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Water, sanitation, and hygiene practices among rural households and related health impacts: a case study from some North Indian villages

Anjali Malan [a], Meenakshi Suhag[a], Pankaj Kumar Gupta[b] and Hardeep Rai Sharma [a,*]

[a] Institute of Environmental Studies, Kurukshetra University, Kurukshetra, Haryana 136119, India
[b] Department of Geography and Environmental Management, Faculty of Environment, University of Waterloo, Ontario, N2L3G1, Canada
*Corresponding author. E-mail: hrsharma74@yahoo.co.in

AM, 0000-0001-9679-9678; HRS, 0000-0002-5130-5205

ABSTRACT

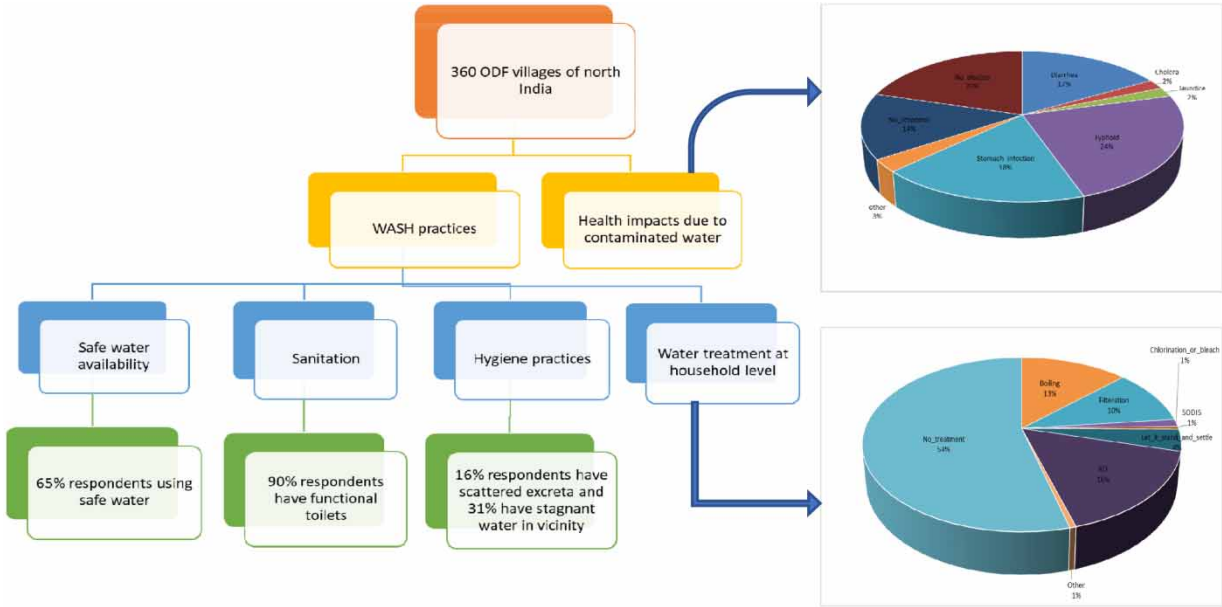
The present study was carried out to assess the water availability, hygiene practices, and sanitary conditions in the households of open defecation-free (ODF) villages after achieving ODF status. Monitoring was conducted from 360 households of 9 ODF villages from 3 blocks of the Kurukshetra district of north India, using a questionnaire. The results interpreted that 78.33% of the surveyed population were using water supplied from government borewells and 65.55% of respondents agreed that their water is safe for drinking as they did not have any water-related diseases. Many respondents (57.2%) replied that someone in their family had suffered from waterborne disease in the preceding year. About 42.8% of households were treating their drinking water at the house level through methods like boiling, chlorination, and reverse osmosis systems. 90.8% of respondents said that they have access to a functional latrine facility. However, 5% population responded that they still prefer fields for open defecation (OD). Logistic regression results showed that the presence of garbage or litter and stagnant water near the household were associated with an increased risk of disease occurrence among the households. The findings suggested that people should maintain good sanitation and hygiene in their household surroundings to avoid health problems.

Key words: health impacts, hygiene, monitoring, open defecation free, sanitation, Swachh Bharat Mission

HIGHLIGHTS

- Open defecation-free villages of the Kurukshetra district were surveyed for water, sanitation, and hygiene (WASH) practices.
- The health impacts of using contaminated water were assessed among users.
- Treatment and management of drinking water at the household level were analyzed.
- The toilet facilities and solid waste management techniques of the households were also studied.

