of goats with uncrushed grass was observed in some instances. Further research may be necessary to explore specific practices related to grass processing and cleaning for animal feed.

Reproductive work per se (within residences)

Activities with greater characteristics of reproductive work are carried out by women within homes throughout the day. Activities include cooking food for three meals a day, washing dishes used for meals, general cleaning of the house, caring for children aged between 0 and 11 years, including monitoring their studies and homework, tutorial classes for the village children, preparing their children to go to school, cooking and packing food for the husbands who work outside the village or who have lunch in the plantation fields, and washing clothes. As shown earlier, only one man interviewed (F08) does some reproductive work at home, claiming to help his wife in the kitchen at the end of the afternoon. The women interviewed stated that the dynamics of work within the residences do not change throughout the year, showing no seasonal differences.

4.1.6 Seasonal calendar results

In the village of Alaulapur, the seasonal calendar (Table 13) reveals that farmers closely associate the seasons with specific farming activities. The monsoon, often referred to as the "**kharif season**" or "monsoon/autumn crops," is believed to begin around July 10th and conclude around November 10th; this is the primary rice cultivation period. The summer, designated as the "**zaid season"** or "summer crops," spans from April 1st to the early weeks of July, during which fodder crops are predominantly cultivated. The winter season, termed the "**rabi season**" or "winter crops," commences on November 11th and persists until the end of March, aligning with the wheat cultivation period. No other season was mentioned or recognized by the interviewee.

The village's residents are primarily farmers engaged in the cultivation of rice, wheat, and the production of animal fodder. They are also involved in animal husbandry, predominantly raising buffaloes, along with cows and goats. Grain production follows a seasonal pattern, with rice being cultivated during the monsoon season and wheat during the winter (Table 13).

In Alaulapur, August and September were identified as months requiring the most irrigation using effluent water from the cement canal (Figure 17), coinciding with the monsoon and rice cultivation period. Conversely, May and June were noted as the driest months, with June experiencing the highest annual temperatures (Figure 18).

Figure 17 a) the cement canal of Alaulapur; b) cement canal at the centre and secondary canal on the left.

Table 13 Seasonal calendar from Alaulapur village, Kanpur, Uttar Pradesh State.

	Components/Activities	जनवरी (Chittirai) January				फ़रवरी (Vaikasi) February				मार्च (Aani) March				अप्रैल (Aadi) April				मई (Aavani) May				जून (Puratasi) June				जुलाई (Aippase) July				अगस्त (Karthikai) August				सितम्बर (Margazhi) September				अक्टूबर (Thai) October				नवंबर (Masi) November				दिसंबर (Panguni) December			
SEASONS	MONSOON (Kharif season)																										10																		10						
	SUMMER (Zaid season)													1												9																							
	WINTER (Rabi season)												31																																	11					
GENERAL INFORMATION	Rainy months																																																
	Driest months																																																
	Higher temperature																																																
	Worst irrigation water																																																
	Irrrigation more necessary																																																
	Men in crop fields																																																
	Women in crop fields																																																
	Children in crop fields*																																																
	People's illnesses																																																
	Fever																																																
	Stomach pain																																																
	Weakness																																																
	Skin																																																
	Vomit																																																
LIVESTOCK	Green fodder (3)													3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3						
	Dry fodder (bought)																																																
	Animal illnesses																																																
	Fever																																																
	Digestion problems																																																
	Throat infection																																																
	Feet infection																																																
	Stomach pain																																																
CROPS	Rice (1), Wheat (2)	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
	Tractor work (plowing)																								1																		2	2					
	Sowing/Planting seedlings													3	3											1	1	1																2	2				
	Fertilizing	2	2	2		2	2	2		2	2	2															1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			2	2	2	
	Weed/Pest control		2		2		2		2		2																			1		1		1		1		1		1		1					2		2
	Harvesting											2	2	23	23	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	13	13	3						
	Processing													23	23	23	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	13	13	13						

Figure 18 The village of Alaulapur in different seasons. Source: Google Earth.

Concerning the water quality in channels, the information given was that its quality remained subpar throughout the year, summarized by a local remark: "The water is bad throughout the year." Feedback from community members included questions like, "Why isn't the water quality ever improved?" During the interview, two individuals interjected, expressing scepticism about the efficacy of our research, suggesting that despite ongoing studies, the community's living conditions remained unchanged. Both our translator and driver clarified that the recurring community grievance pertained specifically to the consistently poor quality of effluent from the treatment plant channelled into the community.

In the flood effluent irrigated fields (Figure 19), it was reported that family members of all genders and ages are present year-round. Our visits predominantly revealed the presence of men, mostly alone, and groups of women. While children were not observed during our visits, their occasional presence, especially among adolescents and post-adolescents, was confirmed through the daily routine assessments. They were less frequently observed than anticipated, especially among children up to 11 years old.

Figure 19 a) One of the secondary channels carrying the effluent for flooding the plantation fields; b) Flooded rice fields surrounding the village of Alaulapur.

Health issues, including fever, stomach pain, vomiting, fatigue, irritation, skin discoloration, and itching, were reported to persist throughout the year. Skin ailments were particularly pronounced during the summer and monsoon seasons (Figure 20), whereas in winter, their occurrence, though present, was less frequent.

Figure 20 Skin ailments shown by the interviewee.

Rice cultivation in the region commences between late June and the first week of July, starting with soil preparation via tractor ploughing. Instead of conducting this activity themselves, farmers opt to rent tractors with drivers, with the drivers completing the task within roughly 30 minutes. Following soil preparation, rice seedlings are planted over a span of 20 to 25 days, concluding by the end of July. Our initial visits allowed us to witness this process. Both male and female farmers, devoid of protective gear, wade barefoot into fields inundated with malodorous effluent, manually planting rice seedlings (Figure 21). The daily routine technique highlighted that some farmers even consume their lunch in this environment without adequate sanitation post-activity. Subsequent to the planting phase, fields undergo fertilization using manure, urea, and zinc salt. After an initial flooding, the fields are left to dry for 8 to 10 days. Post-fertilization, the fields are inundated once more, initiating a cycle of irrigation/fertilization that persists for four months.

Pest and weed control activities coincide with fertilization and are conducted biweekly, utilizing what the interviewee referred to as “medicine” - namely, agrochemicals, pesticides, fungicides and herbicides in both powder and liquid forms. Although during the interview we were shown a bag of granulated substance by the interviewee (the “medicine”), its exact nature remained unidentified. During our observation in the first week of August, a farmer, donning only shorts and a t-shirt and lacking protective equipment, used a knapsack sprayer to administer the liquid on the rice for weed control. Insect management involves the application of granulated insecticides in a similar manner. The culmination of the rice production cycle is marked by the harvesting and processing stages, occurring from the last week of October to approximately November 10th-15th. The 2022 annual report from the Indian Institute of Wheat and Barley Studies (ICAR 2022) states that the predominant insects in Uttar Pradesh's fields include the Shoot fly, Brown wheat mite, foliar and root aphids, termites, and the pink stem borer.

Figure 21 Farmers (groups of women) planting seedlings in the rice field.

Rice is harvested between the last week of October and the first week of November, while wheat is harvested from mid-March to mid-April. In both instances, farmers conduct the process without any personal protective measures. Data regarding the interval between the final pest control application using agrochemicals and the respective harvests was unattainable. Pertaining to processing, the interviewee indicated that both rice and wheat are processed mechanically by a machine situated outside the community. The post-processed rice and wheat are taken back to the households where they are used for family consumption and the surplus is sold.

In irrigated fields, another significant activity involves the cultivation and harvest of grass for animal fodder, intended for buffaloes, cows, and goats (Figure 22a). Both planting and harvesting predominantly occur during the summer and monsoon seasons, where farmers have direct tactile engagement with the grass, especially in areas irrigated with effluent. Post-harvest, the fodder is transported to the vicinity of their residences (as depicted in Figure 22b and 22c) and subsequently processed using a shredder machine (illustrated in Figure 22d).

Figure 22 a) photo of planted fodder in the irrigated field; b) transport of the harvested fodder to the house; c) fodder been eaten by goats in front of the house and; d) shredder machine inside the house (authorized photo).

The study did not ascertain whether the fodder undergoes cleaning prior to processing. As conveyed by the interviewee, the harvesting and chopping of fodder is a daily routine. During winter, farmers procure dry grass for animal feed, and field activities largely pivot to wheat production. The frequent proximity of animals to, and occasionally within, dwellings results in a pervasive fly issue. Notwithstanding daily cleaning endeavours, substantial quantities of animal waste permeate the surroundings, affecting both the immediate vicinity of the houses and the broader community (as seen in Figure 23).

Figure 23 Photos of animal waste in the village of Alaulapur.

Grazing primarily involves buffaloes being taken to the channels and areas flooded with effluent (Figure 24a). Buffaloes were notably observed almost entirely submerged in one of the channels (as shown in Figure 24b), consuming grasses along the channel's periphery. Subsequent to this immersion, the animals return to the spaces adjacent to the households where they rest, feed, and are milked daily (depicted in Figures 24c and 24d). As the cows use the dry areas for grassing, they have fewer diseases, like throat infections, as explained by the interviewee.

Figure 24 a) Farmers walking with buffaloes to the canals and flooded fields; b) buffaloes submerged in a canal; c) buffalos resting in front of a house after submersion in the canal; d) buffaloes being milked (authorized photo).

The milk finds daily buyers from outside the community. Although ailments in animals are prevalent year-round, the summer sees frequent cases of fever and stomach discomfort. During the monsoon, digestive issues and infections, particularly affecting the throat and feet, are common - the latter being a recurrent concern for farmers. Analogous to humans, animals exhibit reduced illness incidence during winter.

4.1.7 Seasonal calendar discussion

According to Chhokar et al (2012) and ICAR (2022), farmers favour the utilization of agrochemicals for insect, fungus, and weed control due to their cost-effectiveness, reduced time investment, and enhanced mid-term efficacy. Additionally, these methods are less likely to damage crops compared to mechanical control. Post-emergence agrochemicals, applied after the initial germination and growth of plants, are a commonly used practice confirmed in our interviews. As Chhokar et al (2012) suggest, the optimal time frame for irrigation post-application is 7 to 10 days. In Alaulapur, farmers typically wait 8 to 10 days prior to administering agrochemicals, a process that recurs throughout the aforementioned four-month period. The interval between agrochemical application and subsequent irrigation was not specified, raising potential concerns regarding farmers' simultaneous exposure to both irrigation water and agrochemicals.

