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Research Article

Sanitation-hygiene Knowledge, Practices and Human Health Impacts: Insights from Coastal Bangladesh

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ABSTRACT

Better sanitation and hygiene are very significant for sound health for human lives and it protects various water borne disease. This study aims to find sanitation-hygiene knowledge, practices and impacts on human health of coastal Bangladesh. Rajoir (Sarankhola), Gangarampur (Batiaghata) and Ganapatipur (Kalaroa) villages are purposively designated from shoreline, interim and inland coast. Data are collected with semi-structured questionnaire between July-October 2022 and analyzed through SPSS and map is produced with Arc GIS. Overall about 9.6, 36.3 and 54.1% respondents have good, moderate and poor knowledge regarding sanitation and hygiene. Overall about 57% respondents have accessed sanitary latrines. About 67% respondents claimed that their children deface are thrown in the toilet, followed by, around the house (16%). About 70, 83 and 84% respondents wash their hands with soap/handwash after defecation in shoreline, interim and inland area, followed by, 34, 35 and 27% before taking meal; 19, 19 and 4% before cooking; 9, 21 and 16% after household chores. Cleanliness index are categorized into satisfactory levels except water containers for shoreline (0.677) and inland (0.718) areas. About 96% (shoreline), 91% (interim) and 95% (inland) respondents claim women play a direct role during collection of water. Based on sanitation inspection tool, overall 6, 41, 47 and 3% tube-wells are grouped into very high, high, intermediate and low risk categories. About 57% (shoreline), 48% (interim) and 36% (inland) water sources are grouped into 'high's category. The study suggest to format management committee to monitor proper sanitation and hygiene systems.

Keywords : Coastal area; human health; cleanliness; sanitary inspection tool

INTRODUCTION

Globally, better water, sanitation and hygiene (WASH) are one of the most fundamental concerns among the individuals (Hsan et al., 2019; Joshi et al., 2013) for better and sound health as well as sustainable public health development (Hossain et al., 2022). WHO &UNICEF (2017) reported that about 2.3 billion people are deprived from basic sanitation (practice open defecation or pit latrine without slab or hanging latrine) in 2015 and living surroundings go together with underprivileged WASH systems are responsible for development of many transmittable diseases,

i.e., diarrhea, cholera and diphtheria, etc. (Cousins, 2018; Ahmed et al., 2018). About 88% of diarrheal diseases are accredited to polluted/contaminated water, and insufficient sanitation and hygiene (Banda et al., 2007; WHO, 2004). Water borne disease, diarrhea should be deduced 6-25% by better-quality water supply and 32% by better cleanliness (Esrey et al., 1991), 47% by washed hands with detergent/soap (Luby et al., 2005). Without access to fresh drinking water, improved WASH facilities, hand washing practices with soap, the health status of millions of people (primarily for women and children) are at risk and vulnerable (Begum et al., 2023). Freeman et al. (2014) reported that about 19% of the world population used soap during handwashing after contact with excreta. Knowledge and practices regarding WASH mainly depend upon education, norms, races and customs of the community and the rules/regulations implemented by the local authority.

Several studies are done by various objectives in different areas of Bangladesh, i.e., Begum et al. (2023) reported on household WASH amenities and practices in Rangpur District. Jubayer et al. (2022) explored household WASH and severe diarrhea among children in St. Martin's Island, Bangladesh. Akter et al. (2022) studied about elements of upgraded sanitation in rural-urban Bangladesh and Pakistan. Kabir et al. (2021) claimed that issues prompting sanitation-hygiene practices on public university students in Bangladesh. Hsan et al. (2019) argued issues connected with the practice of WASH among the Rohingya refugees in Bangladesh. In addition, sanitary inspection form/tool is used by Kelly et al. (2021); Snoad et al. (2017); Mushi et al. (2012); Parker et al. (2010); Vaccri et al. (2010). This tool is used to identify the real or potential origins of sources of pollution of ground water extraction points declared by World Health Organization (WHO, 1997) and it is the inclusive and supplementary risk calculation of water quality (Mushi et al., 2012; WHO, 2004). In Bangladesh, about 85.66% household's used water from tube wells, (BBS, 2022), thus, this tool is selected for risk calculation of water sources. This demarcated the water points by indicating a definite guideline for counteractive achievement to defend and advance the water supply system (Luby et al., 2008). This risk form (supplementary Table S1) structured as 'yes' indicating the possible risk of pollution (one point) and 'no' indicating the risk is insignificant (zero point). Final risk score is the risk of contamination/pollution status and higher risk score represents the more risk of contamination by fecal pollution from the surroundings of the tube well (Kelly et al., 2021).

Few studies were done in the world, such as, sub Saharan Africa (Kelly et al., 2021), Bangladesh (Ercumen et al., 2017); West Bengal, India (Snoad et al., 2017), Tanzania (Mushi et al., 2012), north east Uganda (Parker et al., 2010), Bangladesh (Luby et al., 2008). Best of our acquaintance, we didn't find any research in the coastal belt of Bangladesh regarding sanitary risk inspection score with WASH systems and there isn't any comparison among shoreline, interim and inland areas of Bangladesh. As a reason, the researchers identified these areas to perform the study. The objective of this scientific study was to distinguish the sanitation and hygiene knowledge and practices along with the impact on human health of the selected coastal region of Bangladesh.

METHODS

Study Area

The coastal area of Bangladesh was characterized into three categories, i.e., shoreline, interim and inland zone depending upon the position from shoreline, salinity, tidal fluctuations and risk of cyclone (PDO-ICZMP, 2003). Among the 147 coastal upazilas, Sarankhola (Bagerhat), Batiaghata (Khulna) and Kalaroa (Satkhira) Upazila were purposively nominated from above mentioned three south western coastal zones which were interconnected. The detailed characteristics of these upazilas are depicted in Table 1. Rajoir (shoreline), Gangarampur (interim) and Ganapatipur (inland) villages from Sarankhola, Batiaghata and Kalaroa Upazila were carefully chosen purposively based on literature review and Delphi Technique (Figure 1).

Table 1. Basic features of the study area

Shoreline (Sarankhola)	Interim (Batiaghata)	Inland (Kalaroa)
The shoreline upazila is located between 22°13'-22°24'N latitudes and 89°46'-89°54'E longitudes with an area of 756.61 km² (Banglapedia, 2021a).	The interim upazila is located between 22°34'-22°46'N latitudes and 89°24'-89°37'E longitudes with an area of 248.32 km² (Banglapedia, 2021b).	The inland upazila is located between 22°48'-22°57'N latitudes and 88°54'-89°09'E longitudes with an area of 232.64 km² (Banglapedia, 2021c).
The main source of fresh water is rain water, pond water or river water (50.28%) (BBS, 2011a).	The main source of freshwater is tube wells (96.4%) (BBS, 2011b).	The main source of freshwater is tube wells (97.56%) (BBS, 2011c).
About 36.34, 58.66 and 5.02% rural households have access to sanitary, non-sanitary latrines and no latrine facilities, respectively (Banglapedia, 2021a).	About 52.37, 42.33 and 5.29% households have access to sanitary, non-sanitary latrines and no latrine facilities, respectively (Banglapedia, 2021b).	About 25.97, 39.06 and 34.97% households have access to sanitary, non-sanitary latrine and no latrine facilities, respectively (Banglapedia, 2021c).