GRAPHICAL ABSTRACT



INTRODUCTION

Out of the global freshwater resources, only 29.9% are covered by groundwater (Li & Qian 2018). The shortage of various water resources has become an important challenge to mankind (Robertson & Sharp 2013; Wang *et al.* 2016). The availability of safe and improved drinking water sources is a basic need, and it must be accessible to all. It is essential for human health, nutrition security as well as the socioeconomic development of a country (Shahid *et al.* 2018; Shakoor *et al.* 2018). The supply of safe and clean drinking water is one of the major challenges in the world, specifically in Asia (Niazi *et al.* 2018; Tabassum *et al.* 2019). Groundwater becomes an important source of drinking water for about half of the global population (Omar *et al.* 2020) due to the unavailability of surface water with good quality (Omar *et al.* 2021a). However, both surface water and groundwater are depleting at a fast rate and their conservation is the main concern for humans (Omar *et al.* 2021b).

Worldwide, 844 million people lacked access to improved drinking water, and out of them, 564 million reside in India (UNICEF/WHO (World Health Organization) 2017). Around 79% of the rural population in the world was deprived of safe drinking water (WHO 2017). Whereas, in developing countries, 22% of healthcare facilities have no water service, 21% no sanitation service, and 22% no waste management service, and globally half of the population will be facing water-stressed conditions by the year 2025 (WHO 2019). The mortality rate in India from infectious diseases was 417 per 1,00,000 population in 2016 (WHO 2016). As per the Indian Ministry of Health and Family Welfare, from 2014 to 2016 huge number of cases were registered for waterborne diseases such as enteric fever (typhoid), acute diarrheal diseases, cholera, and viral hepatitis, and approximately 85% were diarrhea (Ministry of Drinking Water and Sanitation (MDWS) 2017).

Safe water and good sanitation are basic human rights and they have always remained the focus of development goals. Waterborne diseases are not only correlated with safe water availability, other factors like usage and storage of water, safe disposal of excreta, and good hygiene practices are also equally important in spreading waterborne diseases (Kamara *et al.* 2017). Consumption of unsafe drinking water, open defecation (OD), lack of personal hygiene, and improper environmental sanitation are the major causes of diarrheal infections and waterborne illness (Prüss-Ustün *et al.* 2017). According to WHO (2016), India got a very high percentage of infections mainly through bacteria, broadly in areas having improper water, sanitation, and hygiene (WASH). According to an estimate, around 37.7 million Indians are affected by waterborne diseases annually, diarrhea causes the death of 1.5 million children, and waterborne disease leads to a loss of 73 million working days each year. It results in an economic burden of around $600 million per year (Pathak 2015).

OD is the leading cause of contamination in drinking water and food and has been found related to a higher occurrence of fecal-borne diseases such as typhoid, diarrhea, hepatitis, cholera, dysentery, and polio, as well as increasing rates of mortality

and stunted growth among children (Mara 2017; WHO 2019). Globally, around 2 billion people are using a contaminated fecal source of drinking water (WHO 2019). The present study was carried out to assess the WASH conditions in the open defecation-free (ODF) villages of the Kurukshetra district of north India, which were awarded ODF status for their completely sanitized and ODF conditions in the village under the Swachh Bharat Mission-Gramin (SBM-G) or Clean India Mission. Formerly, the Nirmal Gram awards were given to the ODF villages for their completely sanitized households, schools, and anganwadis (Daycare homes). However, the scheme was discontinued consequent upon the launch of SBM-G. The SBM-G mission was launched in India on 2 October 2014 by the honorable Prime Minister of India. The aim of SBM-G was to eliminate OD from India by 2 October 2019. The results of this scheme were effective as the number of people going for OD dropped to around 300 million by the year 2017. Later 98% Indian population gained access to safe sanitation practices in 2019, which was only 39% in 2014 (MDWS 2019).

The key objective of this study is to monitor the water availability, sanitation, and water-related health issues in the villages of north India that have been declared as ODF by the government. Sometimes people do not manage the cleanliness, sanitation, and safe water in their houses and sudden monitoring can help to assess the safe water and sanitary conditions especially in the rural areas where people keep their farm animals in the vicinity of the house and also little unaware about the benefits of using pure and treated water. Therefore, this kind of survey and examination helps in assessment as well as to aware of the society about the importance of WASH.

MATERIAL AND METHODS

Study area

The study was conducted in the Kurukshetra district with an area of 1,530 km^2 and is in the north-eastern part of Haryana state. As per the 2011 census, the total population of the district is 964,231, which is spread over six blocks, namely Shahabad, Babain, Ladwa and Thanesar, Pehowa, and Ismailabad. The three blocks selected for the present study were Ladwa, Shahabad, and Thanesar as these blocks had a maximum number of ODF villages until the survey was conducted. Moreover, the blocks Thanesar and Ladwa were included in red zones (depleted water table) as per the Central Ground Water Board (CGWB 2013) report. The ODF villages were selected based on their location, groundwater level, and population size. The present study was carried out from September to November 2017 in the rural areas (ODF villages) of the Kurukshetra district. A survey was conducted across ODF villages to monitor the various health impacts related to improper sanitation and unimproved drinking water. The sample size for the population to be surveyed was calculated using the following method.

