BANGLADESH MICS 2012-2013

WATER QUALITY THEMATIC REPORT

BANGLADESH BUREAU OF STATISTICS

unicef

BANGLADESH

MICS 2012-2013

WATER QUALITY THEMATIC REPORT

MARCH 2018

Bangladesh Bureau of Statistics
Statistics Division, Ministry of Planning
Government of the People's Republic of Bangladesh

Foreword

Bangladesh has made remarkable progress towards achieving its goal of universal access to improved water supply and as a result, today only two percent of the population is without access to improved drinking water. The Government of Bangladesh has clearly articulated its commitment to *'Ensure access to safe drinking water for all urban and rural population of Bangladesh'* in its 7th 5-year plan (2016-2020). Investments by government and donor agencies stakeholders have ensured that an additional 65 million people gained access to improved water sources between 1990 and 2015.

Though there has been laudable progress, some challenges remain; considering drinking water quality, an estimated 65 per cent of the population still lack access to drinking water that is arsenic safe and free from microbial contamination.

In an endeavor to provide all its citizens with safe drinking water, The Government of Bangladesh has recently approved an estimated 240 million dollars four -year arsenic mitigation project. The project aims to provide safe drinking water for the people living in the 3,200-arsenic prone Union Parishads and Pouroshavas in 110 Upazilas of the 29 districts identified as having higher than 60% arsenic contamination and below 60 per cent safe water supply coverage.

This *Drinking Water Quality Thematic Report* will benefit this service delivery project and other water supply interventions by providing evidence which enables the sector to understand better the socio-economic and geographical disparities and to target the most vulnerable people. The report provides quantitative evidence of critical aspects of water supply and drinking water safety at the division and district levels. This publication presents information on arsenic and fecal contamination of drinking water at source and household level, provides relevant insights using the equity lens to examine the disparities between districts by key variables such as education, socio economic status, as well as household water treatment and storage practices. The evidence presented, facilitates equitable and inclusive planning, programming, advocacy and effective targeting of the most vulnerable, as well as bench marking for the SDG 6.1.

We are of the firm belief that the publication will be of benefit to technocrats and policy makers and will contribute to the ongoing efforts of the Government of Bangladesh to meet the Sustainable Development Goal for safe drinking water.

We thank and congratulate all the stakeholders that contributed to the review of this publication and wish to affirm our commitment to our partnership and joint efforts for evidence based planning and progressive improvement in drinking water quality in Bangladesh.

Edouard Beigbeder
Representative
UNICEF Bangladesh

Md. Amir Hossain
(Additional Secretary)
Director General
Bangladesh Bureau of Statistics (BBS)

Table of Contents

1. Executive Summary

The Bangladesh Multiple Indicator Cluster Survey (MICS) 2012-2013 survey was conducted from December 2012 to April 2013 in all the 64 districts of seven divisions of Bangladesh. A stratified random sample of 51,895 households were interviewed about their child survival and development related practices including drinking water, sanitation and hygiene. The sources and stored drinking water of a proportion of the selected households were analyzed for arsenic and microbial quality.[1]

This Drinking Water Quality Thematic report, presents division and district wise data about arsenic and faecal contamination of drinking water in the 64 districts of Bangladesh based on the MICS 2012-2013. The report uses an equity lens to explore geographic, gender and socio-economic disparities in access to improved and safe drinking water.

The results indicate that Bangladesh has made significant progress in improving water coverage and that improved drinking water sources are used almost universally without significant disparities in access between divisions, rural and urban areas[2] or between the poorest and richest households. Most households in Bangladesh use water from tubewells for drinking. The majority of the population have a water source that is close to home or within a 30 minute roundtrip but there are still 4.9 million people living in households where it takes more than 30 minutes to collect drinking water from improved sources.

The survey demonstrates that water quality remains a major challenge in Bangladesh, with high faecal contamination and arsenic levels in many parts of the country.

Nationally, 41.7% of the households used drinking water sources that were faecally contaminated[1] (presence of *E. coli*), which increased to 61.7% at the point of consumption. In all divisions except Rangpur, at least 30% of the households use faecally contaminated water sources. The three worst affected divisions are Sylhet, Dhaka and Chittagong.

1 MICS 2012 -2013 report was published by the Bangladesh Bureau of Statistics with the support of UNICEF Bangladesh in March, 2015

2 Disparities remain in had to reach areas

The microbial quality of the drinking water worsens from source to household, with an estimated 65.5 million people using drinking water that is microbiologically contaminated at source and 97 million people at the household level. Only about a quarter of households that use unimproved water sources reported that they treat their water at household level. There was no observed improvement in three quarters of these self-reporting treatment households.