Sampling and Data Collection

Total number of household data is collected from respective union parisad office and total number of samples are calculated by using Kothari (2004) formula for known population with 95% confidence level. After that total number of samples are proportionately distribute among three coastal villages. 15% respondents are preserved and these samples are used in case of absence or migrate or lock the houses of the selected respondents. The respondents are determined on the basis of simple random sampling method and generally, household head is interviewed but it is ensured that at least 15% respondents are women who directly engaged with sanitation and hygiene practices. A total of 338 questionnaire surveys are carried out to perform the objectives of the study with pretested self-administered semi structured questionnaires from July-October 2022.

Table 2a. Sample distribution

Coast	Village	Total HH*	Total sample (a)	Reserve sample (15%)	FGD* participants (b)	Total (a+b)
Shoreline	Rajoir	1518	184	28	14	
Interim	Gangarampur	581	71	11	14	378
Inland	Ganapatipur	690	83	13	12	
Total	3	2789	338	52	40	

**Note: HH and FGD represent the households and focus group discussions*

Furthermore, 3 focus group discussions (FGDs) are directed to know the perception on human health of the respondents. About 12-14 individuals for each FGD are designated by integrating rural village leaders, women, businessman, NGOs head, etc. and it lasted 60-70 min with a prearranged worksheet by the moderator and a note taker. In addition, informal discussions and observations are used to triangulate the result collected from questionnaire survey. Collected data are coded carefully and processed by SPSS (version 22.0) software and some selected GPS (global positioning system) locations are noticed by using the GPS machine (Garmin eTrex 10 hand held GPS navigator). Study area map is formed by using Arc GIS (version 10.3) software with the help of GPS positions and source map of LGED (2019).

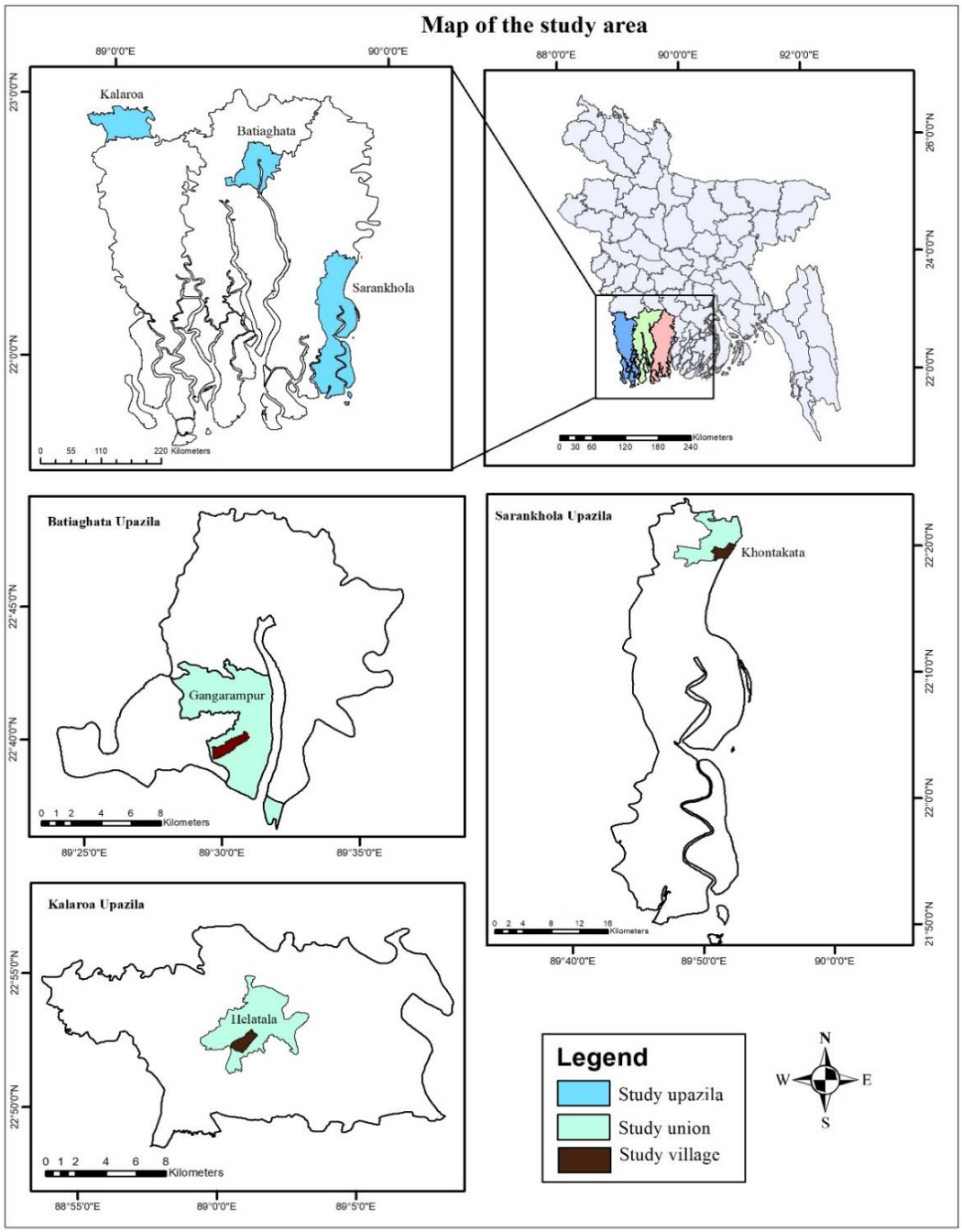

Figure 1. Study area with study village, union and upazila

Table 2b. Summary of research methods and sampling structure

Total samples	Purposes of data collection	Methods of data collection	Target people	Duration
338 (proportionately distributed)	To assess sanitation and hygiene knowledge and practices	Semi-structured questionnaire survey (QS) through simple random sampling	Household head	July-October, 2022
129 (have access to tube well)	To know the sanitation inspection risk score	Through sanitation inspection risk form	Ownership of tube well	March-May, 2022
3 focus groups (one from each area)	To triangulate and validate data obtained from QS and to know the perception on human health	Focus group discussion	Local community leaders, teachers, quack, businessman, community-based organization's head, etc.	July-October, 2022
Sampling structure of the study				
Districts	Bagerhat (shoreline)	Khulna (interim)	Satkhira (inland)	
Upazila	Sarankhola	Batiaghata	Kalaroa	
Union	Khontakata	Gangarampur	Helatala	
Village	Rajoir	Gangarampur	Ganapatipur	
Samples (338)	184	71	83	

Weighted Average Index Formulation

Weighted average index is used by Paul (2019); Hossain & Paul (2018). Weighted average cleanliness index (WAICi) and source of pollution index (WAIPi) are formulated based on the three-point and five-point Likert scale with the help of Eq. (1) and (2). The details are tabulated in Table 2c along with assessment criteria.