Sample population size

The size of the population to be surveyed was determined by using the formula given by Cochran (1977) and the United States Agency for International Development (USAID) 2008. Based on the population of the three blocks of the Kurukshetra district, every fifth household was selected for survey by simple random sampling method to cover the larger part of the village population. A total of 9 ODF villages were selected as survey sites, 40 households were selected from each village, and the maximum population size was calculated as 360 households. Before sampling and filling out the questionnaire, the households were informed about the study objective. Their oral consent was taken, and the Sarpanch (village head) was also informed regarding the purpose of the survey.

The questions for the questionnaire were adapted from the core questions on water supply and sanitation provided by WHO/UNICEF Joint Monitoring Programme (JMP) 2006. The questionnaire contained six sub-sections. The first part covered a brief introduction about the socioeconomic status of the respondent (i.e., gender, age, education), and the second section had questions related to water supply, water quality, and storage. The third section contained information about waste management practices, the fourth on water treatment practices, whereas the fifth and sixth sections covered questions on water-related diseases and household hygiene, respectively. Along with the questionnaire, transect walk observations were also made in the village to access the ground level conditions regarding the presence of different sanitary facilities at the village level, and the village head was also interviewed. Data confidentiality was strictly maintained throughout the study period.

Statistical analysis

The collected data were entered, cleaned, and analyzed using Statistical Package of Social Sciences version 20.0. Descriptive analysis was carried out with the help of the frequency distribution for the categorical variables, and logistic regression analysis was performed to study the health impacts (disease frequency) among households.

RESULTS AND DISCUSSION

Among the total surveyed population, the majority of the households voluntarily agreed to participate in the survey. The observations from the survey depicted that among respondents, 52.5% were male, and the rest, 47.5% were female. Moreover, females preferred the male members to answer to questionnaire rather than respond themselves. Therefore, the frequency of male respondents was high in the survey. Maximum respondents (28.6%) were of the 36–45 years age group and a minimum (8.1%) with the age of >60 years (Table 1). Regarding the education status of the respondents, a maximum (26.9%) was educated up to senior secondary (12th grade) level followed by 8th grade (21.9%), whereas 12.2% of the respondents were uneducated (Table 1). However, survey results from rural Maharashtra, India, showed that age, gender, education, and the socioeconomic status of households did not have any influence on the responses related to the quality of water (Seifert-Dähnn *et al.* 2017).

Among the surveyed population, 78.33% had water supply from government borewells (45–137 m depth) to their houses, 14.16% had their own private borewells (36–91 m depth), and 5.83% were using both facilities. Only 1.66% of households did not have any type of water supply in their houses, and they collected water from the public tap or from neighbors' houses. The government water supply varied between <4 and 12 h per day (Table 2). According to the National Family Health Survey (NFHS-4) report of Haryana (2015–16), 94% of households in rural areas had piped water supply into their yard, dwelling or plot.

Regarding water storage methods, 93.3% of households had storage tanks, whereas 5.6% did not have any tanks to store water. Out of the total storage tanks, 95.2% of tanks were covered and closed with a lid, while 4.8% were without cover (Table 2). Closing the lid of a water container is safe and avoids contamination (Centres for Disease Control and Prevention (CDC) 2011). The location of the water storage tank is also important as a tank located at an elevated level can prevent contamination from insects present in the ground and other germs. About 83.63% of people had water tanks at an elevated level, 13.7% had them at ground level, and 2.67% had both types of tanks, i.e., ground and elevated levels. Among the surveyed households, 85.11% had tanks made from plastic material, 10.71% had concrete tanks, and 4.18% had both types of tanks (Table 2). Some of the respondents (31.39%) told water storage tanks were cleaned frequently in a period of <3 months, 30.83% cleaned in 3–12 months, 15.83% in 1–5 years, and 1.67% cleaned their tanks in a duration of >5 years. Also, 20% of the users do not know or remember the exact time period of the cleaning of the water tanks. It may lead to waterborne diseases (Table 2). The cleaning of the water storage tanks should be performed frequently to remove settled solids (if any), control the growth of algae, especially in concrete tanks, and avoid any kind of contamination.

There is no universal definition of safe water. However, according to Fogden & Wood (2009), drinking water is considered safe if it does not pose any health risk of overconsumption throughout life. About 65.55% of respondents agreed that their

Table 1 | Sociodemographic information of the respondents

Sr. No.	Sociodemographic parameter	Respondents	Percentage (%) ($n = 360$)
1	Gender	Male	52.5
		Female	47.5
2	Age group (years)	18–25	20.6
		26–35	20.3
		36–45	28.6
		46–55	19.7
		56–60	8.1
		Above 60	2.8
		Don't know	–
3	Education	5th grade	8.9
		8th grade	21.9
		10th grade	19.2
		12th grade	26.9
		Graduate	10
		Post-graduate	0.3
		Higher education	0.6
		Uneducated	12.2