Arsenic contamination exceeded the Bangladesh standard of 50 ppb in 12.4% of households, and all 64 districts had some households with arsenic concentrations above 50 ppb. Sylhet, Chittagong and Khulna divisions had the highest proportion of inhabitants using water sources contaminated with arsenic above 50 ppb. Progress in reducing arsenic contamination has been slow with approximately a one percentage point reduction in population exposed to arsenic above the Bangladesh standard between the 2009[3] and 2012-2013 MICS surveys. According to the MICS 2012-2013 survey, 19.5 million people use drinking water that contains arsenic levels above the Government of Bangladesh (GoB) standards (50 ppb), and twice that number drink water above the World Health Organization (WHO) guidelines (10 ppb). More than 1 out of 5 people in Sylhet, Chittagong, and Khulna divisions had arsenic concentrations above 50ppb in their stored drinking water.

In summary, although access to improved water sources is high in Bangladesh, access to safe drinking water is low as only 35% of households have access to drinking water that is free from both arsenic and microbial contamination; ranging from 23.0% to 46.5% in Sylhet and Barisal divisions respectively.

The 7th 5 year plan clearly articulates The GoB's commitment to ensuring access to safe water to all its rural and urban population by 2025. Though the magnitude of the problem is high, provision of arsenic and bacteriologically safe water sources can be scaled up under government leadership by addressing the multi-dimensional challenges to water safety in Bangladesh.

The priority interventions necessary to address the challenges and scale up drinking water safety include:

- Scaling up water safety planning within a drinking water safety framework and advocating for high level involvement, increased investments and integration of sanitation improvement and faecal sludge management within the water safety planning process.
- Advocating for a review of the GoB standard for drinking water from 0.05mg/l to 0.01mg/l in line with the health based targeting component of the drinking water safety framework

3 Water Quality thematic report 2009

- Institutionalizing systematic drinking water quality monitoring and surveillance in line with the sustainable development indicators for water supply, prioritizing Sylhet, Dhaka and Chittagong divisions.
- Adopting a harmonized sector-wide approach and protocol for arsenic mitigation in drinking water to reduce the use of divergent approaches by stakeholders which is a major bottleneck to scaling up drinking water safety in Bangladesh.
- Funding and implementing the national plan on arsenic mitigation in drinking water (2016 -2025), by developing action plans for priority areas
- Developing and operationalizing a national communication strategy for water safety to facilitate the definition and targeting of primary and secondary audience with key water safety messages
- Prioritizing urban poor, arsenic prone, hard to reach areas for safe water provision to reduce disparities in access.
- Building the capacity of the private sector to construct arsenic and microbiologically safe water points as most of the wells drilled in Bangladesh is provided by private sector.
- Developing and operationalizing integrated drinking water supply and sanitation management information system to facilitate timely access to reliable information for planning and monitoring progress.
- Developing and operationalizing a national operation and maintenance strategy to facilitate sustainability of water supply facilities.

2. Introduction

Although Bangladesh has made progress towards achieving its goal of universal access to improved water supply and improved sanitation for all its citizens, significant challenges remain in terms of quality and sustainability of water supply, sanitation and hygiene services. Other challenges are disparities in access in urban slums and areas that are hard to reach, arsenic and disaster prone. Although according to the MICS 2012-2013, 97.9 per cent of the population has access to improved water sources, about 65 per cent of the population lacks access to drinking water that is arsenic safe and free from microbial contamination. Furthermore, only 55 per cent of the population have access to both improved water and improved sanitation.

Bangladesh suffers from the worst case in the world of geogenic contamination of ground water with arsenic particularly of the shallow aquifers. About 19.5 million people i.e. 12.4 per cent of the population are exposed to water with arsenic contamination above the national standard, and double this number exposed to drinking water with arsenic levels about the WHO recommended guideline. Arsenicosis has short and long term social and health related implications, such as cancers, social stigmatization and poor cognitive development of children. In a study in Bangladesh, Flanagan et al. (2012)[4] found that the mortality from cancer increases with increased arsenic concentration in drinking water. Relatedly, Kylie et al. (2016)[5] in a study in Bangladesh found that the higher the arsenic concentration in a pregnant woman's drinking water, the lower her baby's birthweight, even at concentrations below the Bangladesh standard.