While beyond the primary scope of this study, it is noteworthy to mention that organophosphate agrochemicals, characterized by molecules comprising carbon and phosphate, rank among the most frequently employed herbicides and insecticides globally (Lerro et al., 2015). According to the authors numerous organophosphates, such as Dichlorvos, Parathion, and Tetrachlorvinphos, are considered possibly carcinogenic to humans, while others like Malathion and Diazinon are probably carcinogenic. Research conducted in the USA, Canada, and Italy has correlated certain organophosphate insecticides with an elevated cancer risk (Lerro et al., 2015; Bastos et al., 2020). Additionally, Hongsibsong et al. (2017) highlight that beyond cancer, organophosphates have been linked to various adverse health outcomes, including numbness, ADHD, and muscle weakness. Other widely used agrochemicals are organochlorine pesticides, these are still widely used in low- and middle-income countries and applied, especially in rice cultivation, causing risks to human health and the environment due to their ability to bioaccumulate in animal tissues and food crops (Schreinemachers and Tipraqsa 2012, and Sarker et al 2021). The health risks associated with agrochemical use hinge on both the pesticide's toxicity and the probability of human contact with it. As articulated by the USEPA (2023): RISK = TOXICITY × EXPOSURE. Both exposure and toxicity must be present for a risk to materialize. If a highly toxic pesticide lacks exposure, then no risk ensues, just as significant exposure to a non-toxic pesticide bears no threat. Nonetheless, the utilization of pesticides invariably entails a degree of risk given that both toxicity and exposure are inevitably present, especially in areas with prolonged use over the years, as in Alaulapur.

The predominance of rice and wheat cultivation in Alaulapur and in the wider region, coupled with the production of fodder grasses, underscores the potential for extensive agrochemical use, a combination of different herbicides being used and/or the possible persistence of herbicides in crop fields. This is due to the shared botanical classification of these crops - all being grasses. Typically, these crops are susceptible to grassy weed invasions. Consequently, the herbicides employed must exhibit discerning selectivity, given the comparable physiological reactions of the cultivated plants and the invasive weeds to these chemicals. In our interview, the respondent mentioned the use of urea, leaving ambiguity regarding its application solely as a fertilizer or also as an herbicide. For instance, sulfonyl urea-based herbicides, known for their prolonged environmental persistence, are generally favoured by farmers for their broad-spectrum weed control capabilities (Chokkar et al., 2012). Table 14 provides a representative list of agrochemicals, encompassing insecticides, fungicides, and herbicides, utilized in rice cultivation globally, along with their recommended application dosages, exemplifying potential agrochemical usage in Alaulapur.

Table 14 Pest management in rice worldwide. Source: Asiah et al (2018).

Insecticide	Application rate/ha	Fungicide	Application rate/ha	Herbicide	Application rate/ha
Carbofuran	10 - 20 kg	Hexaconazole	-	Benzofuran methyl	0,05 kg
Etofenprox	4 L	Kresoxim methyl	1 - 1,25	Bentazone	1 - 2kg
Fenitrothion	0,1 - 0,2 L/ton grain	Trifloxystrobin	0,5 - 0,8 L	Bispyribac sodium	0,02 kg
Pirimiphos methyl	0,08 L/ton grain	Carbendazim	-	Cyhalofop butyl	0,2 - 0,3 kg
Metiocarb	6 kg/ton seed	Tebuconazole	0,45 - 1 kg	Clomazone	0,4 kg
Diazinon	0,75 L	Tricyclazole	0,3 - 0,4 kg	Glyphosate	0,5 - 4 kg
Chlorpyrifos	0,06 - 0,15 L	Prochloraz	0,5 L	Molinate	2 - 4 kg
Trichlorfon	0,6 - 0,85 L	Thiphanate methyl	0,7 - 1 L	Pretilachlor	0,6 kg
Teflubenzuron	0,07 L	Isoprothiolane	1 - 1,5 L	Propanil	3 - 4 kg
Malathion	-	Carbaryl	1,2 L	Quinclorac	0,5 - 0,6 kg

4.2 Seasonal variation in effluent quality

The data presented by Babalola (2022) for the Monsoon yielded the subsequent findings (Figure 25). Concentrations were determined through dilution for both the irrigation channel (10-3) and the agricultural field (10-2). Validation of these findings from the use of the compact dry plates was achieved by comparison with the use of Aquagenx CBT kits, which involved a dilution of 10-5, as outlined in Aquagenx (2022).

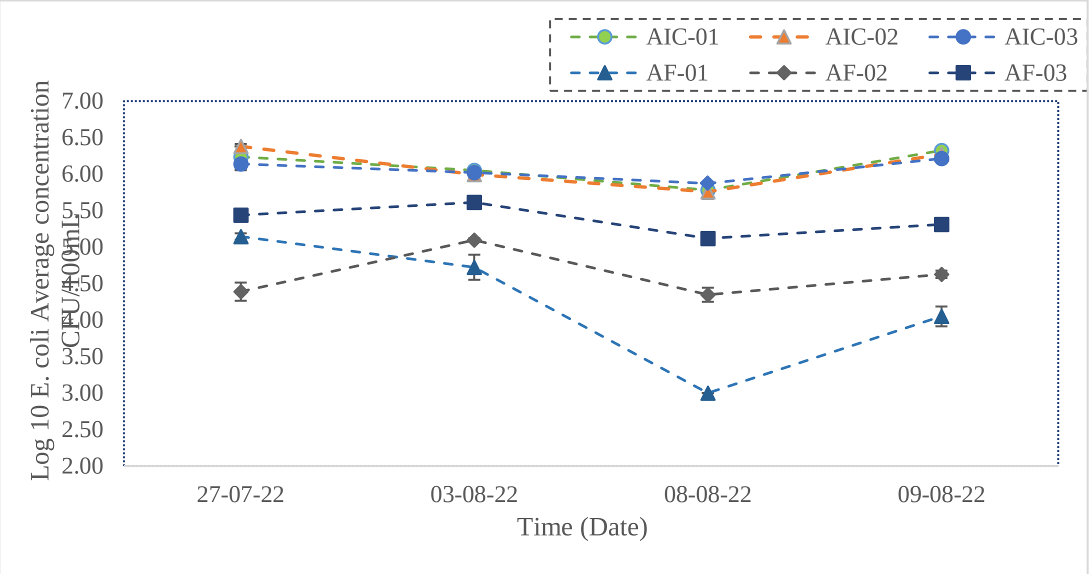

Figure 25 Results on average E. coli concentration from Babalola (2022), with three samples collected in the monsoon season (AL-IC: Alaulapur irrigation channel; AL-AF: Alaulapur agricultural field). Source: Babalola (2022).

As shown in Figure 25, the E. coli average concentrations from the samples collected vary from between 6.0 – 6.5 (±0.1) Log10 CFU/100mL. As a validation, the result for the Aquagenx method, also used in her work was 6.1 Log10 MPN/100mL. The author initially observed no substantial disparities in effluent quality between samples collected from the canal and those obtained from the planting fields. However, upon further comparison considering environmental factors such as turbidity and monsoon season precipitation, which can result in effluent contact with additional sources of contamination and increased dilution, the author ultimately concludes a notable distinction between canal and planting field effluent quality. The concentration of E. coli in the planting fields was significantly lower than that in the canal effluent.

Data from Babalola (2022) reveals results from only the monsoon season. Meanwhile, data from FHNW, IHE and AKVO (2022) displays the concentration of E. coli during both the monsoon and winter seasons, emphasizing the disparity in concentration between the two seasons (Figure 26).

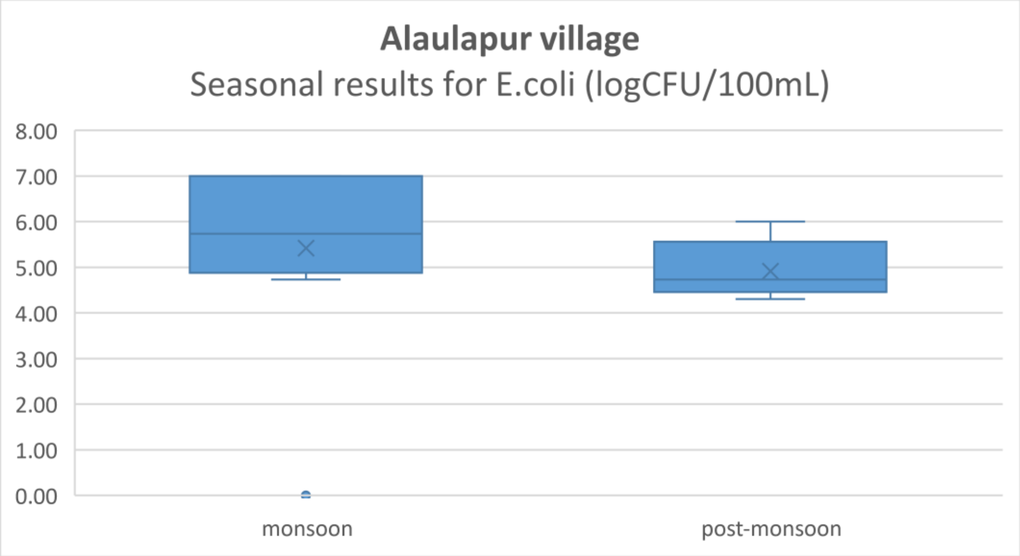

Figure 26 Results for E. coli in the channels and agricultural fields of Alaulapur, for the seasons of monsoon and post-monsoon (winter). Source: FHNW, IHE & AKVO (2022).

It is possible to observe in Figure 26 that the average concentrations of E. coli of the 10 samples collected during monsoon in the irrigation channels vary between 4.73 – 7.0 (±0.1) Log10 CFU/100mL. During winter, referred to as post-monsoon, concentrations varied between 4.30 – 6.0 (±0.1) Log10 CFU/100mL. An analysis of variance (ANOVA) was conducted to assess the variation in E. coli concentrations concerning location and time of visit. P-values of ≤ 0.05 were regarded as indicative of significant differences (Appendix D). The results showed a significant difference in the concentration of E. coli in the effluent reaching the village between the Monsoon and Winter seasons, with Monsoon having the highest concentration. It's noteworthy that farmers plant rice crops precisely during the monsoon, which results in increased direct contact with the effluent in the flooded fields. Figure 27 shows the points of collection of samples in the channel which brings treated effluent to the village.

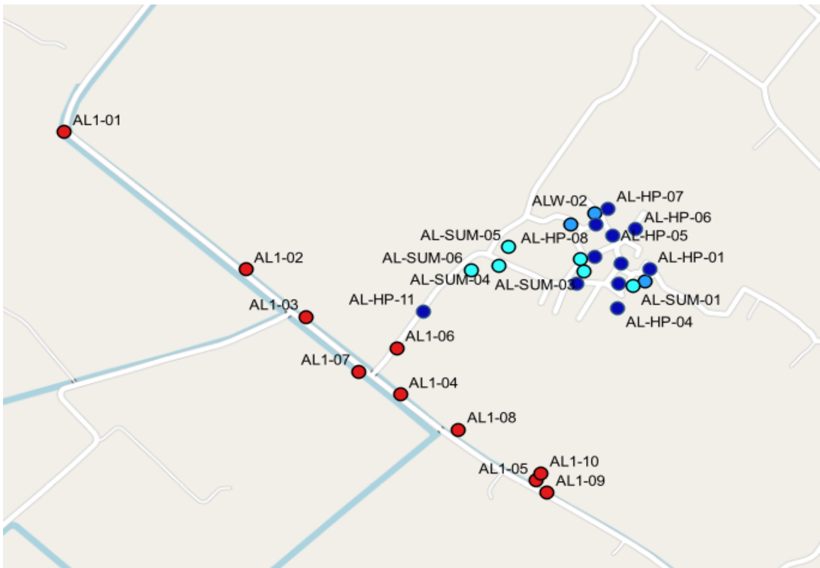

Figure 27 Sample collection points in Alaulapur village. In red, the points where the effluent samples were collected. Source: FHNW, IHE & AKVO (2022).