Table 2c: Likert scale and assessment criteria

Variables	Perception	Perception	Perception	Perception	Perception
Cleaning status	Not clean (0)		Clean (0.5)	Very clean (1.0)	
Assessment criteria	Dissatisfied (0-0.33)		Satisfied (0.34-0.66)	Very satisfied (0.67-1.0)	
Source of pollution	Very strongly agree (1.0)	Strongly agree (0.75)	Agree (0.5)	Disagree (0.25)	Strongly disagree (0)
Assessment criteria	Very strongly agreed (>.8)	Strongly agreed (.6-.8)	Agreed (.4-.6)	Disagreed (.2-.4)	Strongly disagreed (<.2)

The index (WAICi) of each variable (household, yard, toilet, kitchen and water storage container) was calculated by the following Eq. (1) and the index (WAIPi) of each determinant (household waste, agricultural pesticide, arsenic contamination, etc.) was calculated by the following Eq. (2).

$$WAICi = \{fNC(0) + fC(0.5) + fVC(1.0)\}/N \quad (1)$$

$$WAIPi = \{fSD(0) + fD(0.25) + fA(0.5) + fSA(0.75) + fVSA(1.0)\}/N \quad (2)$$

Here, f (NC) = Frequency of not clean; f (C) = Frequency of clean; f (VC) = Frequency of very clean; f (SD) = Frequency of strongly disagree; f (D) = Frequency of disagree; f (A) = Frequency of agree; f (SA) = Frequency of strongly agree; f (VSA) = Frequency of very strongly agree; N = Total observations (184, 73 and 84 for shoreline, interim and inland area)

Water Quality Sanitation Inspection Risk

Onsite water quality sanitary inspection risk score was determined based on the form

developed by WHO (1997) for selected 10 questions (yes or no) for hand pump tube well in the study area (form attached in Table 1s as supplementary material) from March-May, 2022. Those household have the access to functional tube well and they consumed tube well water either for drinking purpose or other household chores, these types of tube well were considered for filling in the sanitary inspection risk form. The risk score was categorized into four groups low (0-2), intermediate (3-5), high (6-8) and very high (9-10), respectively. This score is also determined the water quality indirectly because of higher risk might be responsible for poor quality of water but it should not be able to determine the biological or chemical risk of the water source directly.

RESULTS AND DISCUSSION

Demographic Profile

The demographic profile along with area of the respondents (frequency and percentage) consists of gender, age, family size, occupation and education level (Table 3). About overall 81.95 and 18.05% respondents are male and female, respectively of which male representative from shoreline (85.3%), interim (73.2%) and inland (81.9%). The family size is reduced from shoreline (4.34) to inland (3.73) and overall family size is 4.14 which is lower/higher than the national average (4.0) of the entire Bangladesh (BBS, 2022). The age of the respondents varies from 25-84 years in the study area. About 51.09, 32.39 and 32.53% respondents complete primary level from shoreline, interim and inland zone. About 24% of the respondent's occupation in the shoreline area are fishermen whereas no respondents are found in this category from interim and inland area. About 20, 15 and 6% respondent's occupation are day labor in the shoreline, interim and inland area, respectively.

Table 3. Gender, age structure, family size, education and occupation of the respondents

Variables	Groups	Shoreline		Interim		Inland		All	
		f	%	f	%	f	%	f	%
Gender	Male	157	85.3	52	73.2	68	81.9	277	81.95
	Female	27	14.7	19	26.8	15	18.1	61	18.05
	Total	**184**	**100**	**71**	**100**	**83**	**100**	**338**	**100**
Age	25-34	26	14.13	13	18.31	17	20.48	56	16.57
	35-44	24	13.04	12	16.90	31	37.35	67	19.82
	45-54	58	31.52	15	21.13	12	14.46	85	25.15
	55-64	39	21.20	16	22.54	15	18.07	70	20.71
	65-74	29	15.76	9	12.68	8	9.64	46	13.61
	75-84	8	4.35	6	8.45	0	0.00	14	4.14
	Total	**184**	**100**	**71**	**100**	**83**	**100**	**338**	**100**
Family members	2	7	3.8	7	9.86	8	9.64	22	6.51
	3	34	18.48	17	23.94	31	37.35	82	24.26
	4	53	28.8	19	26.76	25	30.12	97	28.70
	5	71	38.59	21	29.58	14	16.87	106	31.36
	6	17	9.24	6	8.45	4	4.82	27	7.99
	>6	2	1.09	1	1.41	1	1.2	4	1.18
	Total	**184**	**100**	**71**	**100**	**83**	**100**	**338**	**100**
Family size		4.34		4.07		3.73		4.14	
Education	Illiterate	9	4.89	12	16.90	11	13.25	32	9.47
	Only read and write	21	11.41	10	14.08	9	10.84	40	11.83
	*Primary	94	51.09	23	32.39	27	32.53	144	42.60
	*Secondary	47	25.54	14	19.72	23	27.71	84	24.85
	*Higher secondary	9	4.89	9	12.68	9	10.84	27	7.99
	*College	4	2.17	2	2.82	2	2.41	8	2.37
	*University	0	0.00	1	1.41	2	2.41	3	0.89

	Total	**184**	**100**	**71**	**100**	**83**	**100**	**338**	**100**
Occupation	Agriculture and livestock	13	7.07	19	26.76	15	18.07	47	13.91
	Agricultural labor	11	5.98	5	7.04	24	28.92	40	11.83
	Day labor	37	20.11	11	15.49	5	6.02	53	15.68
	Fisherman	45	24.46	0	0.00	0	0.00	45	13.31
	Skilled labor	12	6.52	4	5.63	14	16.87	30	8.88
	Petty business	11	5.98	1	1.41	2	2.41	14	4.14
	Business	19	10.33	11	15.49	4	4.82	34	10.06
	House wife	24	13.04	13	18.31	14	16.87	51	15.09
	Driver	6	3.26	6	8.45	2	2.41	14	4.14
	Govt. service	4	2.17	1	1.41	1	1.20	6	1.78
	Others	2	1.09	0	0.00	2	2.41	4	1.18
	Total	**184**	**100**	**71**	**100**	**83**	**100**	**338**	**100**

**Note: Primary, secondary, higher secondary, college and university represented the respondents completed five, eight, ten, twelve, sixteen years education level*

Knowledge and Practices of About Water, Sanitation and Hygiene

The study reveals that overall about 9.6, 36.3 and 54.1% respondents have good, moderate and poor knowledge about water, sanitation and hygiene (WASH) practices. This result is almost consistency with previous study from Rohingya refugee's area of Cox's Bazar District in Bangladesh (Hsan et al., 2019). The knowledge of WASH practice is reduced from inland to shoreline of the study area, probably the caused by the comparative higher education level. It is also increased from the older to younger, might be the cause of using modern technologies and higher literacy rate.

Sanitation and Hygiene Security

The sanitation and hygiene security are very important for water borne diseases and health issues. Water borne diseases are increasing worldwide due to scarcity of fresh water and lack of proper sanitation in the developing countries of the world (Hunter et al., 2010). Household water scarcity is strongly related with several health diseases in India instigated by communicable diseases (Motoshita et al., 2011). People are forced to drink contaminated water due to fresh water crisis and suffered from dysentery or diarrhea or salmonellosis. Abedin et al., (2019) argued a study in Satkhira District that skin diseases, dysentery, throat, eye, nose and ear infections, gastrointestinal diseases, fever, peptic ulcers, vomiting, pneumonia, etc. are common diseases and part of their daily life due to fresh water and more than 90 and 70% respondents have been suffered from dysentery and skin diseases, and diarrhea, respectively, due to drinking of contaminated water.

Types of latrines

The majority of the respondents (57%) have been accessed to sanitary latrines of all the study area, followed by, ring slab without water seal (22%), direct pit latrine (18%), open defecation (1%), respectively. The highest (69%) respondents in the inland area have accessed to sanitary latrine in inland area, followed by, shoreline (55%) and interim (45%), respectively. A small portion (1% in shoreline and 2% in interim area) of household used to open defecation system but the figure is absent in inland area of coastal zones of Bangladesh. This study is almost (in)consistency with the national data of latrine facilities in Bangladesh, sanitary (56.04%), ring slab without water seal (34.58%) , direct pit latrine (8.15%) and open defecation (1.23%), respectively (BBS, 2022).