Access to safe water in Bangladesh is further reduced by the occurrence of manganese at concentrations exceeding the WHO health-based guideline

---

4 Flanagan, S.V., Johnston, R.B. and Zheng, Y., 2012. Arsenic in tube well water in Bangladesh: health and economic impacts and implications for arsenic mitigation. Bulletin of the World Health Organization, 90(11), pp.839-846.

5 Kile, M.L., Cardenas, A., Rodrigues, E., Mazumdar, M., Dobson, C., Golam, M., Quamruzzaman, Q., Rahman, M. and Christiani, D.C., 2016. Estimating effects of arsenic exposure during pregnancy on perinatal outcomes in a Bangladeshi cohort. Epidemiology (Cambridge, Mass.), 27(2), p.173.

of 0.4mg/l in two out of five tubewells (Hasan and Ali, 2010)[6]. Furthermore, nationwide, about a third of the wells that met the Bangladesh standards for arsenic had unsafe levels of manganese (Hasan and Ali, 2010). Exposure to high manganese in drinking water has been linked to impaired cognitive function in children. Wasserman et al. (2005)[7] found that even after adjustment for sociodemographic covariates, exposure to manganese through drinking water was associated with reduced full-scale, performance, and verbal raw scores of children.

High levels of chloride in drinking water particularly in coastal areas also impacts on water safety access. In coastal areas of Bangladesh, a significant proportion of the population lack access to freshwater sources due to the contamination of drinking water sources with high levels of chlorides. Saltwater intrusion from rising sea levels, cyclone and storm surges, and upstream withdrawal of freshwater exposes the population to higher than normal intake of salt, predisposing them to higher risks of hypertension and other associated diseases.

In addition to the challenges related to the chemical quality of drinking water, the environmental vulnerability of Bangladesh results in microbiological contamination of available water sources, from flooding and destruction of existing water sources. This is compounded by poor operation and maintenance of existing water supply infrastructure. In recent decades, the GoB has invested more than US$10 billion to make the country less vulnerable to natural disasters.[8]

The United Nations General Assembly Resolution 64/292 affirms that access to safe drinking water and sanitation is a human right, which forms the basis of the realisation of all other human rights. Therefore, the inadequate quality and sustainability of WASH services in Bangladesh has attendant short and long-term impact on the survival, development and protection of children's right to education, health, nutrition and WASH.

This drinking water quality thematic report explores the rich data collected by the MICS 2012-13 in more detail, to shed further light on the populations most exposed to unsafe levels of arsenic and microbial contamination, and risk factors associated with exposure. This detailed information will assist the Government of Bangladesh in setting targets for drinking water services, in the context of the global 2030 Agenda for Sustainable Development.

---

6 Hasan, S. and Ali, M.A., 2010. Occurrence of manganese in groundwater of Bangladesh and its implications on safe water supply. J Civil Eng, 38(2), pp.121-128.

7 Wasserman, G.A., Liu, X., Parvez, F., Ahsan, H., Levy, D., Factor-Litvak, P., Kline, J., van Geen, A., Slavkovich, V., Lolacono, N.J. and Cheng, Z., 2006. Water manganese exposure and children's intellectual function in Araihazar, Bangladesh. Environmental health perspectives, 114(1), p.124.

8 Government of Bangladesh, 2009, Bangladesh Climate Change Strategy and Action Plan 2009. Dhaka.

Context

The Bangladesh MICS 2012-2013 was conducted from December 2012 to April 2013 by the Bangladesh Bureau Statistics, Ministry of Planning. Technical and financial support for the survey was provided by the United Nations Children's Fund (UNICEF) in Bangladesh.

MICS 2012-2013 provides valuable information and the latest evidence on the situation of children and women in Bangladesh, updating information from the previous 2009 Bangladesh MICS survey as well as earlier data collected in the MICS rounds since 1996.

The survey presents data from an equity perspective by indicating disparities by sex, area, division, education, living standards, and other characteristics. Bangladesh MICS 2012-2013 is based on a sample of 51,895 households interviewed and provides a comprehensive picture of children and women in the seven divisions of the country. Topics covered by the MICS include: child mortality, nutritional status and breastfeeding, child health and care of illness, water and sanitation, reproductive health, early childhood development, literacy and education, child protection, HIV/AIDS and orphanhood, and access to mass media and ICT.