4.3 Seasonal occupational health risks

4.3.1 Semi-quantitative risk assessment results and discussion

During the 11 field visits in the village of Alaulapur was possible to observe the exposure of the farmers (men and women) in the crop fields and the identification of some of hazards they are exposed interacting with the effluent used for irrigation. These observations were triangulated with the data obtained during the interviews of the daily schedules and seasonal calendar methods to be used in the elaboration of the risk matrix. The results of E. coli were also used to determine the severity of the identified risks, and all the data obtained with all methods were compiled and summarized.

The matrix is divided into two parts (Tables 15 and 16): one for productive work in the crop fields and animal areas, and another for reproductive work in the crop fields, animal areas, and inside homes. Exposure of interviewed family members is categorized based on their daily routines and some findings from Babalola (2022). It's important to note that neither the interviews nor our observations in the village identified children under 11 years old working in the crop fields, which was observed by Babalola in their 2022 study. Therefore, in the columns for girls and boys in this matrix, the presence of children/adolescents aged 12 to 18 is indicated, along with the information from Babalola's work for children younger than this age group. Further investigation is needed in future studies to explore the presence of children in specific activities. As previously mentioned, the risk matrix was developed using information gathered from the daily routine methods (4.1.1), the seasonal calendar (4.1.3), and E. coli concentration results during the Monsoon and winter seasons (4.2.1) as well as field observations. The matrix developed by Babalola (2022) at the same location was also used as a reference.

The matrices are categorized into productive and reproductive work, conducted in three different areas: 1. Crop fields, 2. Animal area (in front of the houses), and 3. Inside the house. They show that productive work is performed by both genders, with a slight predominance of men. Women, on the other hand, can engage in both productive and reproductive work, such as those actively working in the fields while also managing domestic responsibilities. Women who primarily stay at home typically dominate reproductive activities. However, men may participate in these tasks when they are related to activities in the crop fields, such as grass chopping for fodder. It is considered in the matrices both women working in the fields and those working at home. The risk for men and women in the crop fields is considered the same, as well as for children aged 12 to 18, specifically boys, who also engage in activities in these areas irrigated with treated wastewater.

The matrix identified various hazards, including 29 microbial and 1 vector-related biological hazards, 1 ergonomic hazard, and 3 potential chemical hazards. Microbial hazards were determined through E. coli analysis, and those related to helminths were considered present based on Ganguly et al.'s findings (2015), which studied soil-helminth illnesses in India, reporting over 50% occurrence in two-thirds of agricultural regions. Most microbial risks were found in crop fields (15), followed by animal areas (7) and households (7). The presence of flies and mice was prominent in animal areas and households during interview visits, likely due to the high volume of animal faeces throughout the village, especially in front of houses (animal areas). Mosquitoes were also observed in these areas, with a higher concentration inside households.

An unpublished Baseline Survey from the Pavitra Ganga Project (N.D.) identified chemical hazards in the effluent entering Alaulapur village. CPCB's 2020 analyses of effluent from the CETP combined with STP effluent for irrigation detected chromium levels in the range of 6.4

mg/l, exceeding the 2.0 mg/l discharge limit (CPCB, 2021). Physical hazards identified are related to the working positions in the fields, carrying harvested products on their backs, gases produced by effluents and animal faeces and urine found throughout the village. Additionally, we were shown skin problems by the village head and also observed in several villagers. Residents repeatedly attribute these skin issues to contact with the effluent.

Table 15 Seasonal Risk Matrix with Productive work.

Context		Activities and Situations	Hazard identification			Exposure family members				Justification for risk assessment	RISK ASSESSMENT																	
											Existing control measures		SUMMER				Existing control measures		MONSOON				Existing control measures		WINTER			
			Hazardous event	Hazard	Exposure pathways	W	G	M	B		Description	Source of data	L	S	Score	R	Description	Source of data	L	S	Score	R	Description	Source of data	L	S	Score	R
Reuse of treated effluent for irrigation in Alaulapur village — Productive Work	Crop fields	Planting rice seedlings	Direct exposure to contaminated soil while touching effluent flooded soil in rice crop fields	Microbial pathogens, soil helminths, skin irritants	Skin penetration and absorption					Effluent microbiological and chemical quality unsafe (Babalola 2022) and FHNW, IHE & AKVO (2022); farmers interact directly with irrigation water and soil.	No measures	Interviews	5	8	40	VH	No measures	Interviews, observation, E. coli analisys	5	8	40	VH	No measures	Interviews, E. coli analisys	1	1	1	L
	Crop fields	Seeding wheat	Direct exposure to contaminated soil while touching previously effluent flooded soil in wheat crop fields	Microbial pathogens, soil helminths, skin irritants	Skin penetration and absorption					Effluent microbiological and chemical quality unsafe (Babalola 2022) and FHNW, IHE & AKVO (2022); farmers interact directly with previously effluent flooded soil.	No measures	Interviews	1	1	1	L	No measures	Interviews, observation, E. coli analisys	1	1	1	L	No measures	Interviews, E. coli analisys	4	8	32	H
	Crop fields	Fertilizing rice	Exposure to effluent and manure	Microbial pathogens, soil helminths, skin irritants	Skin penetration and absorption, ingestion					Use of manure and other fertilizers like urea and zinc, observed in monsoon and informed in interview. Direct interaction with effluent and soil.	No measures	Interviews	3	4	12	M	No measures	Interviews	5	8	40	VH	No measures	Interviews	1	1	1	L
	Crop fields	Fertilizing wheat	Exposure to effluent and manure	Microbial pathogens, soil helminths, skin irritants	Skin penetration and absorption, ingestion					Use of manure and other fertilizers like urea and zinc, observed in monsoon and informed in interview. Direct interaction with soil previously flooded.	No measures	Interviews	2	2	4	L	No measures	Interviews	2	2	4	L	No measures	Interviews	5	8	40	VH
	Crop fields	Pest controlling rice	Exposure to effluent, herbicides, funicides and insecticides	Microbial pathogens, soil helminths, toxic agrochemicals, and skin irritants	Skin penetration and absorption, inhalation					Evidence of pesticide used observed inside house and from interview.	No measures	Interviews	2	2	4	L	No measures	Interviews, observation	5	8	40	VH	No measures	Interviews	5	8	40	VH
	Crop fields	Pest controlling wheat	Exposure to previously effluent flooded field, herbicides, funicides and insecticides	Microbial pathogens, soil helminths, toxic agrochemicals, and skin irritants	Skin penetration and absorption, inhalation					Evidence of pesticide used observed inside house and from interview.	No measures	Interviews	1	1	1	L	No measures	Interviews, observation	1	1	1	L	No measures	Interviews	5	8	40	VH
	Crop fields	Harvesting rice	Direct exposure to effluent while touching the flooded planting field	Microbial pathogens, soil helminths, skin irritants	Skin penetration and absorption, inhalation, ingestion					Effluent microbiological and chemical quality unsafe (Babalola 2022) and FHNW, IHE & AKVO (2022); farmers interact directly with irrigation water and soil.	No measures	Interviews	5	8	40	VH	No measures	Interviews, E. coli analisys	5	8	40	VH	No measures	Interviews, E. coli analisys	5	4	20	H
	Crop fields	Harvesting wheat	Direct exposure to previously effluent flooded soil while touching the harvested wheat	Microbial pathogens, soil helminths, skin irritants	Skin penetration and absorption, inhalation, ingestion					Effluent microbiological and chemical quality unsafe (Babalola 2022) and FHNW, IHE & AKVO (2022); farmers interact directly with previously effluent flooded soil.	No measures	Interviews	1	1	1	L	No measures	Interviews, E. coli analisys	1	1	1	L	No measures	Interviews, E. coli analisys	5	8	40	VH
	Crop fields	Conveying rice	Indirect exposure to effluent while touching harvested crops	Microbial pathogens, soil helminths, skin irritants	Skin penetration and absorption, inhalation, ingestion					Effluent microbiological and chemical quality unsafe (Babalola 2022) and FHNW, IHE & AKVO (2022); farmers interact directly with harvested crops.	No measures from crop fields to road	Interviews	1	1	1	L	No measures from crop fields to road	Interviews	4	8	32	H	No measures from crop fields to road	Interviews	1	1	1	L
	Crop fields	Conveying wheat	Indirect exposure to previously effluent flooded soil while touching harvested crops	Microbial pathogens, soil helminths, skin irritants	Skin penetration and absorption, inhalation, ingestion					Effluent microbiological and chemical quality unsafe (Babalola 2022) and FHNW, IHE & AKVO (2022); farmers interact directly with previously effluent flooded soil.	No measures from crop fields to road	Interviews	1	1	1	L	No measures from crop fields to road	Interviews	1	1	1	L	No measures from crop fields to road	Interviews	4	8	32	H
	Crop fields	Position when carrying out agricultural activities (ergonomics)	Squatting position and/or spine tilted forward in crop fields for long periods of time. Farmers carrying harvested produce on their backs	Ergonomic related illnesses	Work in the crop fields and conveyance of products					Ergonomically poorly done work can lead to physical spinal problems	No measures	Interviews	5	4	20	H	No measures	Interviews and observation	5	4	20	H	No measures	Interviews	5	4	20	H
	Crop fields	Foul odour leads to disconfort	Malodour	Gases from bacteria, and decomposing organic matter	Inhalation					Prolonged malodour exposure may lead to headaches and comfort (Babalola 2022). Observed and felt in monsoon	No measures	Interviews	4	8	32	H	No measures	Interviews, observation	4	8	32	H	No measures	Interviews	3	4	12	M
	Crop fields	Repairing and mantaining irrigation channels	Exposure to irrigation water while creating pathways from irrigation channel to field leads to illness	Microbial pathogens, soil helminths, skin irritants	Skin penetration and absorption, inhalation, ingestion					Effluent microbiological and chemical quality unsafe (Babalola 2022) and FHNW, IHE & AKVO (2022); farmers interact directly with irrigation water and soil	No measures	Babalola (2022)	5	8	40	VH	No measures	Observation, Babalola (2022)	5	8	40	VH	No measures	Babalola (2022)	5	8	40	VH
	Crop fields	Taking animals for grazing	Indirect exposure to effluent while touching the wet buffaloes	Microbial pathogens, skin irritants	Skin penetration and absorption					Effluent microbiological and chemical quality unsafe (Babalola 2022) and FHNW, IHE & AKVO (2022); farmers interact directly with buffaloes (observed in monsoon)	No measures	Interviews	3	2	6	M	No measures	Interviews, observation	3	2	6	M	No measures	Interviews	2	2	4	L
	In front of the houses (Animal area)	Milking buffaloes	Indirect exposure to effluent while touching the wet (no or badly washed) buffaloes udder	Microbial pathogens, skin irritants	Skin penetration and absorption					Effluent microbiological and chemical quality unsafe (Babalola 2022) and FHNW, IHE & AKVO (2022); farmers interact directly with buffaloes (observed in monsoon)	Bathing buffaloes and themselves (No evidence that is done always before milking)	Interviews	4	2	8	M	Bathing buffaloes and themselves (No evidence that is done always before milking)	Interviews, observation	4	2	8	M	No measures	Interviews	3	2	6	M
	In front of the houses (Animal area)	Selling milk	Milk contamination by indirect exposure to effluent while touching the wet (no or badly washed) buffaloes udder	Microbial pathogens	Ingestion					No information	No information	No information	3	4	12	M	No information	Observation	3	4	12	M	No information	No information	3	2	6	M

Table 16 Seasonal Risk Matrix with Reproductive work.