Table 4. Types of latrines

Types of latrines	Shoreline		Interim		Inland		All	
	f	%	f	%	f	%	f	%
Sanitary	103	55.98	32	45.07	58	69.88	193	57.10
Ring slab without water seal	45	24.46	14	19.72	17	20.48	76	22.49
Direct pit latrine	33	17.93	23	32.39	8	9.64	64	18.93
Open defecation	3	1.63	2	2.82	0	0.00	5	1.48
Total	184	100	71	100	83	100	338	100

Child defecation management practices

Previously, child open defecation was very general scenario in low-income developing and under developing countries in the world (Islam et al., 2020). Though, government has taken several initiatives to access to sanitary latrines over the Bangladesh, however UNICEF (2015) reported it as the second lowest position for safe disposal of child defecation management practices in the South-central Asia of the world. Poor defecation management system should be exposed to health risk for the child rather than other age groups (Walker et al., 2012) and children's feces comprise more numbers of contagious pathogens (Islam et al., 2020). The existence of a sanitary latrine cannot diminish experience to fecal-oral pathogens from children defecation (Banda et al., 2007), particularly for children who mostly live in the home surroundings and continuous contact to contaminated soils or feces (Kwong et al., 2016). The current study revealed that overall about 67% respondents claimed that their child's defaces throw in toilet, followed by, around the house (16%), in nearest water bodies (10%), in the nearest garden (4%), and open places (1%), respectively. The result reported that about 74% respondents of shoreline area used the toilet to management the child's defecation, followed by, around the house (15%), respectively.

Table 5a. Child defecation management system

Places	Shoreline		Interim		Inland		All	
	f	%	f	%	f	%	f	%
Around the house	29	15.76	14	19.72	13	15.66	56	16.57
In toilet	137	74.46	42	59.15	49	59.04	228	67.46
In water bodies	11	5.98	6	8.45	18	21.69	35	10.36
In the garden	4	2.17	9	12.68	2	2.41	15	4.44
Open places	3	1.63	0	0.00	1	1.20	4	1.18
Total	184	100	71	100	83	100	338	100

Table 5b. Practices of child defecation throwing

	Shoreline		Interim		Inland		All	
	f	%	f	%	f	%	f	%
Very often	111	60.33	42	59.15	56	67.47	209	61.83
Sometimes	67	36.41	25	35.21	23	27.71	115	34.02
Never	6	3.26	4	5.63	4	4.82	14	4.14
Total	184	100	71	100	83	100	338	100

Hand washing practices

World Health Organization (WHO) reported that hands washing with detergent or handwash or soap and water at a devoted handwashing ability (WHO, 2021) and cost-effective human sound health interference which reduced the diseases, globally (Chatterjee et al., 2022; Jamison et al., 2006). Handwashing is collectively impacted the well-being of human and protected from various diseases. It is one of the most crucial practices for distributing germs or pathogens to surroundings and washing with water is not as fruitful as using handwash or soap (Phillips et al.,

2015). These practices are varied based upon the hand washing facility at dedicated place (Jenkins et al., 2013), knowledge, behavior, gender, literacy rate, economic solvency and infrastructure (Biswas & Karmakar, 2022; White et al., 2020). Lessons in Bangladesh, Hoque (2003) claimed that 14-40% reduction of diarrheal or water borne diseases due to proper handwashing with soap. The observations and procedures connected to handwashing differ in Bangladesh due to socio-economic and common indigenous practices. Rabbi & Dey (2013) reported that hand washing practice with soap is improved from 71-88% after defecation and 8-21% before taking food from 2006-2011. About 41% rural females washed their hands with water (Hoque, 2003), 30% before cooking and 75% before taking food (Rabbi & Dey, 2013). Majority of the respondent (almost 100%) cleaned their hands with soap or handwash or water. Female respondents claimed that they washed hands with soil and rinsed with water because of their financial crisis or economic affordability, after self-defecation or child's defecation. The previous study argued that spreading out the harmful germs and viruses and interlinked infections should be reduced due to hand washing with soap and water at several periods (post defecation, feeding child, before eating, before cooking), diarrhea (40-47%) (Freeman et al., 2014), respiratory diseases (23%) and playing significant role to deduce infant and child mortality (Chatterjee et al., 2022; Wolf et al., 2022; Greenland et al., 2013) and decrease risk of respirational infections (21-23%) (Phillips et al., 2015; Aiello et al., 2008). Halder et al. (2010) argued that Bangladeshi people trusted that soap is not essential, water itself enough for washing/purifying hands.

The study reported that 70, 83 and 84% respondents washed their hands with soap or handwash after defecation in the shoreline, interim and inland areas, followed by, 34, 35 and 27% before taking meal; 19, 19 and 4% before cooking; 11, 2 and 8% before feeding child; 9, 21 and 16% after household chores, in the study area. The overall result showed that 76% used soap after defecation, followed by, before taking meal (33%), before cooking (15%), after household chores (11%) and before feeding child (8%), respectively. From the study, it is warried that overall about 24, 67, 84, 89 and 91% respondents didn't use soap after defecation, before taking meal, before cooking, after household chores and before feeding the child, respectively and these individuals might be washed their hands with water only. This study is almost (in)consistency with Begum et al. (2023) that washing hand using soap after defecation (98%), before cooking (65%), before meal (84%), before feeding child (61%), after child's defecation (72%) and Hsan et al., (2019) that washing hands after defecation (92%), before taking meal (94%), before feeding child (63%), respectively. Another study aggregate from eleven published articles from various regions of the world reported by Curtis et al. (2009) averaged the result which (in)consistency with that hands washing with soap and water, after defecation (17%), after cleaning children's defection (19%), before taking meal (13%), before feeding child (5%), with only water after defecation (45%), respectively.

Table 6a: Hand washing practices with soap/handwash

Options	Shoreline		Interim		Inland		All	
	f	%	f	%	f	%	f	%
Before taking meal	64	34.78	25	35.21	23	27.71	112	33.14
Before cooking	36	19.57	14	19.72	4	4.82	54	15.98
Before feeding child	21	11.41	2	2.82	7	8.43	30	8.88
After defecation	130	70.65	59	83.10	70	84.34	259	76.63
After household chores	9	4.89	15	21.13	14	16.87	38	11.24

Soap using practices during bath

Children are rarely used soap during bath because soap increases the freezing properties of water and dried the skin (Zeitlyn & Islam, 1991). Soap or detergent is used widespread for washing clothes all over the country. The study reports about 6, 14 and 6% respondents never used soap during bath in the shoreline, interim and inland village, followed by, about 59, 39 and 63% respondents used soap rarely in the study area. These results should be the cause of better education level or consciousness of inland and shoreline respondents' rather than interim

respondents. Small percentage of respondents (6%) used soap once a week and 0.89% used once a month in the study area. This study is almost consistency with Begum et al. (2023) that 92% respondents used soap during bath in Rangpur District.