The MICS 2012-2013, like the previous MICS conducted in 2009, included a module for measurement of drinking water quality. In the 2009 MICS, samples of household water were collected and sent to Dhaka for arsenic analysis with field kits, and a subset were sent for analysis of a suite of metals and metalloids, including arsenic. The 2012-13 survey expanded upon the MICS 2009 by measuring microbiological quality of drinking-water at both the household level and at the drinking water source. In the 2012-13 survey, unlike the 2009 survey, field teams conducted water quality tests in the field using portable test kits. A total of 12,952 household samples, and 2,554 source samples were measured for arsenic, while 2,588 household and 2,538 source samples were measured for *E. coli*, an indicator of faecal contamination.

The MICS is based on an assessment of 51,895 households (rural: 83.8% and urban: 16.2 per cent), with a mean household size of 4.6. The households were mainly headed by men (90.3 per cent) and almost half (42 per cent) of the household heads had no formal education. Two out of five households had children aged <5; majority (77.6 per cent) of their primary caretakers had attended primary or secondary school and about 1 in 4 of the care takers were from the poorest quintiles and 1 in 5 from the richest. One in five of the household members were adolescents.

Table 1: Selected Characteristics of Households Interviewed

Indicator	Value
No. of Households interviewed	51,895
Area (%)	
Urban	16.2%
Rural	83.8%
Mean household size	4.6
Sex of Household Head (%)	
Male	90.3
Female	9.7
Education of Household Head (%)	
None	42.1
Started or completed primary	24.8
Started or completed secondary	33.1
Percentage of Household interviewed with Children under 5	40.3
Sex of Children under 5 (%)	
Male	51.3
Female	48.7
Education of primary caretakers (%)	
None	22.5
Started or completed primary	29.7
Started or completed secondary or higher	47.9
Wealth Quintiles: primary caretaker (%)	
Poorest	24.4
Second	20.5
Middle	18.6
Fourth	17.9
Richest	18.5
Percentage of adolescents in Household Members	21.5
Sex of adolescent (%)	
Male	21.9
Female	20.2

Child survival and development. The population sampled had a child mortality rate (U5MR) 58/1000 live births with 2 out of 5 of the children U5 moderately or severely stunted. The children in the poorest households exhibited more than double the stunting prevalence of the richest households. Although 73.2 per cent of the children of primary school age were in school, less than half (46.1 per cent) of the children of secondary school are currently attending school.

Water, Sanitation and Hygiene. The majority of the population had access to improved water sources (97.9 per cent) in both urban (99.1 per cent) and rural (97.6 per cent) areas, with majority being on the premises or less than 30 minutes away from the household. The main improved drinking water option used was the tubewell (90.6 per cent), though this option was used more by rural household members (96 per cent) than those in urban areas (70.1 per cent); there was also disparity in use of piped water between urban (28.7 per cent) and rural (1.3 per cent). Only about 1 in 4 of the households that used unimproved water sources used an appropriate water treatment method. Although only 3.9 per cent of the population practice open defecation, over half used improved sanitation facilities that are not shared. Just a little over one third (38.7 per cent) of the population disposes of child faeces safely, and more than half (59.1 per cent) of the households had water and soap at their handwashing station.

Progress towards global and national targets

The Government of Bangladesh Seventh Five-Year Plan (2016-2020), summarizes the country's vision for economic and social development, seeks to increase economic growth that is inclusive, pro-poor, and supports environmental sustainability. The Five-Year Plan calls for providing access to safe water to the entire rural and urban population by 2020, This target is in line with the global 2030 Agenda for Sustainable Development which calls for achieving universal and equitable access to safe and affordable drinking water for all by 2030. The global target will be tracked with the indicator of 'population using safely managed drinking water services', which are defined as the use of an improved drinking water source which is located on premises, available when needed, and meets microbiological and priority chemical drinking water standards. The priority chemicals for monitoring at the global level are arsenic and fluoride, while *E.coli* is the indicator for microbiological quality

Bangladesh has made substantial progress on several key indicators of development including underweight children and hunger, gender parity in primary and secondary education, child and maternal mortality, and access to improved drinking water and improved sanitation (Table 2).