Table 2 | Source and quality of drinking water in the study area

Sr. No.	Drinking water questions	Categories	Percentage (%) ($n = 360$)
1	Source of drinking water	Government borewell	78
		Private borewell	14
		Both	6
		Public/shared/neighbour's tap	2
2	Duration of government water supply	< 4 h per day	37
		5–12 h per day	48
		Not connected	8
		No government supplies	4
		Don't know	1
		No response	2
3	Location of water storage tank in households	Elevated	79.2
		Ground level	12.8
		Both	2.5
		No tank	4.4
		No response	1.1
4	Material of water tank in households	Plastic	80
		Concrete	10
		Both	4
		No tank	5
		No response	1
5	Frequency of tank cleaning in households	<3 months	31
		3–12 months	31
		1–5 years	16
		>5 years	2
		Don't know	0
		No response	20
6	Households' response regarding safe drinking water	Yes	65
		No	21
		Sometimes	11
		No household tap	3
		No response	0
7	Reasons for dissatisfaction with water quality	Satisfied	52
		Inadequate supply	5
		Low pressure of water	7
		Poor taste	9
		Bad smell	7
		Suspended matter	6
		Hard water	3
		Leakage	6
		Causes diseases	3
		No response	2

water is safe for drinking, 20.55% answered water is unsafe, while 10.83% believed water is safe, but sometimes problems were faced related to safe supply. Other 2.77% of households did not have a household tap connection, and 0.3% had not responded (Table 2). Moreover, the water quality of all surveyed villages was within permissible limits except for Total dissolved solids (TDS), Ca^{2+}, Mg^{2+}, and K^{+} in some groundwater samples. Based on the Water Quality Index (WQI) classification, the groundwater was excellent to good category and was found suitable for drinking and other purposes (Malan & Sharma 2018). However, the total coliforms were found in the groundwater of ODF villages, indicating contamination in the water (Malan *et al.* 2020).

Among all households surveyed, 51.8% of respondents were completely satisfied with the present quality of drinking water, and others reported unsafe water quality due to poor taste (9.2%), inadequate supply (4.9%), low pressure (6.7%), bad smell (6.7%), suspended matter (6.5%), leakage (6.1%), hard water (3.4%), and disease-causing (3.1%) (Table 2). In a similar study

from rural Maharashtra, India, the majority of respondents (93%) were satisfied with the present drinking water quality, but only 50% stated that water is of good quality. The reasons given by the villagers for bad water quality were turbidity, bad taste, and smell, and some reported the presence of bugs and worms in the water (Seifert-Dähnn *et al.* 2017).

Respondents were asked about the practice of water treatment at the household level, and only 42.8% of households treat their drinking water, and 54.7% of people consume it without treatment. The respondents said that the frequency of diseases gets reduced when they consume treated water (Table 3). The households preferred reverse osmosis (RO) (32.2%) and boiling (27.4%) over other treatment methods such as filtration (24.67%), standing and settling of water (10%), chlorination (3.24%), solar disinfection (1.2%), and with other methods (1.29%) (Figure 1). Whereas according to a report of NFHS-4 (2015–2016), only 22% of households followed household water treatment interventions to make it fit for drinking and preferred electronic water purifier (6%) or water filter over other traditional treatments, such as boiling (0.9%), ceramic or sand filters (4.2%) and use of cloth for straining water (1.3%). In another study from the Jhajjar district of Haryana, India, among the surveyed population, 60% were not using any treatment method for water purification and were drinking raw untreated water, 30% were buying filtered drinking water from the market, and only 10% households have water filtration systems installed at home (Gupta & Misra 2019).

Among respondents, 40.6% of households responded (confirmed by the first author) that they have piles of garbage or litter within 3 m vicinity of their houses. When the households were asked for a compost pit near their house, only 19.4% responded 'yes'. Regarding solid waste disposal, only 30.8% of households agreed that they segregate waste at a household level before dumping it into dustbins (Table 4). However, the waste should be segregated before dumping, mainly into wet (degradable) and dry (non-degradable).

Most respondents (67%) were disposing of their household waste on a waste pile in the village, 16% were making compost, 7% were practicing open dumping, and 4% burning the waste. In addition to the above, in 4% of the households, the waste was collected by the ground staff and disposed of on the waste piles (Figure 2). About 15% of respondents also answered that excreta and stagnant water are present nearby their house. In the report of the National Statistical Office (NSO 2019), 72.4% of rural households were disposing of their waste in a household or community dumping spot in the village as there is no proper/effective collection system in the rural areas.

Regarding household sanitation and hygiene on their premises, about 91% of the respondents have access to a functional toilet at home (Table 5). The majority of the respondents (89.72%) informed that they have their own functional toilet at home, while 5.5% were using a shared toilet with their neighbors. Other 1.38% depended on public or community toilets constructed by the Gram Panchayats (village council) in the villages (Table 5). According to a report by NSO (2019), 71.5% of rural households had latrine facilities like flush/pour-flush to a septic tank. However, around 3.5% of them did not use latrines. In the current study, around 30% of the respondents replied that they did not have any water facility in or around their latrines, which is quite higher than 4.5%, as reported by NSO (2019). The availability of water affects the hygiene and proper functioning of the toilet. About 5% of households also replied that some members of their family still prefer going for OD even after having a functional toilet at home. According to a study carried out in the rural community of Hawzien district of Ethiopia, cultural beliefs (44%), foul smell (22.6%), and inconvenience of use (17.8%) were the major reasons cited by the respondents for the non-use of latrines (Ashebir *et al.* 2013).