Context		Activities and Situations		Hazard identification			Exposure family members				Justification for risk assessment	RISK ASSESSMENT: Existing control measures		SUMMER				Existing control measures		MONSOON				Existing control measures		WINTER			
				Hazardous event	Hazard	Exposure pathways	W	G	M	B		Description	Source of data	L	S	Score	R	Description	Source of data	L	S	Score	R	Description	Source of data	L	S	Score	R
Reuse of treated effluent for irrigation in Alaulapur village	Reproductive Work	Crop fields	Harvesting grass for fodder	Direct exposure to effluent while touching the flooded planting field	Microbial pathogens, soil helminths, skin irritants	Skin penetration and absorption, inhalation, ingestion					Effluent microbiological and chemical quality unsafe (Babalola 2022) and FHNW, IHE & AKVO (2022); farmers interact directly with harvested grass	No measures	Interviews	5	8	40	VH	No measures	Interviews, observation, E. coli analisys	5	8	40	VH	Not done during winter	Interviews, E. coli analisys	2	2	4	L
		Crop fields	Conveying collected fodder	Indirect exposure to effluent while touching the harvested grass	Microbial pathogens, soil helminths, skin irritants	Skin penetration and absorption, inhalation, ingestion					Effluent microbiological and chemical quality unsafe (Babalola 2022) and FHNW, IHE & AKVO (2022); farmers interact directly with harvested grass	No measures from crop fields to road	Interviews	5	8	40	VH	No measures from crop fields to road	Interviews, observation, E. coli analisys	5	8	40	VH	Not done during winter	Interviews	2	2	4	L
		Crop fields	Presence of children playing in the the irrigation channels	Exposure to irrigation water while playing in the open irrigation channels leads to illness	Microbial pathogens, skin irritants	Skin absorption, ingestion		0-11 yo		0-11 yo	Children assist their parents on the farm and were observed playing in the irrigation channels by Babalola (2022)	No measures	Babalola (2022)	5	4	20	H	No measures	E. coli analisys, observation by Babalola (2022)	5	4	20	H	No measures	E. coli analisys	3	4	12	M
		In front of the houses (Animal area)	Processing and shredding grass for fodder	Indirect exposure to effluent while touching the harvested grass	Microbial pathogens, soil helminths, skin irritants	Skin penetration and absorption, inhalation, ingestion					Effluent microbiological and chemical quality unsafe (Babalola 2022) and FHNW, IHE & AKVO (2022); farmers interact directly with harvested grass	No measures	Interviews	4	4	16	H	No measures	Interviews, observation, E. coli analisys	4	4	16	H	Not done during winter	Interviews	2	2	4	L
		In front of the houses (Animal area)	Bathing animals	Indirect exposure to effluent while touching the wet buffaloes coming back from bathing inside the effluent channel	Microbial pathogens, skin irritants	Skin penetration and absorption, inhalation, ingestion					Effluent microbiological and chemical quality unsafe (Babalola 2022) and FHNW, IHE & AKVO (2022); farmers interact directly with buffaloes (observed in monsoon)	No measures	Interviews	5	2	10	M	No measures	Interviews, observation, E. coli analisys	5	2	10	M	No measures	Interviews, observation, E. coli analisys	3	2	6	L
		In front of the houses (Animal area)	Cleaning the animal area	Direct exposure to animal faeces and effluent washed from the buffaloes bodies	Microbial pathogens, skin irritants	Skin penetration and absorption, inhalation, ingestion					Effluent microbiological and chemical quality unsafe (Babalola 2022) and FHNW, IHE & AKVO (2022); farmers interact directly with buffaloes' faeces and urine buffaloes, and effluent from buffaloes bodies (observed in monsoon)	No measures	Interviews	4	2	8	M	No measures	Interview, observation, E. coli analisys	4	2	8	M	No measures	Interviews, E. coli analisys	4	1	4	L
		In front of the houses (Animal area)	Presence of mosquitoes and flies	Vector related diseasesaids the transmission of malaria, dengue fever, potential contamination of food and infections	Bacteria and other microbial pathogens	Mosquito bites, flies landing on the skin					As flies are included, the severity selected was increased, comparing with Babalola (2022)	No measures	Interviews	5	4	20	H	No measures	Interviews, observation	5	4	20	H	No measures	Interviews	4	4	16	H
		In front of the houses (Animal area)	Foul odour	Foul odour leads to disconfort	Malodour from animal faeces and urine	Inhalation					Prolonged malodour exposure may lead to headaches and comfort (Babalola 2022). Oberved and felt in monsoon	No measures	Interviews	4	8	32	H	No measures	Interviews, observation	4	8	32	H	No measures	Interviews	4	2	8	M
		In front of the houses (Animal area)	Feeding the animals	Possible indirect exposure to effluent while touching the wet buffaloes coming back from bathing inside the effluent channel	Microbial pathogens, skin irritants	Skin penetration and absorption					Related to grass shreding without cleaning the grass from the irrigated fields	No measures	Interviews	2	2	4	L	No measures	Interviews, observation	2	2	4	L	No measures	Interviews	2	1	2	L
		Inside houses	Processing	Indirect exposure to effluent while touching the harvested grass	Microbial pathogens, soil helminths, skin irritants	Skin absorption					Effluent microbiological and chemical quality unsafe (Babalola 2022) and FHNW, IHE & AKVO (2022); farmers interact directly with harvested grains	No measures	Interviews	4	2	8	M	No measures	Interviews	4	3	12	M	No measures	Interviews	2	1	2	L
		Inside houses	Storing milk	Indirect exposure to effluent while touching the wet (no or badly washed) buffaloes udder	Microbial pathogens, soil helminths, skin irritants	Skin absorption, ingestion					Related to grass shreding without cleaning the grass from the irrigated fields	No measures	Interviews	3	1	3	L	No measures	Interviews	3	1	3	L	No measures	Interviews	3	1	3	L
		Inside houses	Drinking milk produced	Possible contaminated milk from the milking process	Microbial pathogens, soil helminths, skin irritants	Ingestion					Milk is consumed by the family apparently without higienic milking practices	Cooking process	Interviews	3	4	12	M	Cooking process	Interviews, observation	3	4	12	M	Cooking process	Interviews	3	4	12	M
		Inside houses	Cooking meals and consuption of contaminated crops	Indirect exposure to effluent microbial pathogens while back from the field and cooking without adequate bathing	Microbial pathogens, soil helminths, skin irritants	Skin absorption, ingestion					Harvested crops are cooked without proper cleaning and sanitizing and consumed immediately	Cooking process	Interviews, Babalola (2022)	3	4	12	M	Cooking process	Interviews, Babalola (2022)	3	4	12	M	Cooking process	Interviews, Babalola (2022)	3	4	12	M
		Inside houses	Cleaning dishes and cookware	Indirect exposure to effluent while back from the field and cleaning dishes and cookware without adequate bathing	Microbial pathogens, soil helminths, skin irritants	Skin absorption, ingestion					Possible cross-contamination	No information	No information	3	2	6	L	No measures	Interviews, observation	3	2	6	L	No information	No information	3	2	6	L
		Inside houses	Cleaning the house	No	No	No						No information	Interviews	3	1	3	L	No information	Interviews, observation	3	1	3	L	No information	Interviews	3	1	3	L
		Inside houses	Preparing children to school	No	No	No						No information	Interviews	2	1	2	L	No information	Interviews	2	1	2	L	No information	Interviews	2	1	2	L
		Inside houses	Packaging food for husband	No	No	No						No information	Interviews	3	1	3	L	No information	Interviews	3	1	3	L	No information	Interviews	3	1	3	L
		Inside houses	Preparing uniform for husband	No	No	No						No information	Interviews	1	1	1	L	No information	Interviews	1	1	1	L	No information	Interviews	1	1	1	L
		Inside houses	Teaches children	No	No	No						No information	Interviews	1	1	1	L	No information	Interviews	1	1	1	L	No information	Interviews	1	1	1	L
		Inside houses	Filling water tank	Indirect exposure to effluent while back from the field and filling water tank without adequate bathing	Microbial pathogens, soil helminths, skin irritants	Skin absorption, ingestion					Possible cross-contamination	No measures	Interviews	3	4	12	M	No measures	Interviews	3	4	12	M	No measures	Interviews	3	4	12	M
		Inside houses	Laundry	No	No	No						No information	Interviews	1	1	1	L	No information	Interviews	1	1	1	L	No information	Interviews	1	1	1	L
		Inside houses	Prepares table for meals	Indirect exposure to effluent while back from the field and prepare table without adequate bathing	Microbial pathogens, soil helminths, skin irritants	Skin absorption					Possible cross-contamination	No information	Interviews	3	1	3	L	No information	Interviews	3	1	3	L	No information	Interviews	3	1	3	L
		Inside houses	Lack of adequate cleaning of the animal area	Foul odour leads to disconfort	Malodour from animal faeces and urine	Inhalation					Malodour may lead to headaches and discomfort (Babalola 2022)	No measures	Interviews	5	2	10	M	No measures	Observation during interviews, Babalola (2022)	5	2	10	M	No measures	Interviews	3	2	6	L
		Inside houses	Lack of adequate cleaning of the animal area	Mice breeding inside the house leads to illness	Vector related diseases	Skin contact, bites					Exposure to mice faeces and urine may lead to illness. Observed in monsoon	No information	Interviews	5	4	20	H	No information	Observation during interviews	5	4	20	H	No information	Interviews	5	4	20	H

One identified activity that may pose an indirect risk, warranting further investigation, is milk production in the village. Buffaloes, cows, and goats are milked in front of houses with minimal hygiene precautions. Buffaloes were observed being milked after returning from the fields where they were completely immersed in one of the effluent canals. The milk is stored inside houses, used for family consumption, and sold twice daily in the village.