Table 2: Key Development Indicators (MICS 2012-2013)

Description	Value
Child population (millions, under 18 years, 2015)	59.9
Under five morality rate (per 1,000 live births)	58
Stunting prevalence in Children under 5 (moderate and severe)	42.0
Stunting disparities (%, urban/rural, poorest/richest)	31/38, 50/21
Maternal mortality ratio - MMR (per 100,000 live births, 2015)[9]	176
Percentage of children of primary school age currently attending primary or secondary school	73.2
Percentage of children of secondary school age currently attending secondary school or higher	46.1
GNI per capita (US$, 2015)[10]	1,314

9 Trends in Maternal Mortality: 1990-2015, Estimates by Maternal Mortality Estimation Inter-Agency Group (MMEIG)

10 Bangladesh Economic Review 2015 for financial year 2014-2015

With regard to water and sanitation facilities, Bangladesh has made progress towards achieving the goal of its 7th 5 year plan to provide access to safe water and sanitation to all its rural and urban population by 2020. Access to improved water sources increased from 68 per cent to 97.9 per cent between 1990 to 2013. The MICS surveys indicate that access to improved sanitation improved from 40.4 per cent to 55.9 per cent between 1998 and 2013 while the practice of open defecation reduced from 27 per cent to 3.9 per cent within the same period.

Table 3 shows the status of some WASH related indicators according to the 2012-2013 Multiple Indicator Survey.

Table 3: Summary of Key WASH Indicators (MICS 2012-2013)

Indicator	National (%)	Urban (%)	Rural (%)
Population using improved drinking water sources	98.0	99.1	97.6
Main improved drinking water sources:			
Tubewell/Borehole	90.6	70.1	96.0
Piped water	7.0	28.7	1.3
Other improved sources	0.4	0.3	0.4
Time taken to collect drinking water			
water on premises	74.2	83	71.9
<30 mins	20.4	14.4	22.0
>30 mins	3.1	1.6	3.4
Population practicing open defecation	3.9	1.4	4.6
Population using improved sanitation	55.9	58.6	55.2
Safe disposal of child's faeces	38.7	60.2	33.1
Availability of a handwashing facility with soap and water	59.1	70.3	55.8

Despite considerable progress towards the Millennium Development Goals (MDGs) and the Government of Bangladesh's strong commitment to increasing access to basic services; poverty and disparities still pose challenges to the provision of quality basic services at the beginning of the SDGs. For example, the national poverty rate stands at 31.5 per cent, varying from 46 to 26 per cent in Rangpur and Chittagong division, respectively. Sub-national disparities are also evident in the coverage of basic social services between rural/urban locations, geographic regions, by gender and wealth; particularly to the urban poor, hard-to-reach areas and areas that are vulnerable to climate change.

Concerning water supply and sanitation, substantial challenges still remain in achieving the SDG of Safe and sustainable management of drinking water particularly in relation to the quality and sustainability of water supply, sanitation and hygiene services. Other challenges are disparities in access in urban slums and areas that are hard to reach, arsenic and disaster prone. Although 97.9 per cent of the population has access to improved water sources (MICS 2012 -2013), about 65 per cent of the population lack access to drinking water that is arsenic safe and free from microbial contamination (MICS 2012-2013). Furthermore, only 55 per cent of the population have access to both improved water and improved sanitation.

3. Methods

3.1 Survey design

The sample for the Bangladesh Multiple Indicator Cluster Survey (MICS) was designed to provide estimates for a large number of indicators on the situation of children and women at the national level, for urban and rural areas, seven divisions and sixty four districts. The districts were identified as the main sampling strata and the sample was selected in two stages. Within each stratum, a specified number of census enumeration areas were selected systematically with probability proportional to size (pps). After a household listing was carried out within the selected enumeration areas, a systematic sample of 20 households was drawn in each of 2,760 sample enumeration areas. Four of the selected enumeration areas were not visited because they were inaccessible due to rough weather and hilly remote road communication during the fieldwork period. These enumeration areas were one each from Bagerhat, Gaibandha, Rangamati and Sirajganj districts. The sample was stratified by districts, and is not self-weighting. For reporting summary results, sample weights are used. A more detailed description of the sample design can be found in Appendix A of the final report.

In each enumeration area, a subsample of five households was randomly chosen to test household drinking water from among the 20 households that were randomly selected for the main survey. Respondents in selected households were asked to provide "a glass of water which you would give a child to drink" for arsenic testing. In addition, one of the five households was selected for additional water quality testing, which included measurement of *E. coli* in household drinking water, and of *E. coli* and arsenic at the source of the drinking water. Selection tables containing random numbers were provided to all supervisors, to ensure that households selected for water quality testing were randomly chosen.

Household response rates[11] were high, and similar for water quality testing and completion of the full questionnaire (Table 4). The household response rates were similar across divisions and areas of residence.