Table 6b. Using soap during bath by family members

Opinion	Shoreline		Interim		Inland		All	
	f	%	f	%	f	%	f	%
Never	12	6.52	10	14.08	5	6.02	27	7.99
Rarely	109	59.24	28	39.44	53	63.86	190	56.21
Often	51	27.72	21	29.58	24	28.92	96	28.40
Once a week	11	5.98	10	14.08	1	1.20	22	6.51
Once a month	1	0.54	2	2.82	0	0.00	3	0.89
Total	184	100	71	100	83	100	338	100

Cleanliness index

Cleanliness index is formulated separately considering the household, yard, toilet and kitchen cleaning status. The study resulted that all the indicators (household, yard, toilet, kitchen) cleanliness index are categorized into satisfactory level except water container cleanliness index for shoreline (0.677) and inland (0.718). The pattern of homestead, yard and kitchen are shown in a similar way, shoreline>interim>inland. The trend of index value of water container is satisfied level with inland>shoreline>interim. Finally, the toilet cleaning status is observed shoreline>inland>interim pattern (Table 8a). Thus, the result concluded that the overall cleanliness index in the shoreline and interim and inland area are satisfied level rather than water conservation container cleanliness index of shoreline and inland study area of Bangladesh. As people were aware about their water container (either plastic drum or plastic pot or bottle or earthen container or silver pot or plastic jug, etc.) clean because they think disease should spread out from dirty container.

Role of women in cleanliness practices

Hand washing and hand hygiene is the basic and fundamental actions to prevent of spreading of any transmittable disease in our daily life settings and everyday home or office activities (Imtiaz et al., 2014). Luby et al. (2005) claimed that 54% of global population maintains strict personal hygiene of which about 60% are women. This also represents the better role of women regarding their hygiene. As women are playing vital role to feeding child, preparing foods, collection of fresh/drinking water, clean the house/yard/toilet/kitchen, etc. Therefore, they are also playing highest role in cleanliness practices. The study resulted that about 96% respondents of shoreline area claimed women played direct role (washing container/pot, serving water into glass, collection of water from source, pumping/operating the source, filling the container/pot, etc.) during collection of water, followed by, inland (95%) and interim (91%), respectively (Table 7). Overall 2.96% respondents claimed that women played indirect role (helping the collector of water) in the study area. About 2.82% respondents of interim area reported neutral regarding this opinion.

Table 7. Role of women during water collection

	Shoreline		Interim		Inland		All	
	f	%	f	%	f	%	f	%
Directly	178	96.74	65	91.55	79	95.18	322	95.27
Indirectly	5	2.72	3	4.23	2	2.41	10	2.96
Never	1	0.54	1	1.41	2	2.41	4	1.18
Don't know	0	0	2	2.82	0	0	2	0.59
Total	184	100	71	100	83	100	338	100

Perception on sources of water pollution

Sources of pollution was determined based on weighted average index (WAI) considering five-point Likert scale with multiple responses. The study resulted the household waste was the source of water pollution (inland>shoreline>interim), followed by, agriculture pesticide (inland>interim>shoreline), arsenic contamination (inland>shoreline>interim), iron contamination (inland>interim>shoreline), biomass fuel ashes (interim>inland>shoreline), oil spillage (shoreline>interim>inland), dumping waste into canal (shoreline>interim>inland), septic tank (interim>inland>shoreline), industry pollution (interim>inland>shoreline)and salinity intrusion (interim>shoreline>inland), respectively. The study also reported that respondents from interim and inland area claimed that the perception of the sources of water pollution (index), agricultural pesticide is assessed into strongly agreed (0.602 and 0.633) for both areas but agreed (0.537) for shoreline area. Industrial pollution was indexed the following pattern, interim (0.585) >inland (0.568) >shoreline (0.302); arsenic contamination, inland (0.593)> shoreline (0.419)> interim (0.345), respectively (Table 8b).

Table 8. Index of (a) cleanliness (b) sources of water pollution

a. Cleanliness index

Variables	Shoreline	Interim	Inland
Household	0.613	0.605	0.601
Yard	0.564	0.539	0.512
Toilet	0.591	0.568	0.578
Kitchen	0.630	0.614	0.598
Water container	0.677	0.662	0.718

b. WAI on sources of water pollution

Sources	Shoreline	Interim	Inland
Household waste	0.594	0.486	0.687
Agricultural pesticide	0.537	0.602	0.633
Arsenic contamination	0.419	0.345	0.593
Iron contamination	0.192	0.275	0.412
Biomass fuel ashes	0.298	0.391	0.365
Oil spillage by tanker	0.331	0.218	0.158
Dumping waste into canal	0.361	0.268	0.241
Septic tank	0.309	0.369	0.327
Industrial pollution	0.302	0.585	0.568
Salinity intrusion	0.306	0.356	0.112

Disposal place of household solid and e-waste

As we reported in Table 8(b) that household waste was dominantly responsible for the pollution of fresh water in the whole study area. The study argued that overall highest (31%) respondents sell to hawker the household solid and e-waste, followed by, burnt (27%), bush around the house (21%), anywhere (14%), and buried (5%), respectively. This scenario was observed to shoreline, interim and inland as follows, sell to hawker (31, 57, 7%); burnt (21, 11, 56%); bush around the house (15, 26, 29%); anywhere (22, 4, 7%); buried (9, 0, 0%), respectively (Table 9). From this survey result, we can conclude that the individual of inland are more conscious rather than other two study areas based upon the burning the solid and e-waste.

Table 9. Disposal place of household solid and e-waste

	Shoreline		Interim		Inland		All	
Places	f	%	f	%	f	%	f	%
Anywhere	41	22.28	3	4.23	6	7.23	50	14.79
Bush around the house	29	15.76	19	26.76	24	28.92	72	21.30
Burnt	39	21.20	8	11.27	47	56.63	94	27.81
Sell to hawker	58	31.52	41	57.75	6	7.23	105	31.07
Buried	17	9.24	0	0.00	0	0.00	17	5.03
Total	184	100	71	100	83	100	338	100

Water Quality Sanitary Inspection Risk

Water quality sanitary inspection risk score was determined of 7, 43 and 79 tube wells from shoreline, interim and inland study area. Overall 6, 41, 47 and 3% tube wells were grouped into very high, high, intermediate and low risk category. About 57% water sources of shoreline area are grouped into high category, followed by, intermediate (28%) and very high (14%), respectively. This scenario is changed for interim area which is high (48%), intermediate (41%) and very high (9%) and for inland area, intermediate (51%), high (36%), low (6%) and very high (5%), respectively (Table 10). This study is (in)consistency with Luby et al. (2008) that conducted research in Cumilla (low: 4%, intermediate: 41%, high: 46%, very high: 9%); Brahmanbaria (low: 28%, intermediate: 21%, high: 38%. very high: 13%); Sirajganj (low: 0%, intermediate: 6%, high: 82%. very high: 12%) District in Bangladesh. In addition, Luby et al. (2008) reported that 86% tube wells are positioned <10 m of latrine and 70% had some sources of pollution, i.e., fertilizers, cow sheds, polluted surface water, etc. This increased the risk of human health which might be susceptible to higher risk of contamination of biological pathogens. This risk score is the determination of indirect or complementary water quality report because of higher risk reported the poor quality of water. It should not possible to comment on the biological/chemical quality of water based on the sanitation inspection tool score. This risk is supported from physio-chemical parameters reported by the authors (Khan & Paul, 2023; Khan, 2022) that presented the groundwater quality in coastal areas of the country.