The graphs in Figure 28 reveal that there is no seasonal difference in the quantity of risks; differences are related solely to work locations. Seventeen hazards were identified in crop fields, nine in the animal area, and a surprising fifteen potential hazards inside houses.

Seasonal differences, particularly between the Monsoon and Winter seasons, were noteworthy. During our visits, community members frequently mentioned that Monsoon season brings increased dirt and disease due to the presence of rainwater throughout the village. The variations in risks between seasons are illustrated in Figure 28, which depicts seasonal differences at each location, and Figure 29, showing no differences in the total numbers and levels of identified risks for each season: summer (41), Monsoon (41) and Winter (40).

As expected, there is a correlation between the type of crop and the associated risks, as rice is planted and grows in fields irrigated with effluent. This suggests that the risk is more related to the type of crop than the season of the year. The village head informed us during one of the interviews that the effluent quality remains poor throughout the year. However, the results of E. coli analyses revealed higher contamination levels during the Monsoon season, precisely when flooded rice cultivation takes place. Consequently, an already risky practice becomes even riskier during this period. This situation calls for increased caution or the avoidance of effluent use for this crop during Monsoon season.

Regarding the classification of identified risks, there were seventeen risks classified as very high in crop fields and none in the animal area and inside houses. For risks classified as high, there were eleven in crop fields, seven in the animal area, and three inside houses. For medium risks, five were identified in crop fields, thirteen in the animal area, and thirteen inside houses, while for low risks, eighteen were found in crop fields, six in the animal area, and twenty inside houses.

Exposure to irrigation water is being considered, as discussed by Babalola (2022), which includes direct contact with effluent on the skin without protection during activities such as planting seedlings, fertilizing with chemical fertilizers and animal manure, pest control using backpack sprayers, harvesting, and carrying harvested products on the back.

Children and adolescents observed working in the crop fields, aged between 12 and 18, were noted. Children below this age group were neither observed nor mentioned in interviews as working in the crop fields. However, Babalola (2022) and the community leader observed the presence of children, with the latter affirming their year-round presence in the fields.

Additional hazardous events are related to the presence of large quantities of livestock faeces and urine, as well as the characteristic odour of wastewater. It's important to note that the strong odour detected along the channels was surprising, as properly treated wastewater should not have such a pungent odour. The pervasive foul odour in the village, along with the abundance of animal waste, may be responsible for the large number of flies observed, especially inside houses and in the animal area. This raises concerns regarding food preparation and consumption in households, as flies are important vectors of various diseases.

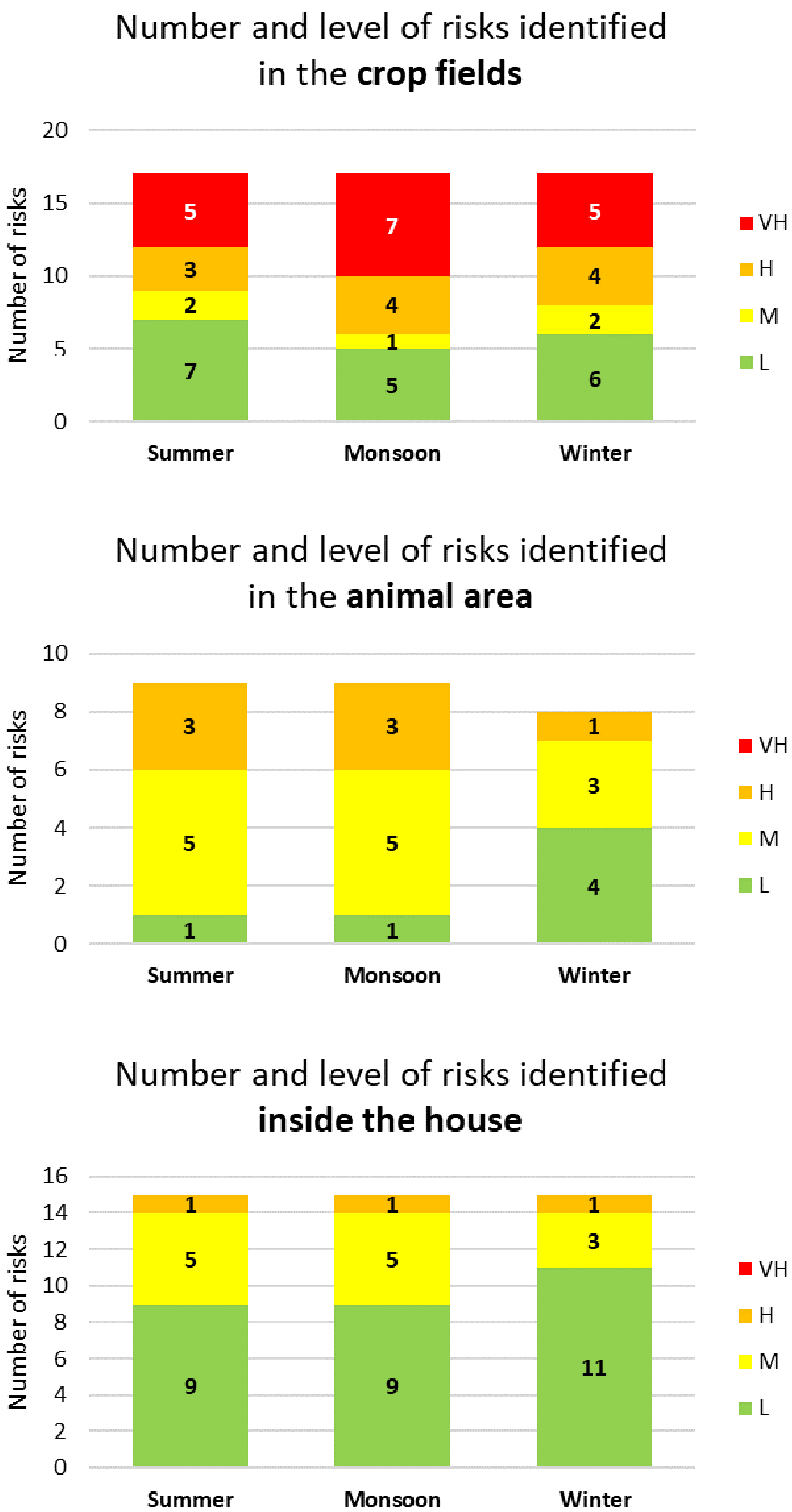

Figure 28 Number and level of risks identified in the crop fields, in front of the houses (animal areas), and inside of the house, in different seasons (Summer, Monsoon, and Winter).

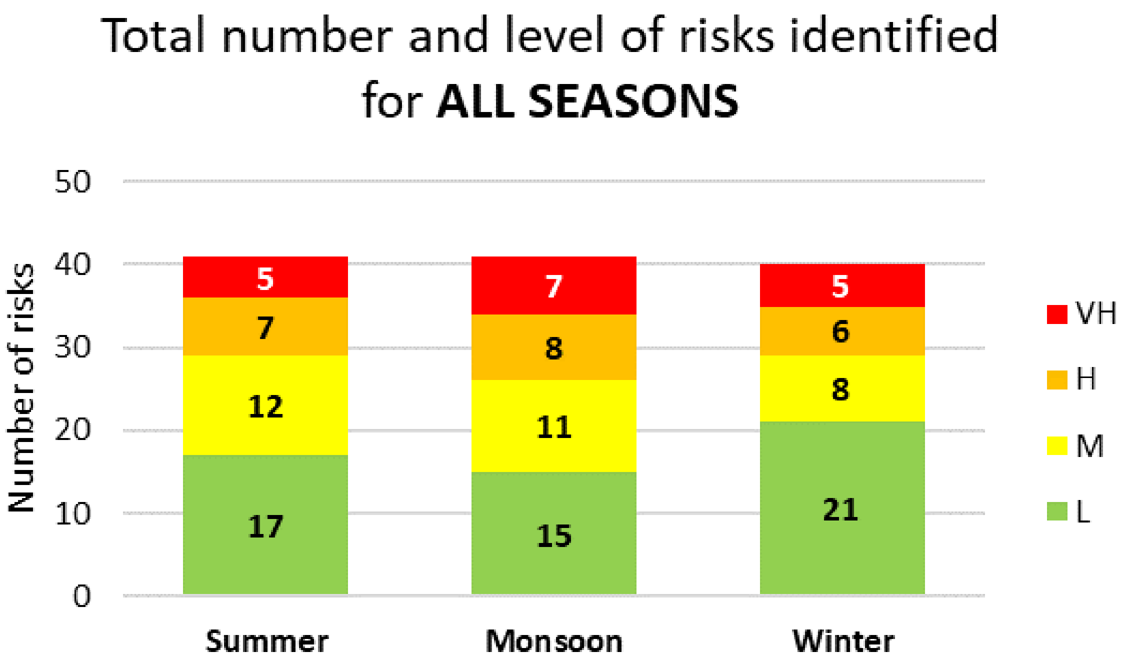

Figure 29 Total number and level of risks identified in the crop fields, in front of the houses (animal areas), and inside of the house, in different seasons (Summer, Monsoon, and Winter).

During interviews with families and the village head, it was mentioned that no protective measures are taken for work in the rice fields. This was also observed during village visits, where both men and women were seen working with their legs immersed without any protection in the flooded fields (Cover figure of this document). These findings confirm what Babalola (2022) identified, that farmers have not implemented any control measures to mitigate risks related to direct contact through skin absorption and ingestion during farm work.

Regarding the fly situation, some "mortein coil" insecticides were observed, but they appeared ineffective due to the large number of flies. The only measure taken to protect against contamination of both the produced grains and potential contamination of milk was boiling and cooking them before consumption. Detailed information about diseases in the village beyond those presented through the seasonal calendar was not available, and there was no in-depth investigation into pesticide use without protection.

Based on the analysis results from both Babalola (2022) (> 5.8 Log10CFU/100mL) and FHNW, IHE & AKVO (2022) (> 6.0 Log10CFU/100mL and >4.9 Log10CFU/100mL), the levels exceeded the threshold limit of <3.0 Log10 CFU/100mL set for safe use in labour-intensive irrigation practices. These values may reduce health risks but still remain unsafe due to the concentrations exceeding the limit.

Figure 30 presents graphs for each season, showing that during summer and monsoons, women are exposed to a greater quantity of risks with lower intensity levels, while men and boys face nearly the same quantity of hazards but with higher risk levels compared to women. The situation is the same in winter, confirming that there are no noticeable seasonal differences in the quantity of risk to which genders are exposed.