---

11 Defined as the ratio of the number of households completed to the number of households targeted.

Table 4: Household response rates

	Households selected	Households completed	Household response rate (%)[12]
Main MICS questionnaire	55,120	51,895	94.0%[12]
Arsenic testing (household)	13,800	12,952	93.9%
Arsenic testing (source)	2,760	2,554	92.5%
E. coli testing (household)	2,760	2,588	93.8%
E. coli testing (source)	2,760	2,538	92.0%

The questionnaires are based on the MICS5 model questionnaire[13] tested during the global MICS5 pilot study in Sirajganj and Bogra during May-June 2012. From the MICS5 pilot English version, the questionnaires were translated into Bengali and tested during the global MICS5 pilot. Based on the results of the pre-test, modifications were made to the wording and translation of the questionnaires. A copy of the Bangladesh MICS questionnaires is provided in Annex 4.

3.2 Training and fieldwork

The overall MICS data collection was conducted by 32 teams; each was comprised of four female interviewers, one editor, one male measurer and a supervisor. The measurers were selected to conduct water quality tests using portable field equipment.

Training of the 32 measurers in water quality testing was conducted for 14 days in November, 2012. Supervisors were also oriented on the testing procedure. Two MICS international consultants conducted the training, and one international consultant provided follow-up support for the first several weeks of survey implementation. Supervisors who had participated in the Bogra pilot training provided expert support.

In order to get hands on experience in water quality testing, measurers were trained in two separate groups of 16 people each. Measurers could practice the test protocol in small groups, so that each measurer conducted at least five practice tests, in the presence of other trainees. Towards the end of the training period, trainees spent two days in practice interviewing in Dhaka and Narayanganj. Fieldwork began in December, 2012 and concluded in April, 2013.

12 Response rate calculated based on household completed by households selected

13 The model MICS5 questionnaires can be found at http://www.childinfo.org/mics5_questionnaire.html

3.3 Sample collection

Water samples were collected at both the household and from the source of water used by that household. At the household level, survey respondents were asked to provide "*a glass of water you would give a child to drink*". In households selected for additional water quality testing, the measurer would also test the household sample for arsenic, and would ask to see the source of the water supplied for testing. The measurer would then collect a sample directly from the source for testing for arsenic and *E. coli*. In the case of piped water supply, the source sample was collected directly from the tap, without collection in a glass or other vessel.

Sources were not sterilized prior to sample collection, so it is possible that some of the *E. coli* contamination found in source samples is due to unhygienic handling of taps and tubewell spouts. However, this method provides a good measure of the quality of water as it is actually collected by household members.

3.4 Arsenic testing

Arsenic was measured using the Arsenic Econo-Quick™ Test Kit (Industrial Test Systems, USA), which yields a semi-quantitative measure of arsenic in drinking water. Table 5 indicates the testing procedure followed by teams.

Table 5: Arsenic testing procedure

Step	Description
1	Fill sample bottle to top line (50 mL) with sample water.
2	Add 1 pink spoon full of Reagent 1 to the sample bottle. Close using the red cap and shake gently for 15 seconds.
3	Open sample bottle and add 1 red spoon full of Reagent 2. Close using the red cap and shake gently for 15 seconds. The water may turn yellow, this is normal.
4	Open sample bottle and add 1 white spoon full of Reagent 3. Close using the red cap and shake gently for 5 seconds.
5	Remove the red cap and replace with the white cap. Make sure that the white cap does not get wet.
6	Remove one test strip, and immediately close the test strip bottle. Open the white cap tip and insert the test strip through the small hole. Make sure the red line is facing the back of the cap, and the bromide paper square is inside the bottle. Insert the strip until the red line is touching the tip. Close the tip.
7	Wait 10 minutes.
8	Open the tip and remove the test strip. Check the colour of the bromide paper square against the comparison chart, and record the arsenic level in ppb. Only use the levels indicated on the chart: 0, 10, 25, 50, 100, 200, 300, 500, 1000. If the colour on the bromide paper square is in between two of these colours on the comparison chart, use the higher value. Make sure to check the colour against the comparison chart within 30 seconds of removing the paper.
9	Clean up. Dispose of the test water, it is not hazardous. Shake any powder off of the spoons and replace them in the plastic bag. Place the test strip paper in the bag marked USED Mercuric Bromide Test Strips.
10	Wash hands well with soap.

Unlike the WHO provisional guideline value for arsenic of 10 parts per billion (ppb)[14], the Bangladesh standard for arsenic in drinking water is 50 ppb. Some groundwater in Bangladesh is highly contaminated. A non-statutory level of 200 ppb is used in this report to characterize high levels of health risk.