Table 10. Water sanitation inspection risk for tube well

	Shoreline		Interim		Inland		All	
Risk score	f	%	f	%	f	%	f	%
0-2 (low)	0	0.00	0	0.00	5	6.33	5	3.88
3-5 (intermediate)	2	28.57	18	41.86	41	51.90	61	47.29
6-8 (high)	4	57.14	21	48.84	29	36.71	54	41.86
9-10 (very high)	1	14.29	4	9.30	4	5.06	9	6.98
Total	7	100	43	100	79	100	129	100

Impacts on human health and suggestions

Besides the questionnaire survey and sanitary inspection tool, the researcher conducted three FGDs in the respective study areas to understand the health impacts of the individuals (Table 11). The FGD results supported by Abedin et al. (2019) that almost all the disease broken out in the south western coastal districts of Bangladesh. In addition, we depicted the summary of our results collected from FGDs. All the FGDs concluded that improved water supply system should be reduced various water borne disease in the study area. Likewise, Abanyie et al. (2019) claimed that water borne disease should be reduced (malaria: 95%, cholera: 82%, amoebic dysentery: 46%) for improved water supply system. It is also consistence with WHO (2019) which reported that better-quality water sources decrease the incidence of numerous illnesses.

Table 11. Impacts on human health and suggestions

Shoreline	Interim	Inland
Impacts	Impacts	Impacts
The people of this area suffered from skin disease, cholera, typhoid, diarrhea, fever, throat and nose infections and dysentery.	The people of this area suffered from itching, fever, typhoid, diarrhea, peptic ulcers and different gastrovascular disease.	The people of this area suffered from arsenokosis, vomiting, diarrhea, cholera, pneumonia and different infections of eye, throat and nose.
People of this area suffered from water borne disease frequently because of drinking contamination water and salinity dominant water. Severe fresh water crisis is observed during summer season and unavailability of pure water.	People of this area drink supply water/ deep tube well water collected from neighbor village which is comparatively pure and less suffered from water borne diseases.	This arsenic dominated zone suffered severe crisis of pure drinking water because of industrially polluted water and more suffered from water borne disease and poor sanitation practices.
The upazila health complex is not always supported to take care of patients suffered from diseases create by unhygienic sanitation system	The upazila health complex moderately supported to take care of the patients.	The upazila complex moderately supported to take care of the patients and also provided some essential medicine from here.
The quack of this area played vital role during illness because of insufficient treatment facilities in local health complex and the district health care center is about 51 km.	The patients of this area easily go to the divisional medical college hospital for better treatment during illness and medical college hospital is about 25 km and easy mode of transportation.	The local doctors played significant role during illness because of the district health care center is about 22 km.
Suggestions	**Suggestions**	**Suggestions**
Proper monitoring should be improved the healthy sanitation and hygiene system.	Improved the latrines and ensured the sufficient water supply to each latrine.	Increased the monitoring and improved the sanitary latrine with water seal for all the households.
Formation of community committee led by local government representative incorporating different types of stakeholders.	Formation of committee led by government official (public health engineer) including local teacher, NGO personnel, quack, businessman, etc.	Formation of committee led by local leader including various types of stakeholders.
Supply soap and other sanitary equipment/materials with an interval period by different GOs and NGOs.	Supply sanitary materials at minimum cost to the households to ensure better health and low risk of sanitation.	Ensure soap and sanitary materials for all the households in the entire village.

CONCLUSION

Some phenomenon of WASH securities is discussed in this study but the results are not always standard. The overall 54% respondents have poor knowledge about sanitation and hygiene. The study accomplishes based on the types of latrines, child defecation management practices, hand washing practices with soap and soap using practices during bath, cleanliness index of household, yard, toilet, kitchen and water container, role of women in cleanliness, sources of water pollution and disposal system of household solid and e-waste. Furthermore, sanitation inspection tools are use to determine the risk of water pollution of tube well and finally the health impacts of hygiene and sanitation practices. The important limitations of this study are to conduct the study during the rainy season when people used rainwater for their daily chores and tube well was not generally functionally active in the coastal area in that period. The sanitary inspection tool is used the selected tube wells when the ground water level is highest and possible to better sanitation inspection risk score from other tube wells or other seasons or other locations of other districts of Bangladesh. Further study should be done by incorporating more tube wells and different seasons as well as microbial determinants to find out the seasonal variations and human health risk in the study area.

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DECLARATIONS

Conflict of Interest

The authors declared that they had no known competing interests.

Ethical Approval

The research has been approved by the 'Board of Governors' of Institute of Bangladesh Studies. All research was carried out in accordance with University of Rajshahi research ethics guidelines applicable when human participants are involved.

Informed Consent

On behalf of all authors, the corresponding author states that all participants have been given informed consent and agreed to take part in this study.

DATA AVAILABILITY

Data used to support the findings of this study are available from the corresponding author upon request.

REFERENCES

Abanyie, S.K., Ampadu, B., Frimpong, N.A., & Amuah, E.E.Y. (2023). Impact of improved water supply on livelihood and health: Emphasis on Doba and Nayagnia, Ghana. *Innovation and Green Development*, 2: 100033, https://doi.org/10.1016/j.igd.2023.100033.

Abedin, M. A., Collins, A.E., Habiba, U., & Shaw, R. (2019). Climate change, water scarcity, and health adaptation in southwestern coastal Bangladesh. *International Journal of Disaster Risk Science*. 10:28-42, https://doi.org/10.1007/s13753-018-0211-8.

Ahmed, B., Orcutt, M., Sammonds, P., Burns, R., Issa, R., Abubakar, I., & Devakumar, D. (2018). Humanitarian disaster for Rohingya refugees: impending natural hazards and worsening public health crises. *The Lancet Global Health*, 6(5): e487–e488. https://doi.org/10.1016/S2214-109X(18)30125-6.

Aiello, A.E., Coulborn, R.M., Perez, V., & Larson, E.L. (2008). Effect of hand hygiene on infectious disease risk in the community setting: a meta-analysis. *American Journal of Public Health*, *98*(8): 1372-81. https://doi.org/10.2105/AJPH.2007.124610.

Akter, M., Khan, M., Beg, T.H., & Saker, M.M.R. (2022). Determinants of adapted improved sanitation in rural and urban of Bangladesh and Pakistan. *Asian Journal of Agricultural Extension, Economics & Sociology, 40*(9): 398-410.

Banda, K., Sarkar, R., Gopal, S., Govindarajan, J., Harijan, B.B., Jeyakumar, M.B., Mitta, P., Sadanala, M.E., Selwyn, T., Suresh, C.R., Thomas, V.A., Devadason, P., Kumar, R., Selvapandian, D., Kang, G., & Balraj, V. (2007). Water handling, sanitation and defecation practices in rural southern India: a knowledge, attitudes and practices study. *Trans-actions of the royal society of tropical medicine and hygiene, 101*(11): 1124-30. https://doi.org/10.1016/j.trstmh.2007.05.004.

Banglapedia (2021a). Sarankhola Upazila, The national encyclopedia of Bangladesh, Asiatic Society of Bangladesh, Dhaka, Bangladesh. Retrieved from https://en.banglapedia.org/index.php/Sarankhola_Upazila.

Banglapedia (2021b). Batiaghata Upazila, The national encyclopedia of Bangladesh, Asiatic Society of Bangladesh, Dhaka, Bangladesh. Retrieved from https://en.banglapedia.org/index.php/Batiaghata_Upazila.