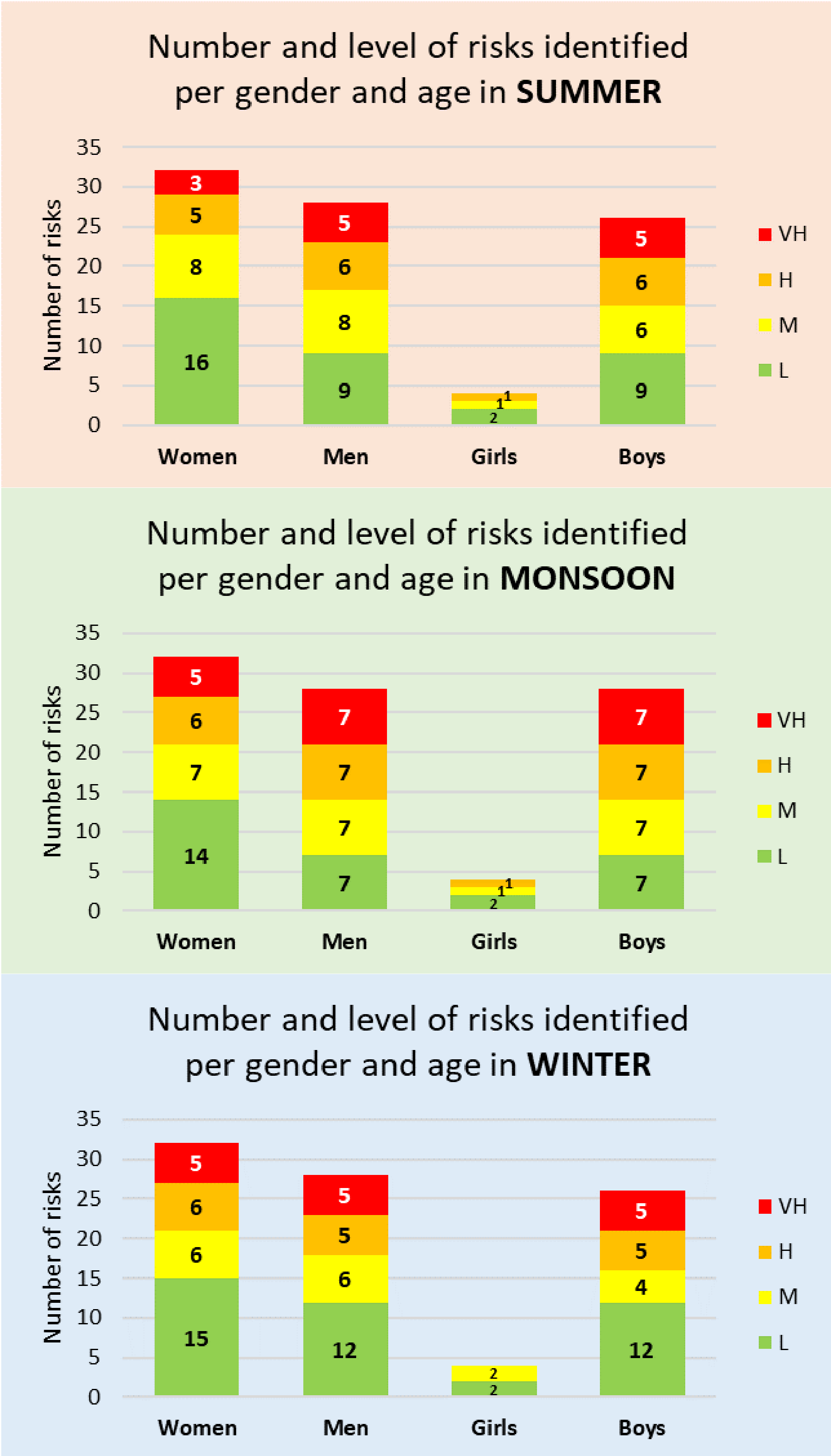

Figure 30 Number and level of risks identified per gender and age in Summer, Monsoon, and Winter.

The results indicate that productive work is performed by both genders, with a slight predominance of men. Women, on the other hand, can engage in both productive and reproductive tasks, such as those actively working in the fields while also managing domestic duties. Women who remain in their residences typically handle reproductive activities, which men participate in primarily when related to fieldwork, e.g., grass chopping for forage. The dual role of women in the field and domestic work may suggest increased exposure to effluent contamination and potential cross-contamination within the household if proper cleaning measures are not taken before domestic tasks. However, further in-depth research on women is necessary to assess the specific details of their fieldwork and the measures they take upon returning home.

Summarizing the risk assessment:

Exposure points and frequency:

Men: Direct contact with wastewater during irrigation in flooded fields; planting rice, wheat, and grass in contaminated fields; bringing buffaloes to irrigation canals and subsequently managing them post-swim; and repairing and maintaining irrigation channels.

Women: Direct contact with wastewater while assisting in planting, handling, and washing crops harvested from contaminated fields, caring for and feeding the animals post-exposure, and cleaning equipment, clothing, and animal resting places.

Children: Playing in or near the flooded fields and canals, assisting parents in farming activities, and handling and playing with animals that have been in contaminated areas.

Animals (Buffaloes, Cows, Goats): Swimming or drinking from irrigation canals, feeding on contaminated crops/grass, physical contact with contaminated soil/sediment. Animals are both exposure grounds and transmission pathways.

Disease risk and transmission pathways:

Men, Women, Children: Consumption of crops grown in contaminated fields, dermal contact leading to infections, inhalation of aerosols during farming activities, transfer of pathogens via hands to mouth, eyes, or other mucous membranes.

Animals: Ingestion of contaminated water leads to internal infections, skin infections from continuous exposure, and transfer of pathogens to humans through direct contact.

Protective measures and hygiene practices NOT identified:

Men: Protective clothing, gloves, and boots during farming activities, showering after working in the fields, safe storage and cleaning of tools and equipment.

Women: Gloves and protective wear during handling of crops and animals, thorough washing of hands post-activities, distinct washing mechanisms for contaminated clothes and tools.

Children: Educative measures to limit playing in contaminated zones, immediate cleaning after potential exposures, and protective clothing if assisting in farming tasks.

Animals: Regular cleaning post-exposure, monitoring for signs of diseases, vaccinations, if available.

Household environment impact:

Men, Women, Children: Transfer of contaminants from fields to homes through clothes, tools, and equipment, contaminated animals living close to the dwelling areas, potential for disease vectors like mice and flies breeding in contaminated zones.

Animals: Close proximity to homes increases the risk of disease transfer, contaminated waste, or faeces in home-front areas.

Socio-cultural practices:

Men: Community meetings or gatherings in or near contaminated zones, shared resources, or tools leading to heightened risk.

Women: Shared water sources for cleaning or cooking, traditional roles exposing them to more contaminated materials. -

Children: Playing in high-risk areas, sharing food or water in these areas, playing with friends in front of the houses and other parts of the village contaminated streets.

Chapter 5 Conclusion

5.1 General conclusions

This chapter provides a summary of the conclusions derived from the analyzed data and findings, addressing each research question. From the results obtained throughout this research, where the seasonal variation in occupational health risk for farming families reusing treated wastewater effluent was explored in an Indian rural village, the following conclusions can be inferred.

5.1.1 Effluent reuse practices, by family members and season

Farmers identified three seasons: Summer, Monsoon, and Winter. Based on the interviews, no differences were identified between Summer and Monsoon regarding the activities performed by farmers. The difference arises between Monsoon and Winter due to the cultivation of rice in the Monsoon season and wheat in Winter. Although the focus of this study was on agricultural activities in the crop fields, animal husbandry, which was not the primary focus, proved to be significant in terms of contact with wastewater. By raising water buffaloes, farmers allow their animals to enter wastewater channels daily and become fully submerged. The return of these animals to their homes after this "bath" can potentially pose a contamination risk to the entire family, as the animals live in front of the houses. The milking of these animals also presents a potential contamination risk, as no pre-milking animal hygiene measures were observed. Seasonally, the identified differences in activities are related to increased contact with wastewater during the Monsoon months when rice is cultivated, as this crop remains flooded, compared to the Winter period when wheat is grown in dry, post-flood fields.

Regarding family members, it was possible to identify that some women actively work in irrigated crop fields, performing the same activities as men, while others remain at home performing domestic tasks and taking care of animals. In the case of children, adolescent boys aged 12 to 18 were identified as engaging in the same activities as their parents in the crop fields. It was not possible to determine if the same applies to girls of the same age. Neither observation nor information from residents indicated the presence of children under 12 years old in the fields. In general, the only activities not performed by all eligible family members are the domestic tasks, primarily undertaken by women, and occasionally accumulated by them.

5.1.2 Seasonal variation in effluent quality

Farmers consistently perceived the quality of irrigation effluent as persistently poor, regardless of the season. However, it's noteworthy that some farmers acknowledged deteriorating conditions during the monsoon due to increased rainfall, leading to heightened village dirtiness and illness among residents. Secondary data analysis, focusing on E. coli concentrations, supported these observations. The effluent within the village consistently exhibited contamination levels exceeding legal thresholds, posing health risks to farmers. Specifically, during the monsoon season, E. coli concentrations were significantly elevated compared to winter. These findings underscore the year-round challenges posed by poor effluent quality and emphasize the exacerbated risks during the monsoon, highlighting the need for enhanced wastewater management and quality monitoring in agricultural practices.

5.1.3 Seasonal occupational health risk

The occupational hazards are primarily associated with direct contact with potentially pathogenic microorganisms and chemicals, and the posture during farming activities. In Alaulapur, these risks are exacerbated due to direct exposure to wastewater effluent, which is confirmed to be contaminated with E. coli and harmful chemicals like chromium. This exposure occurs while working in submerged rice crop fields during the monsoon season and, to a lesser extent, when working with wheat crops in post-flood dry crop fields during the winter. Winter is comparatively less risky than the monsoon due to agricultural practices for wheat cultivation being less reliant on direct contact with wastewater and the absence of the need for forage harvesting for animals. According to farmers, winter, with its lower temperatures and reduced contact with wastewater, experiences fewer diseases in both people and village animals.

Activities conducted within households are closely linked to animal-related activities in front of the houses. The proximity of animals to the house entrances, which have daily direct contact with canal effluents, poses a risk of carrying direct field contamination into homes, putting all family members of all genders and ages at risk throughout the year. Families also consume products from the waterlogged fields and milk produced without adequate hygiene measures. All individuals in these families living under these conditions are exposed to biological risks such as microbial pathogens, soil helminths, and vector-related diseases, as well as chemical hazards involving heavy metals, including substances used for pest control. Additionally, physical hazards related to unpleasant odours and skin irritants are present.

The presence and direct contact of livestock with effluent channels have drawn attention. The lack of observed measures for proper cleaning and disinfection of these animals after contact with effluent, followed by their presence in front of residences for milking, presents a potential contamination risk for all family members, even those who do not work in the fields. This aspect of animal husbandry in contact with effluent should be included in future studies evaluating the reuse of treated wastewater effluent, not limited to agricultural activities alone. Agricultural and animal husbandry activities are highly interdependent in the village of Alaulapur throughout the year, conducted daily without interruption, and should be collectively evaluated in future studies on occupational risk assessments.