The quality of drinking water is alone not responsible for waterborne health issues. However, factors such as safe water storage, safe disposal of excreta and garbage, and hygiene practices also influence water-related diseases (Kamara *et al.* 2017). Only 16.7% of respondents accepted the presence of excreta and water in the vicinity of their house (Table 5).

Table 3 | Household responses regarding water treatment

Sr. No.	Question	Response of households	Percentage (%) ($n = 360$)
1	Is water treated at home?	Yes	42.8
		No	54.7
		No response	2.5
2	Is the method of treatment effective?	Yes	35.8
		No	2.8
		No response	61.4

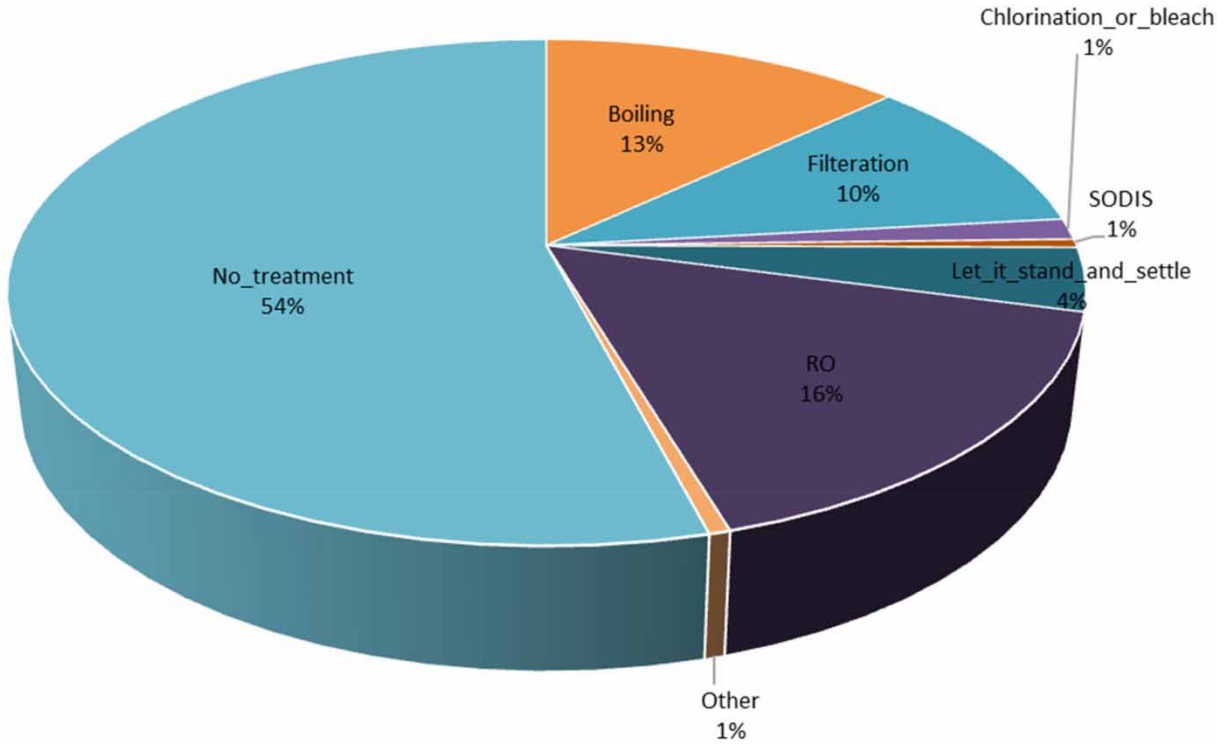


Figure 1 | Fraction of households practising various treatment practices to treat drinking water at home.

Regarding households' reply to the personal hygiene question of cleaning hands, a majority (91.11%) use soap for cleaning their hands before taking meals and after using toilets or other related work (Table 5). In a similar study, all households were washing their hands with water after defecation, and only 14.4% were using soap or ash with water (Banerjee *et al.* 2013).