Banglapedia (2021c). Kalaroa Upazila, The national encyclopedia of Bangladesh, Asiatic Society of Bangladesh, Dhaka, Bangladesh. Retrieved from https://en.banglapedia.org/index.php/Kalaroa_Upazila.

BBS (Bangladesh Bureau of Statistics) (2022). Population and Housing Census 2022, Preliminary Report. Statistics and Informatics Division, Ministry of Planning, Bangladesh. Retrieved from http://www.bbs.gov.bd/site/page/47856ad0-7e1c-4aab-bd78-892733bc06eb/Population-and-Housing-Census, Accessed 11 April 2023.

BBS (Bangladesh Bureau of Statistics). (2011a). Population and Housing Census 2011, Community Report, Satkhira Zila. Statistics and Informatics Division, Ministry of Planning, Bangladesh.

BBS (Bangladesh Bureau of Statistics). (2011b). Population and Housing Census 2011, Community Report, Khulna Zila. Statistics and Informatics Division, Ministry of Planning, Bangladesh.

BBS (Bangladesh Bureau of Statistics). (2011c). Population and Housing Census 2011, Community Report, Bagerhat Zila. Statistics and Informatics Division, Ministry of Planning, Bangladesh.

Begum, M., Morshed, M.S., Islam, R., & Nisa, M.M.I. (2023). Household water, sanitation, hygiene facilities and practices in selected villages of Taraganj Upazilla, Rangpur. *Journal of Rangpur Medical College, 8*(2): 53-58. https://doi.org/10.3329/jrpmc.v8i1.65060.

Biswas, S.S., & Karmakar, R. (2022). Determinants of hand-hygiene practices in India: reflections from the 76th round National Sample Survey, 2018. *Journal of Water and Health, 20*(1): 68-82.

Chatterjee, S., Roy, M.N., Banerjee, K., Mojumder, S., & Osbert, N. (2022). Understanding the gap between knowledge and practice of handwashing in rural India: evidence from a cross-sectional study. *J Water Health, 20*(12): 1701-20. https://doi.org/10.2166/wh.2022.129.

Cousins, S. (2018). Rohingya threatened by infectious diseases. *The Lancet Infectious Diseases*, *18*(6): 609-610. https://doi.org/10.1016/S1473-3099(18)30304-9.

Curtis, V.A., Danquah, L.O., Aunger, & R.V. (2009). Planned, motivated and habitual hygiene behavior: an eleven-country review. *Health Education Research*, *24*(4): 655–73.

Ercumen, A., Naser, A.M., Arnold, B.F., Unicomb, L., Colford, J.M., & Luby, S.P. (2017). Can sanitary inspection surveys predict risk of microbiological contamination of groundwater sources? Evidence from shallow tube wells in rural Bangladesh. *The American Journal of Tropical Medicine and Hygiene, 96*(3): 561-568. https://doi.org/10.4269/ajtmh.16-0489.

Esrey, S.A., Potash, J.B., Roberts, L., & Shiff, C. (1991). Effects of improved water supply and sanitation on ascariasis, diarrhoea, dracunculiasis, hookworm infection, schistosomiasis, and trachoma. Bull. World Health Organization. 69: 609-621.

Freeman, M.C., Stocks, M.E., Cumming, O., Jeandron, A., Higgins, J.P.T., Wolf, J., Pruss-Ustun, A. Bonjour, S., Hunter, P.R., Fewtrell, L., & Curtis, V. (2014). Hygiene and health: systematic

review of handwashing practices worldwide and update of health effects. *Tropical Medicine and International Health, 19*(8): 906-16. https://doi.org/10.1111/tmi.12339.

Godfrey, S., Timo, F., & Smith, M. (2006). Microbiological risk assessment and management of shallow groundwater sources in Lichinga, Mozambique. *Water and Environment Journal, 20*:194-202. https://doi.org/10.1111/j.1747-6593.2006.00040.x.

Greenland, K., Cairncross, S., Cumming, O., & Curtis, V. (2013). Can we afford to overlook hand hygiene again? *Tropical Medicine and International Health, 18*(3): 246-249. https://doi.org/10.1111/tmi.12055.

Halder, A.K., Tronchet, C., Akhter, S., Bhuiya, A., Johnston, R., & Luby, S.P. (2010). Observed hand cleanliness and other measures of handwashing behavior in rural Bangladesh. *BMC public health*, 10(1): 1-9. https://doi.org/10.1186/1471-2458-10-545.

Hossain, M.N., & Paul, S.K. (2018). Vulnerability factors and effectiveness of disaster mitigation measures in the Bangladesh coast. *Earth Systems and Environment,* 2:55-65, https://doi.org/10.1007/s41748-018-0034-1

Hossain, M.R., Khan, M.S., Islam, M.A., & Hasan, M. (2022). Pond sand filter as an alternative system for purifying drinking water: climate change perspective in Mongla, Bangladesh. *International Journal of Energy and Water Resources,* 6: 243-252. https://doi.org/10.1007/s42108-021-00172-y.

Hoque, B.A. (2003). Handwashing Practices and Challenges in Bangladesh. *International Journal of Environmental Health Research, 13* (1): 81-87. https://doi.org/10.1080/0960312031000102831.

Hsan, K., Naher, S., Grifiths, M.D., Shamol, H.H., & Rajman, M.A. (2019). Factors associated with the practice of water, sanitation, and hygiene (WASH) among the Rohingya refugees in Bangladesh. *Journal of Water, Sanitation and Hygiene for Development,* 9(4): 794-800. https://doi.org/10.2166/washdev.2019.038 .

Hunter, P.R., MacDonalds, A.M., & Carter, R.C. (2010). Water supply and health. *PLOS Medicine,* 7(11): 1-9. https://doi.org/10.1371/journal.pmed.1000361.

Imtiaz, K.S., Begum, K., Begum, N., Naureen, S., Barua, J., Faruque, J., & Khalid, A.R. (2014). Practice of personal hygiene among rural women of a selected community in Bangladesh. *Northern International Medical College Journal,* 6(1): 29-32.

Islam, M.A., Sakakibara, H., Karim, M.R., & Sekine, M. (2013). Potable water scarcity: options and issues in the coastal areas of Bangladesh. *Journal of Water and Health, 11*(3): 532-542. https://doi.org/10.2166/wh.2013.215.

Jamison, D.T., Breman, J.G., Measham, A.R., Alleyne, G., Claeson, M., Evans, D.B., & Musgrove, P. (2006). Disease control priorities in developing countries. The International Bank for Reconstruction and Development /World Bank, New York; Oxford University Press, Oxford, UK.

Jenkins, M.W., Anand, A.R., Revell, G., & Sobsey, M.D. (2013). Opportunities to improve domestic hygiene practices through new enabling products: a study of handwashing practices and equipment in rural Cambodia. *International Health,* 5(4): 295-301. https://doi.org/10.1093/inthealth/iht026.

Joshi, A., Prasad, S., Kasav, J.B., Segan, M., & Singh, A.K. (2013). Water and sanitation hygiene knowledge attitude practice in urban slum settings. Global Journal of Health Science, 6(2): 23-34. https://doi.org/10.5539/gjhs.v6n2p23.

Jubayer, A., Islam, M.H., Nowar, A., & Islam, S. (2022). Exploring household water, sanitation, and hygiene and acute diarrhea among children in St. Martin's Island, Bangladesh: A cross-sectional study. *Am. J. Trop. Med. Hyg., 107*(2): 441-448, https://doi:10.4269/ajtmh.22-001.