The arsenic test was completed within the household, and results were shared with the survey respondent. If the result exceeded 50 ppb, the respondent was given a leaflet about arsenic and advised not to drink or cook with the water, and to contact the Department of Public Health Engineering (DPHE) for further advice.

3.5 *E. coli* testing

E. coli is the preferred indicator of faecal contamination in drinking water. In the MICS 2012-13, *E. coli* was measured in the field by MICS teams, by filtering 100 mL of sample through a 0.45 micron filter (Millipore Microfil®) which was then placed onto Compact Dry EC growth media plates (Nissui, Japan). A 1 mL sample was also tested from the same source directly onto a second media plate. The Compact Dry plates contain a chromogenic compound (X-gluc) which reacts with the beta-glucuronidase enzyme produced by *E. coli*, resulting in blue coloured colonies.

Incubation was done at ambient temperature, and field teams were given padded sacks for storing media plates close to their bodies in case of cold weather. After 24 hours, the number of blue colonies, signifying the presence of *E. coli* colony forming units (cfu), was recorded. Table 6 describes the testing procedure followed by teams.

Table 6: *E. coli* testing procedure

Step	Description
1	Open Compact Dry Plate packet. Label two plates with Sample ID using permanent marker or sticker.
2	Wash hands well with soap, or use hand sanitizer.
3	Sterilize filter support using alcohol wipes.
4	Sterilize forceps using alcohol wipes. Put forceps down on flat surface, on top of the alcohol wipe, without touching the forcep tips.
5	Using forceps, remove one sterile filter paper. Do not use the blue paper sheets.
6	Place a filter paper on the filter support, with the grid lines up. Put the forceps down on the alcohol wipe, without touching the tips. Remove one Microfil funnel from package, without touching the rims.
7	Place a Microfil funnel on the support and press down

14 One ppb (part per billion) is equivalent to one μg/L (microgramme per liter)

Step	Description
8	Pour the sample into the Microfil funnel, up to the 100 mL line.
9	Open a sterile 1 mL syringe, being careful to not touch the tip. Draw 1 mL of sample from the funnel into the syringe.
10	Add 1 mL of sample to each of the two Compact Dry plates. Do not touch the plates with the syringe (or with fingers). Replace the lid on the Compact Dry plate after adding the sample.
11	Attach syringe to filter support and turn valve to open position (vertical).
12	Create vacuum with syringe, slowly filtering sample.
13	After all the sample is filtered, close the valve (horizontal position) and remove the funnel.
14	Press the lever and remove the filter paper using the sterile forceps. Remove the lid from one of the Compact Dry plates.
15	Place the filter paper on the Compact Dry plate, taking care to avoid bubbles. Keep the grid lines facing up.
16	Place the lid on the Compact Dry plate.
17	Open the valve and use the syringe to suck any remaining water from filter support. Remove the syringe and dispose of filtered water.
18	Collect all garbage (1 mL syringe and wrapper, alcohol wipe and wrapper, Compact Dry wrapper) and place in rubbish bag. Show respect to the households and do not litter!
19	Wash hands well with soap. Test is done! Read and record test results after 24-48 hours.

Bangladesh has set a standard that no *E. coli* should be found in a 100 mL sample of drinking water. This is aligned with the WHO Guidelines for Drinking Water Quality.

During sample collection, households were provided with a short brochure describing the risks posed by microbiological contamination of drinking water, and simple methods for preventing or removing contamination (See Annex 4).

3.6 Data analysis

The water quality results were recorded on paper questionnaires, and the Bureau of Statistics was responsible for the data entry. All analysis was done with Stata 14, using *svy* functionality for weighting and sampling errors.

During the data analysis the number of colony forming units (CFU) counted on the plates by the measurer were converted into the corresponding WHO risk categories, according to the algorithm shown in Table 7.

Table 7: Algorithm for risk classification based on test results

Test result (100 mL)	Test result (1 mL)	Risk classification	*E. coli* range (CFU/100 mL)
0	0	Low	0
1-10	0 or 1	Medium	1-10
11-30	0 or 1 or 2	High	11-100
31-100	0 or 1	High	11-100
> **100**	0	High	11-100
31-100	2 or more	Very High	> 100
> **100**	1 or more	Very High	> 100

Since both 100 mL and 1 mL samples were analysed, unusual combinations of test results could be identified and flagged, as shown in Table Y. Two main types of inconsistent results: those in which the 1 mL test shows higher colony counts than expected, given the 100 mL test; and those in which the 1 mL test shows surprisingly low results, given the 100 mL test. Where 100 mL tests were significantly lower than would be expected based on the 1 mL test, no risk class was assigned.