Participants were enquired about the frequency of various diseases in their households in the preceding year. This question was framed to assess the different health impacts caused by drinking untreated and contaminated water among users as well as due to improper hygiene and sanitation facilities. Many people (57.2%) replied that they or someone in their family had suffered from waterborne diseases in the preceding year. Waterborne diseases such as acute diarrhea, cholera, viral hepatitis, and typhoid were prevalent in India and have been the reason for 10,738 deaths since 2017 (India Water Portal 2019). Among surveyed households, 25.6% households said that they have the facility of a health care center in their village, while 55.6% responded regarding the non-availability of a health center in their village. Other 18.9% have not responded (Table 6). A major percentage of households have not responded well because some of them neither avail nor visit the health centers, and further some were using private clinics or hospitals in the nearby areas. At the same time, some replied that the facility

Table 4 | Response of households regarding solid waste management

Sr. No.	Parameter	Household response	Percentage (%) ($n = 360$)
1	Garbage or litter in the vicinity of the house	Yes	40.6
		No	56.7
		No response	2.8
2	Compost pit near house	Yes	19.4
		No	71.4
		No response	8.1
3	Segregation of wet and dry waste	Yes	30.8
		No	64.4
		No response	4.7

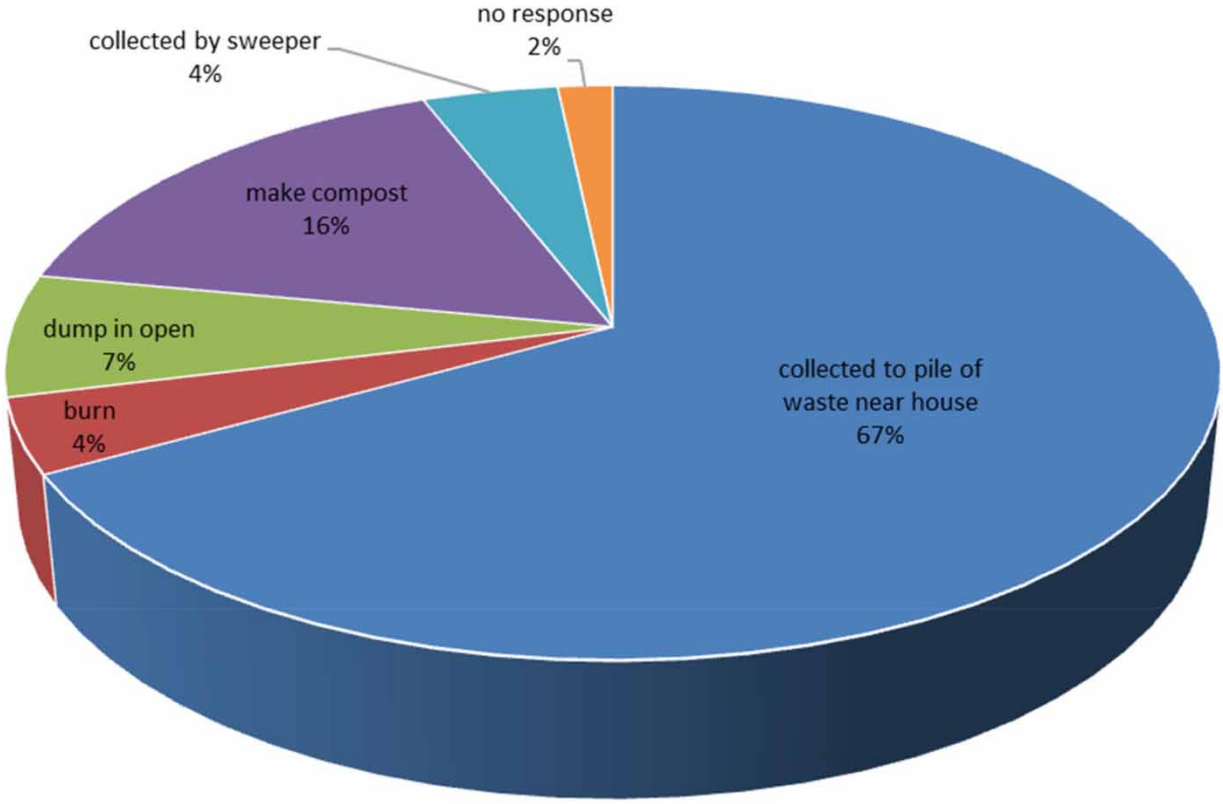


Figure 2 | Methods for solid waste disposal adopted in ODF villages.

of health centers is not good because of the unavailability of doctors and other health equipment and they have also replied with no response. Households were also enquired about the season in which they fall sick more. Nearby 50% of the respondents (51.66%) replied that the summer season was the 'season of the diseases' in which diseases occurred more frequently. Also, around 30% of the respondents (28.33%) answered that the monsoon or rainy season is responsible for the common occurrence of diseases (Table 6).

Regarding various types of water-related diseases in the respondent family and locality, typhoid was reported by 24% of the respondents, followed by stomach infection (18%). Diarrheal cases were reported as 17%, along with minor cases of cholera (2%) and jaundice (2%). About 3% of households replied for other diseases also like frequent fever and problems of stones in the kidney and bladder, etc. About 20% of respondents replied that nobody in their families had suffered from any major disease in the last year in their family. The other 14% of people did not respond to this question (Figure 3).