Kabir, A., Roy, S., Begum, K., Kabir, A.H., & Miah, M.S. (2021). Factors influencing sanitation and hygiene practices among students in a public university in Bangladesh. *PLoS ONE, 16*(9), https://doi.org/10.1371/journal.pone.0257663.

Kelly, E., Cronk, R., Fisher, M., & Bartram, J. (2021). Sanitary inspection, microbial water quality analysis, and water safety in handpumps in rural sub-Saharan Africa. *NPJ Clean Water, 4*(3): 1-8. https://doi.org/10.1038/s41545-020-00093-z.

Khan, M.S. (2022). Assessment of physio-chemical properties of ground water in the south western coastal zone of Bangladesh. *Management of Sustainable Development Journal, 14*(2): 46-51, https://doi.org/10.54989/msd-2022-0016.

Khan, M.S., & Paul, S.K. (2023). Groundwater quality assessment and health issues in the coastal zone of Bangladesh. *Journal of Hazardous Materials Advances, 10*: 100278. https://doi.org/10.1016/j.hazadv.2023.100278.

Kothari, C.R. (2004). Research methodology: methods and techniques (2nd ed.). New Delhi: New Age International Limited.

Kwong, L.H., Ercumen, A., Pickering, A.J., Unicomb, L., Davis, J., & Luby, S.P. (2016). Hand-and object mouthing of rural Bangladeshi children 3-18 months old. *International Journal of Environmental Research and Public Health, 13*(6):563. https://doi.org/10.3390/ijerph13060563.

LGED. (2019). Local Government Engineering Department, The People's Republic of Bangladesh. Retrieved from https://oldweb.lged.gov.bd/ViewMap.aspx.

Luby, S.P., Agobatwalla, M., Feikin, D.R., Painter, J., Billhimer, W., Altaf, A., & Hoekstra, R.M. (2005). Effect of hand washing in child health. Lancet. 366: 225-33. https://doi.org/10.1016/S0140-6736(05)66912-7.

Luby, S.P., Gupta, S.K., Sheikh, M.A., Johnston, R.B., Ram, P.K., & Islam, M.S. (2008). Tube well water quality and predictors of contamination in three flood-prone areas in Bangladesh. *Applied Microbiology, 105*: 1002-1008.

Motoshita, M., Istsubo, N., & Inaba, A. (2011). Development of impact factors on damage to health by infectious diseases caused by domestic scarcity. *International Journal of Life Cycle Assessment, 16*(1): 65-73. https://doi.org/10.1007/s11367-010-0236-8.

Mushi, D., Byamukama, D., Kirschner, A.K., Mach, R.L., Brunner, K., & Farnleitner, A.H. (2012). Sanitary inspection of wells using risk-of-contamination scoring indicates a high predictive ability for bacterial fecal pollution in the peri-urban tropical lowlands of Dar es Salaam, *Tanzania. J Water Health. 10*(2): 236-43. https://doi.org/10.2166/wh.2012.117.

Parker, A.H., Youlten, R., Dillon, M., Nussbaumer, T., Carter, R.C., Tyrrel, S.F., Webster, J. (2010). An assessment of microbiological water quality of six water source categories in north-east Uganda. Journal of Water and Health, 8(3):550-560. https://doi.org/10.2166/wh.2010.128.

Paul, S.K. (2019). Post cyclone household food security in coastal Bangladesh. Khatun, H., Baquee, A.B., Kabir, H. (Ed.), People at risk: disaster and despair, Disaster Research Training and Management Centre, University of Dhaka, Bangladesh. 185-209.

Phillips, R.M., Vujcic, J., Boscoe, A., Handzel, T., Aninyasi, M., Cookson, S.T., Blanton, C., Blum, L.S., & Ram, P.K. (2015). Soap is not enough: handwashing practices and knowledge in refugee camps, Maban County, South Sudan. *Conflict and Health,* 9(1): 1-8. https://doi.org/10.1186/s13031-015-0065-2.

Rabbi, S.E., & Dey, N.C. (2013). Exploring the gap between hand washing knowledge and practices in Bangladesh: a cross-sectional comparative study. *BMC Public Health,* 13(1): 1-7. https://doi.org/10.1186/1471-2458-13-89.

Snoad, C., Nagel, C., Bhattacharya, A., & Thomas, E. (2017). The effectiveness of sanitary inspections as a risk assessment tool for thermotolerant coliform bacteria contamination of rural drinking water: a review of data from West Bengal, India. *The American journal of tropical medicine and hygiene,* 96(4): 976-983. https://doi.org/10.4269/ajtmh.16-0322.

UNICEF. (2015). Multiple Indicator Cluster Survey (MICS). Retrieved from https://www.unicef.org/statistics/index_24302.html.

Vaccari, M., Collivignarelli, C., Tharnpoophasiam, P., & Vitali, F. (2004). Well sanitary inspection and water quality monitoring in Ban Nam Khem (Thailand) 30 months after 2004 Indian Ocean Tsunami. *Environmental Monitoring and Assessment,* 161(1-4): 123-133. https://doi.org/10.1007/s10661-008-0732-5.

Walker, C.L.F., Perin, J., Aryee, M.J., Boschi-Pinto, C., & Black, R.E. (2012). Diarrhea incidence in low- and middle-income countries in 1990 and 2010: a systematic review. *BMC public health,* 12(1): 220. https://doi.org/10.1186/1471-2458-12-220.

White, S., Thorseth, A.H., Dreibelbis, R., & Curtis, V. (2020). The determinants of handwashing behaviour in domestic settings: an integrative systematic review. *International Journal of Hygiene and Environmental Health,* 227, 113512. https://doi.org/10.1016/j.ijheh.2020.113512.

WHO (2004). Water Sanitation and Hygiene, Facts and Figures (updated November 2004). WHO, Geneva. Retrieved from http://www.who.int/water sanitation health/publications /factsfigures04/en.

WHO (World Health Organization) & UNICEF (United Nations International Children's Emergency Fund). (1990). Joint Monitoring Program for Water Supply and Sanitation. Retrieved from http://www.wssinfo. org/en/ 122_definitions.html.

WHO (World Health Organization). (1997). Guidelines for drinking water quality, surveillance and control of community supplies. 2nd ed. vol. 3. World Health Organization, Geneva, Switzerland.

WHO (World Health Organization). (2021). Progress on household drinking water, sanitation and hygiene 2000-2020: five years into the SDGs. World Health Organization, Geneva, Switzerland.

WHO & UNICEF (2017). Progress on drinking water, sanitation and hygiene. Retrieved from: https://www.who.int/mediacentre/news/releases/2017/launch-version-report-jmp-water-sanitation-hygiene.pdf .

WHO. (2019). Safe water, better health. World Health Organization.

Wolf, J., Hubbard, S., Brauer, M., Ambelu, A., Arnold, B. F., Bain, R., & Boisson, S. (2022). Effectiveness of interventions to improve drinking water, sanitation, and handwashing with soap on risk of diarrhoeal disease in children in low-income and middle-income settings: A systematic review and meta-analysis. *The Lancet, 400* (10345): 48-59. https://doi.org/10.1016/S0140-6736(22)00937-0.

Zeitlyn, S., & Islam, F. (1991). The use of soap and water in two Bangladeshi communities: implications for the transmission of diarrhea. *Reviews of Infectious Diseases, 13*: S259–S264.