Chapter 6 Limitations

6.1 General limitations

This chapter discusses the research challenges and limitations that impacted the study's scope.

1. Initially, the research aimed to gather data through participatory methods. However, a significant challenge arose due to the language barrier, making it difficult to find a proficient translator/interpreter. An effective translator for participatory research needed not only translation skills but also sensitivity to the participatory approach, including information exchange, active listening, and the understanding of the importance of asking non-leading and pressing questions.
2. The residents' lack of interest and apparent reluctance towards research and researchers, was consistently expressed during visits. This hindered the use of all initially planned participatory methods. Consequently, certain family members, such as women and girls, did not fully participate, resulting in limited insights into their experiences.
3. The study, originally intended to involve 10 families, ultimately engaged only eight, primarily due to issues with one of the translators and a general lack of community interest.
4. Due to time constraints and the inability to access other identified exposure groups, the study could not encompass the entire community, resulting in limited information regarding the community's health risks.
5. Additionally, the investigation into seasonal variations was constrained because data collection could not be conducted during different seasons.

Chapter 7 Recommendations

7.1 Safety measures

In general:

- Improved wastewater treatment methods before use in irrigation.
- Community awareness campaigns tailored for different gender and age groups.
- Assistance in shifting to safer farming and irrigation methods.
- Regular health check-ups for the community.
- Regular monitoring of water and soil quality in fields.

7.2 Future research

For future studies intending to utilize participatory methods, it's crucial to allocate sufficient time for more extensive and improved community interaction. Even if the study isn't focused on local development, the community will naturally expect it. The desire for the study to be meaningful and beneficial for their future should always be considered, and adequate time should be incorporated for participatory activities with necessary prior interaction between external researchers and the community. Without a minimum level of proper rapport between external researchers and village co-researchers, one cannot expect interest or participation as trust is lacking. Any study that proposes to use participatory methods must always be preceded by the target group's interest in participation, as a result of understanding the need for the study and its possible results to improve their quality of life. Such action is crucial so that the proper depth and detail of the information is achieved.

The strong connection between agriculture and livestock should always be considered in studies evaluating wastewater reuse in agricultural areas. There is significant interaction between animals, cultivated fields, and humans, leading to potential cross-contamination, which offers ample room for further research in this area.

The practice of spraying pesticides, fungicides, and herbicides deserves in-depth study since farmers were observed performing this practice without any protection. This is essential to distinguish risks related to contact with wastewater effluent from risks associated with hazardous chemicals commonly used as herbicides, pesticides, and fungicides.

As emphasized by Babalola (2022), it's crucial to conduct studies assessing the presence of soil-borne helminths associated with wastewater effluent. Such studies are also important to differentiate risks in different types of soil, whether flooded or post-flooding.

Another important aspect to explore in future studies is the activities carried out by women in the fields and upon returning to their homes, and the risks related to them. Such studies should ideally be conducted by female researchers, accompanied when necessary by female translators, using participatory methodology.

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Appendices

Appendix A. - Research ethics declaration form

IHE DELFT Institute for Water Education
under the auspices of UNESCO

Research Ethics Committee
IHE Delft Institute for
Water Education
E ResearchEthicsCommittee@un-ihe.org

Date:	2023-07-19
To:	Delmo Roncarati Vilela
MSc Programme:	Water and Sustainable Development
Approval Number:	IHE-RECO 2023-dro005bwa14

Subject: Research Ethics approval

Dear Delmo,

Based on your application for Ethical Approval, the Research Ethics Committee (RECO) of IHE Delft RECO gives ethical clearance for your research topic "*Seasonal variation in occupational health risk for farming families reusing treated wastewater effluent in Kanpur, India*".

This approval is valid until September 30, 2023.

The approval is based on the information submitted in the research ethics application form and endorsed by your mentor or supervisor. The approval of the Ethical Review Board concerns ethical aspects, as well as data management and privacy issues (including the GDPR). It should be noted that any changes in the research design oblige a renewed review by the Ethical Review Board.

Keep this letter for your records and include a copy of it in the final version of your MSc thesis, together with your personal ethics reflection.

On behalf of the Research Ethics Committee, I wish you success in the completion of your research.

Yours sincerely,

Dr. Emanuele Fantini
Coordinator, Research Ethics Committee IHE Delft

Copy to: Archive

PO Box 3015, 2601 DA Delft, The Netherlands • Westvest 7, 2611 AX Delft • T +31 15 215 17 15 • info@un-ihe.org • www.un-ihe.org

Appendix B. - Personal declaration

I, Delmo Roncarati Vilela, hereby declare that the results and analysis presented in this report, for the thesis titled "Seasonal variation in occupational health risk for farming families reusing treated wastewater effluent in Kanpur, India," have been compiled by me. I designed my research with the guidance and support of my mentor and supervisor. The financial support provided by the Bill and Melinda Gates Foundation (BMGF) facilitated the necessary expenses for accommodation, travel, and other essential costs required for conducting this research.

The research objectives were structured to critically investigate the existence of seasonal variations in occupational health risks associated with wastewater reuse for irrigation by different farm family members in the city of Kanpur, using a semi-quantitative risk assessment approach. To minimize errors and enhance the robustness of the research, I employed a mixed data collection method, obtaining both qualitative and quantitative data through triangulation of participatory methods, key-informant interviews, observations, and secondary microbiological analysis. These methodologies have been chosen with the intention that they can be readily replicated by other researchers.

During the data collection phase, I collaborated with field assistants, providing them with training on my research methods, which included research ethics and obtaining informed consent from participants with documents in Hindi (Appendix C) before engaging in activities such as note-taking, recording, and photography. The welfare of the participants was paramount, and I ensured that their participation was entirely voluntary. Given the linguistic diversity among participants, I employed a translator throughout the study and provided interview guides in simplified language to facilitate translation.

The knowledge acquired during the study period at IHE has been applied in practice, enhancing my understanding of sanitation, wastewater effluent reuse, and research methodologies. Additionally, I incorporated secondary data from reputable sources with proper referencing to augment the thesis's comprehensiveness.

Under the mentorship of Dr. Claire Furlong, the support of the PhD student Ms. Lena Breitenmoser, and the supervision of Prof. Tineke Hooijmans, adhering to ethical standards, I maintained the anonymity of the subjects by employing codes for all families in the village. The results have not been manipulated, and I have followed established grammar rules in discussing the findings to the best of my knowledge. This report has been structured for clarity and comprehension for the benefit of the readers. With these considerations, I certify that I am the author and compiler of this thesis.

Appendix C. - Guides for informed consent process

PARTICIPANT INFORMATION SHEET

Dear Participant, my name is Delmo Roncarati Vilela, an MSc student of IHE - Institute of Water Education. I am working on a research titled: "**Seasonal variation in occupational health risk for farming families reusing treated wastewater effluent in Kanpur, India**".

The objectives are:
1. To describe practices related to reuse of treated effluent in agriculture carried out by different family members in different seasons.
2. To assess seasonal variation in effluent quality from the sewage and common effluent treatment plants.
3. To assess the seasonal occupational health risk for different farming family members using a semi-quantitative risk assessment.

Please take your time to read through the following information carefully to be aware of the research purpose and what it involves before deciding to participate in any activity of research. If you have any questions or would like additional information, please feel free to ask the researcher.

Overview

The research project is a part of the Pavitra Ganga project, which aims to explore the community and occupational health risks associated with wastewater treatment and reuse for irrigation. **In my research, I would like to know if there is a risk of working with irrigation using effluent IN DIFFERENT SEASONS OF THE YEAR and by different people in the family (MAN, WOMAN AND CHILDREN).**

What have you been asked to do? I am inviting you to participate in my MSc research study by participating in anonymous and confidential activities which can be (not necessarily all):

Transect walk: 1-1.5 hour in separate groups of men and women (woman perform for their children). A walk throughout the farm to talk about the places you work there, what you do, who does what, the seasonal environmental differences in each visited place and your activities in each season.

Daily schedule: 1 hour. Man, woman (woman perform for their children). A discussion about what you do during 24h, how is your day usually and, if it changes in different seasons.

Seasonal Calendar: 1.5 – 2 hours in groups of men and women (woman perform for their children). To discuss and create a matrix with each month of the year showing different activities and the conditions of the farm related to presence of water, times to work with the crops, where is used irrigation etc.

Risk Assessment: 1.5 – 2 hours. In groups of men and women (woman perform for their children). A meeting where we going to listen and understand your opinions and current practices regarding wastewater treatment and reuse risks. A matrix will be created with the information about risks in different seasons and foe men, women and children.

- **Your name will not be used**, just your opinion and the information you want to give.
- Data obtained from you will only be used for the study and will not be shared with anyone outside our project team. Your participation is entirely **voluntary**, and you are not obliged to be a part of any methods showed above.
- **You can stop** your participation at any moment if you want.
- **You don't have to answer a question if you don't want to.**

I hope you will agree to participate since your opinion are essential. I will share the summary of my findings with you upon completion of the research. In case you need more information on the study, feel free to contact me on:

Contact information - Delmo Roncarati Vilela.

MSc. Sanitation at IHE- Institute of water education. Westvest 7, 2611 AX Delft/ P.O.Box 3015, 2601 DA Delft The Netherlands +31 (0)6 85022396 / +5531997277299 (Whatsapp) / **India: +91 91208 25177** dro005@un-ihe.org

CONSENT DECLARATION

Consent to take part in the research:

"Seasonal variation in occupational health risk for farming families reusing treated wastewater effluent in Kanpur, India".

The objectives of the study:

1. To describe practices related to reuse of treated effluent in agriculture carried out by **different family members in different seasons**;

2. To assess seasonal variation in **effluent quality** from the sewage and common effluent treatment plants;

3. To assess the **seasonal occupational health risk for different farming family members** using a semi-quantitative risk assessment.

Please check the box to show your agreement to the following points:

I confirm that I have read and understood the information sheet for the above research.	
I have had the opportunity to read the information, ask questions and have had these answered satisfactorily.	
I agree that my participation is voluntary.	
I agree that I am free to withdraw at any moment.	
I consent to have the session recorded and photographs taken.	
I agree to take part in the method(s) described in page 1:	
I agree that you contact me again to clarify any information.	

If you have any questions or concerns about the research, you can contact me:

Delmo Roncarati Vilela.
MSc. Sanitation at IHE- Institute of water education.
Westvest 7, 2611 AX Delft/ P.O.Box 3015, 2601 DA Delft The Netherlands

Phone numbers:
India: +91 91208 25177
Netherlands: +31 (0)6 8502 2396
Brazil: +55 31 9 9727 7299 (Whatsapp)
E-mail: dro005@un-ihe.org

Code of the participant	dd-mm-yyyy	Signature

NOTE: If the participant is illiterate an audio will be recorded with the participant saying he/she is consenting to participate in the explained activities.