Logistic regression analysis of household responses from ODF villages

Adjusted logistic regression analysis was performed for the dependent variable 'frequent occurrence of waterborne diseases among households,' and the independent variables were considered as 'safe drinking water supply', 'water treatment', 'garbage or litter in household premises', and 'presence of stagnant excreta or stagnant water nearby house'. The logistic regression analysis results showed that the presence of garbage or litter near the household and the presence of stagnant water near the household was associated with an increased risk of disease occurrence among the households. Accordingly, those who had garbage or litter near the household were 2.50 times more likely to report a history of having disease than individuals who had no garbage or litter near their households (Adjusted odds ratio or AOR = 2.50, 95% Confidence Interval (CI): 1.30–4.84). Similarly, individuals who had stagnant water near their households were found to report a history of disease occurrence by 3.02 times higher than their counterparts who had no stagnant water near their household (AOR = 3.02, 95% CI: 1.52–5.99) (Table 7). In the unadjusted logistic regression model, the presence of garbage or litter near the household was not statistically associated with disease occurrence among the households (Crude odds ratio or COR = 1.35, 95% CI:

Table 5 | Responses related to sanitation and hygiene

Sr. No.	Parameters related to sanitation and hygiene	Categories	Percentage (%) ($n = 360$)
1	Access to functional household toilet	Yes	90.8
		No	8.1
		No response	1.1
2	Kind of toilet facility	Own toilet	89.7
		Shared toilet	5.6
		Community toilet	1.1
		OD	1.4
		No response	2.2
3	Water availability in toilets	Yes	63.3
		No	29.7
		No toilet	2.5
		No response	4.4
4	Rating of toilet quality	Good	63.3
		Acceptable	28.3
		Poor	1.1
		Don't know	1.7
		No toilet	5.6
5	People going for OD	Yes	5
		No	93.6
		No response	1.4
6	Presence of scattered excreta in household premises	Yes	16.7
		No	83.1
		No response	0.3
7	Presence of stagnant water in household premises	Yes	31.7
		No	66.9
		No response	1.4
8	Material used by households for hand washing	Soap	91
		Ash	1.8
		Sand	2.2
		No response	5

0.82–2.23). However, the presence of stagnant water near the household was statistically significantly associated with an increased risk of disease occurrence (COR = 2.49, 95% CI: 1.41–4.39). According to an adjusted and unadjusted logistic regression model, the remaining variables have no association with disease occurrence (Table 8).

Another study studied the impacts of demographic and socioeconomic variables, drinking water, and latrine facility on the prevalence of diarrhea among children under the age of 5 years in all states of India. The logistic regression model depicted

Table 6 | Responses for water borne diseases among ODF villages

Sr. No.	Water borne diseases	Categories	Percentage (%) ($n = 360$)
1	Suffered from water borne diseases in last 1 year?	Yes	57.2
		No	27.5
		No response	15.3
2	Is heath center facility available in village?	Yes	25.6
		No	55.6
		No response	18.9
3	Season causing highest disease frequency	Summer	51.66
		Monsoon	28.33
		Winter	11.66
		No response	8.33

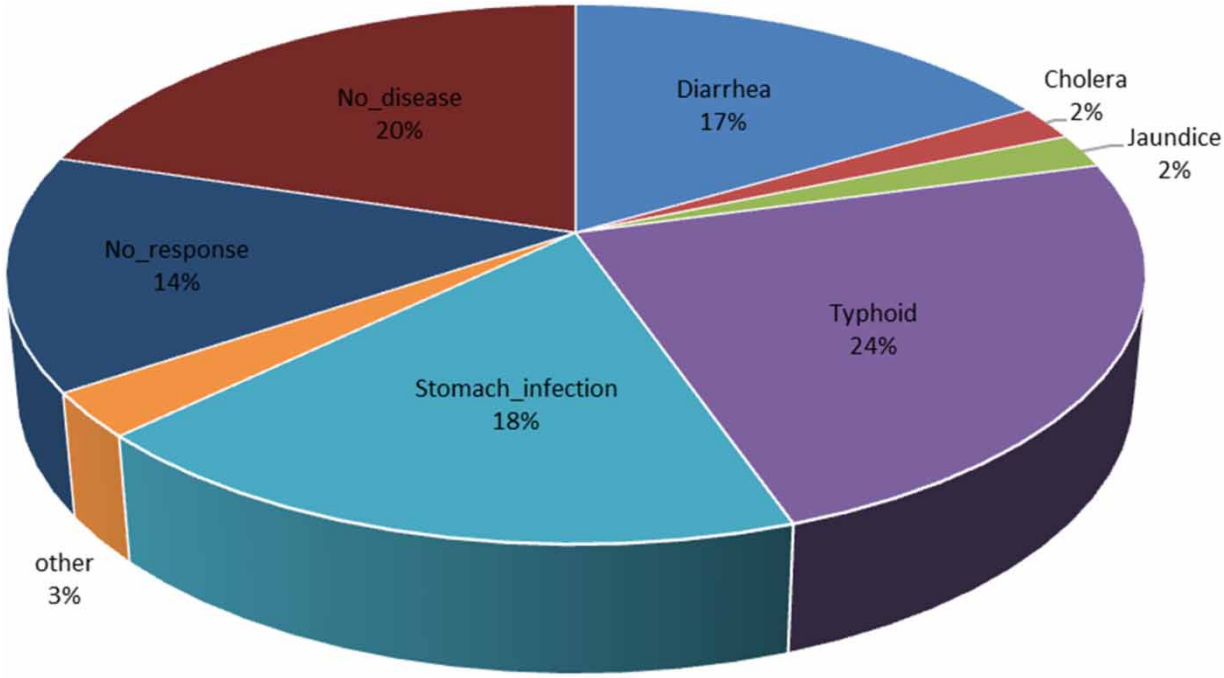


Figure 3 | Percentage of disease occurrence in ODF villages.

Table 7 | Logistic regression table of ODF villages with adjusted odds ratio (AOR)

Variables in the equation (ODFs)		B	S.E.	Wald	Df	Sig.	Exp(*B*)	95% C.I. for Exp(*B*) Lower	Upper
Step 1[a]	Do_you_treat_water_at_home	−0.373	.279	1.787	1	.181	.689	.399	1.190
	Is_water_safe_to_drink	.619	.362	2.923	1	.087	1.857	.913	3.776
	Garbage_or_litter_near_house	.920	.335	7.527	1	.006	2.509	1.300	4.841
	Do_you_have_stagnant_excreta_near_house	−.687	.399	2.965	1	.085	.503	.230	1.100
	Do_you_have_stagnant_water_near_house	1.106	.349	10.046	1	.002	3.024	1.525	5.993
	Constant	−2.970	1.309	5.149	1	.023	.051		

[a]Variable(s) entered on step 1: Do_you_treat_water_at_home, Is_water_safe_to_drink, Garbage_or_litter_near_house, Do_you_have_stagnant_excreta_near_house, Do_you_have_stagnant_water_near_house.

Table 8 | Logistic regression for COR in ODF villages

Sr. No.	Independent variable	*B*	S.E.	Wald	df	Sig.	Exp(*B*)	95% C.I.for Exp(*B*) Lower	Upper
1	Is_water_safe_to_drink	−.100	.246	.166	1	.684	.905	.559	1.464
	Constant	−.525	.341	2.371	1	.124	.591		
2	Do_you_treat_water_at_home	−.444	.246	3.272	1	.070	.641	.396	1.038
	Constant	−.065	.388	.028	1	.866	.937		
3	Garbage_or_litter_near_house	−1.757	.560	9.855	1	.002	.173	.058	.517
	Constant	1.382	.879	2.470	1	.116	3.984		
4	Do_you_have_stagnant_excreta_near_house	−.339	.311	1.189	1	.276	.713	.388	1.310
	Constant	−.113	.575	.039	1	.844	.893		
5	Do_you_have_stagnant_water_near_house	.914	.290	9.957	1	.002	2.493	1.414	4.398
	Constant	−2.275	.522	19.001	1	.000	.103		

that the odds ratio (OR) of suffering from diarrhea was higher among the children using the unimproved type of latrine on household premises (OR = 1.082; 95% CI, 1.011–1.158). However, no association was found between drinking water sources and diarrhea among children (Kumar & Das 2014).

CONCLUSIONS

In this rural household monitoring from north India, the results depicted that around 40% of households were treating their drinking water at house level, and the piles of garbage or litter were observed within 3 m vicinity of their houses. Only 30% of households were practicing waste segregation at the household level before dumping it into dustbins. Around 60% of households answered that someone in their family had fallen sick in the past year mainly due to typhoid, diarrhea, cholera, and jaundice. The results of statistical analysis obtained from the logistic regression model depicted that households who have garbage or litter and stagnant water nearby their house reported the occurrence of diseases in their history. During the study period, in 5% of the surveyed households, OD is practiced, which can spread diseases. This study was conducted through a survey method using a questionnaire covering all aspects from socioeconomic to sanitation status in the ODF villages. However, the study faced several challenges some people were not willing to answer the questions or fill out the questionnaire. It was hard to monitor the sanitation and hygiene of every household as the author has to examine their toilets, water facilities, and household surroundings. People were not ready to answer about OD status as well as the cleaning frequency of water tanks. They were worried that some action may be taken against them. Therefore, it was the main limitation of the study that some households did not answer the questions fairly. Also, it was difficult to cover the whole village with 40 households. So, every fifth household was selected from each lane to cover almost all areas of each village. The finding from the present study indicates that safe WASH are mandatory in rural communities as well as urban areas because unsafe water sources and unsanitary conditions can cause various health problems. To avoid any kind of disease burden and economic losses, it is recommended that each household must have awareness regarding the health impacts and benefits of proper WASH. It would also be helpful in achieving the United Nations' Sustainable Development Goal (SDG) 6 on 'clean water and sanitation for all.'

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DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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