Participant information sheet in Hindi

प्रतिभागी सूचना पत्रक

प्रिय प्रतिभागी, मेरा नाम डेल्मो रोंकाराती विलेला है, जो आईएचई - जल शिक्षा संस्थान का एमएससी छात्र है। मैं एक शोध पर काम कर रहा हूं जिसका शीर्षक है: **"कानपुर, भारत में उपचारित अपशिष्ट जल का पुनः उपयोग करने वाले किसान परिवारों के लिए व्यावसायिक स्वास्थ्य जोखिम में मौसमी भिन्नता"।**

उद्देश्य हैं:

1. विभिन्न मौसमों में परिवार के विभिन्न सदस्यों द्वारा की जाने वाली कृषि में उपचारित अपशिष्टों के पुनः उपयोग से संबंधित प्रथाओं का वर्णन करना।

2. सीवेज और सामान्य अपशिष्ट उपचार संयंत्रों से निकलने वाले अपशिष्ट की गुणवत्ता में मौसमी भिन्नता का आकलन करना।

3. अर्ध-मात्रात्मक जोखिम मूल्यांकन का उपयोग करके विभिन्न कृषक परिवार के सदस्यों के लिए मौसमी व्यावसायिक स्वास्थ्य जोखिम का आकलन करना।

कृपया अनुसंधान की किसी भी गतिविधि में भाग लेने का निर्णय लेने से पहले अनुसंधान के उद्देश्य और इसमें क्या शामिल है, इसके बारे में जागरूक होने के लिए निम्नलिखित जानकारी को ध्यान से पढ़ने के लिए अपना समय लें। यदि आपके कोई प्रश्न हैं या आप अतिरिक्त जानकारी चाहते हैं, तो कृपया बेझिझक शोधकर्ता से पूछें।

अवलोकन

अनुसंधान परियोजना पवित्र गंगा परियोजना का एक हिस्सा है, जिसका उद्देश्य अपशिष्ट जल उपचार और सिंचाई के लिए पुन: उपयोग से जुड़े सामुदायिक और व्यावसायिक स्वास्थ्य जोखिमों का पता लगाना है। **अपने शोध में, मैं जानना चाहूंगा कि क्या वर्ष के अलग-अलग मौसमों में और परिवार में अलग-अलग लोगों (पुरुष, महिला और बच्चे) द्वारा अपशिष्ट जल का उपयोग करके सिंचाई करने में जोखिम है।**

आपसे क्या करने को कहा गया है? मैं आपको गुमनाम और गोपनीय गतिविधियों में भाग लेकर अपने एमएससी अनुसंधान अध्ययन में भाग लेने के लिए आमंत्रित कर रहा हूं जो हो सकता है (जरूरी नहीं कि सभी):

ट्रांसेक्ट वॉक: पुरुषों और महिलाओं के अलग-अलग समूहों में 1-1.5 घंटे (महिलाएं अपने बच्चों के लिए प्रदर्शन करती हैं)। आप जिन स्थानों पर काम करते हैं, आप क्या करते हैं, कौन क्या करता है, प्रत्येक दौरे वाले स्थान में मौसमी पर्यावरणीय अंतर और प्रत्येक मौसम में आपकी गतिविधियों के बारे में बात करने के लिए पूरे फार्म में घूमें।

दैनिक कार्यक्रम: 1 घंटा. पुरुष, महिला (महिला अपने बच्चों के लिए प्रदर्शन करती हैं)। इस बारे में चर्चा कि आप 24 घंटों के दौरान क्या करते हैं, आपका दिन आमतौर पर कैसा होता है और क्या यह अलग-अलग मौसमों में बदलता है।

मौसमी कैलेंडर: पुरुषों और महिलाओं के समूहों में 1.5 - 2 घंटे (महिलाएं अपने बच्चों के लिए प्रदर्शन करती हैं)। वर्ष के प्रत्येक महीने में पानी की उपस्थिति, फसलों के साथ काम करने का समय, सिंचाई का उपयोग कहां किया जाता है आदि से संबंधित खेत की विभिन्न गतिविधियों और स्थितियों को दर्शाते हुए एक मैट्रिक्स पर चर्चा करना और बनाना।

जोखिम मूल्यांकन: 1.5 - 2 घंटे। पुरुषों और महिलाओं के समूह में (महिलाएं अपने बच्चों के लिए प्रदर्शन करती हैं)। एक बैठक जहां हम अपशिष्ट जल उपचार और पुन: उपयोग के जोखिमों के संबंध में आपकी राय और वर्तमान प्रथाओं को सुनने और समझने जा रहे हैं। विभिन्न मौसमों और शत्रु पुरुषों, महिलाओं और बच्चों में जोखिमों की जानकारी के साथ एक मैट्रिक्स बनाया जाएगा।

- आपके नाम का उपयोग नहीं किया जाएगा, केवल आपकी राय और वह जानकारी जो आप देना चाहते हैं।
- आपसे प्राप्त डेटा का उपयोग केवल अध्ययन के लिए किया जाएगा और हमारी परियोजना टीम के बाहर किसी के साथ साझा नहीं किया जाएगा। आपकी भागीदारी पूरी तरह से स्वैच्छिक है, और आप ऊपर दिखाए गए किसी भी तरीके का हिस्सा बनने के लिए बाध्य नहीं हैं।
- आप चाहें तो किसी भी समय अपनी भागीदारी रोक सकते हैं।
- यदि आप किसी प्रश्न का उत्तर नहीं देना चाहते हैं तो आपको इसका उत्तर देने की आवश्यकता नहीं है।

मुझे आशा है कि आप भाग लेने के लिए सहमत होंगे क्योंकि आपकी राय आवश्यक है। शोध पूरा होने पर मैं अपने निष्कर्षों का सारांश आपके साथ साझा करूंगा। यदि आपको अध्ययन के बारे में अधिक जानकारी चाहिए, तो बेझिझक मुझसे इस पते पर संपर्क करें:

संपर्क जानकारी - डेल्मो रोंकाराटी विलेला।

एमएससी. IHE में स्वच्छता- जल शिक्षा संस्थान। वेस्टवेस्ट 7, 2611 एएक्स डेल्फ़्ट/पी.ओ.बॉक्स 3015, 2601 डीए डेल्फ़्ट नीदरलैंड +31 (0)6 85022396 / +5531997277299 (व्हाट्सएप) / भारत: +91 91208 25177 dro005@un-ihe.org

Consent declaration in Hindi

सहमति घोषणा

अनुसंधान में भाग लेने के लिए सहमति:

"किसान परिवारों के लिए व्यावसायिक स्वास्थ्य जोखिम में मौसमी भिन्नता कानपुर, भारत में उपचारित अपशिष्ट जल का पुन: उपयोग करना"।

अध्ययन के उद्देश्य:

1. विभिन्न मौसमों में परिवार के विभिन्न सदस्यों द्वारा की जाने वाली कृषि में उपचारित अपशिष्टों के पुन: उपयोग से संबंधित प्रथाओं का वर्णन करना;

2. सीवेज और सामान्य प्रवाह उपचार संयंत्रों से प्रवाह की गुणवत्ता में मौसमी भिन्नता का आकलन करना;

3. अर्ध-मात्रात्मक जोखिम मूल्यांकन का उपयोग करके विभिन्न कृषक परिवार के सदस्यों के लिए मौसमी व्यावसायिक स्वास्थ्य जोखिम का आकलन करना।

कृपया निम्नलिखित बिंदुओं पर अपनी सहमति दिखाने के लिए बॉक्स को चेक करें:

मैं पुष्टि करता हूं कि मैंने उपरोक्त शोध के लिए सूचना पत्रक को पढ़ और समझ लिया है।	
मुझे जानकारी पढ़ने, प्रश्न पूछने और इनका संतोषजनक उत्तर देने का अवसर मिला है।	
मैं सहमत हूं कि मेरी भागीदारी स्वैच्छिक है।	
मैं सहमत हूं कि मैं किसी भी क्षण पीछे हटने के लिए स्वतंत्र हूं।	
मैं सत्र को रिकॉर्ड करने और तस्वीरें लेने के लिए सहमति देता हूं।	
मैं पृष्ठ 1 में वर्णित तरीकों में भाग लेने के लिए सहमत हूं:	
मैं सहमत हूं कि किसी भी जानकारी को स्पष्ट करने के लिए आप मुझसे दोबारा संपर्क करें।	

यदि आपके पास शोध के बारे में कोई प्रश्न या चिंता है, तो आप मुझसे संपर्क कर सकते हैं:

डेल्मो रोंकाराटी विलेला।
एमएससी. IHE में स्वच्छता- जल शिक्षा संस्थान।
वेस्टवेस्ट 7, 2611 एएक्स डेल्फ़्ट/पी.ओ.बॉक्स 3015, 2601 डीए डेल्फ़्ट नीदरलैंड

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ई-मेल: dro005@un-ihe.org

____________ प्रतिभागी का कोड

____________ dd-mm-yyyy

____________ हस्ताक्षर

ध्यान दें: यदि प्रतिभागी अनपढ़ है तो एक ऑडियो रिकॉर्ड किया जाएगा जिसमें प्रतिभागी यह कहेगा कि वह बताई गई गतिविधियों में भाग लेने के लिए सहमति दे रहा है।

Appendix D. - Raw data for E. coli

E. coli results from FHNW, IHE & AKVO (2022). [E. coli concentrations from selected sampling points in Kanpur using Aquagenx field test kits]. [Unpublished raw data]. European Union Horizon 2020 research and innovation programme. Pavitra Ganga, GA No. 821051.

Location	Season	E.coli (logCFU/100mL)
AL-IC	monsoon	7.00
AL-IC	monsoon	7.00
AL-IC	postmonsoon	6.00
AL-IC	postmonsoon	4.76
AL-IC	monsoon	7.00
AL-IC	monsoon	4.92
AL-IC	postmonsoon	4.57
AL-IC	postmonsoon	4.30
AL-IC	monsoon	5.73
AL-IC	monsoon	4.73
AL-IC	postmonsoon	5.73
AL-IC	postmonsoon	4.73
AL-IC	monsoon	5.04
AL-IC	monsoon	7.00
AL-IC	postmonsoon	4.51
AL-IC	postmonsoon	4.32
AL-IC	monsoon	N.A.
AL-IC	monsoon	5.73
AL-IC	postmonsoon	4.73
AL-IC	postmonsoon	5.51

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Monsoon	9	54.16285	6.018095	0.977901
Post-Monsoon	10	49.16236	4.916236	0.366653

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	***P-value***	*F crit*
Between Groups	5.750965439	1	5.750965	8.789504	**0.008683**	4.451322
Within Groups	11.12308629	17	0.654299			
Total	16.87405173	18				