Table 8: Unusual test results and their risk classification

Test result (100 mL)	Test result (1 mL)	Risk class	Note
0	1 or more	Not classified	Inconsistent
1-10	2 or more	Not classified	Inconsistent
11-30	3 or more	Not classified	Inconsistent
> **100**	0	High	Inconsistent
> **30**	>30	Very High	Surprisingly high – should be rare

4. Arsenic contamination results

A total of 2,554 arsenic tests of source samples were completed, and 12,952 from household water. Test results were grouped into risk categories with reference to three key arsenic concentration levels, shown in Table 9.

Table 9: Description of reference arsenic concentrations

Arsenic Concentration ppb	Description of significance
10	WHO provisional guideline value for drinking water since 1993. The same value has been adopted as a standard by the US EPA and the European Union amongst others
50	The Bangladesh Standard for drinking water. The same value applies in India and some other severely arsenic affected countries. This was the WHO guideline value for drinking water up to 1993.
200	A non-statutory descriptive statistics, used here and previously in MICS 2009, to characterise high levels of health risk.

The degree of arsenic contamination was very similar in source and household drinking water. 25.5 per cent of the population collects water from a source containing over 10 ppb arsenic, and 24.8 per cent of the population consumes water above this level in the household (Figure 1). Similarly, 12.5 per cent of the population collects water containing over 50 ppb arsenic, and 12.4 per cent consumes water above this level. The corresponding figures for arsenic above 200 ppb are 2.5 per cent and 2.8 per cent of the population.

Figure 1: **Arsenic in source and household drinking water compared with the WHO Guidelines (10 ppb) and national standard (50 ppb) in %**

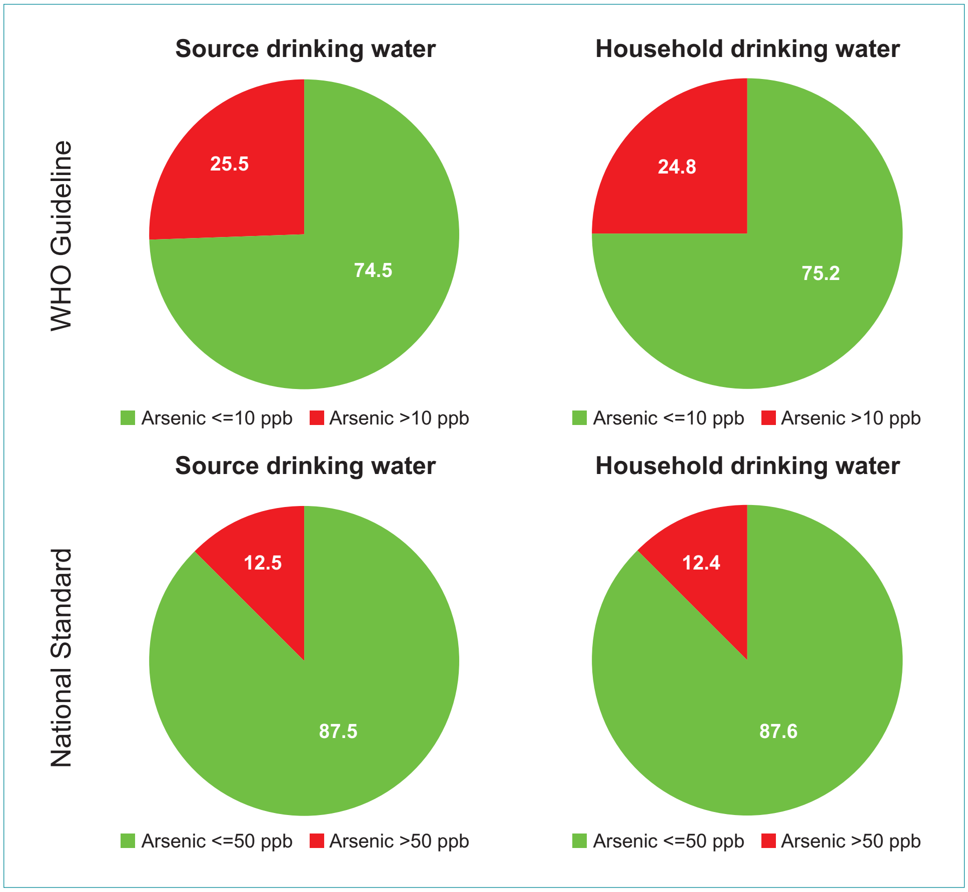
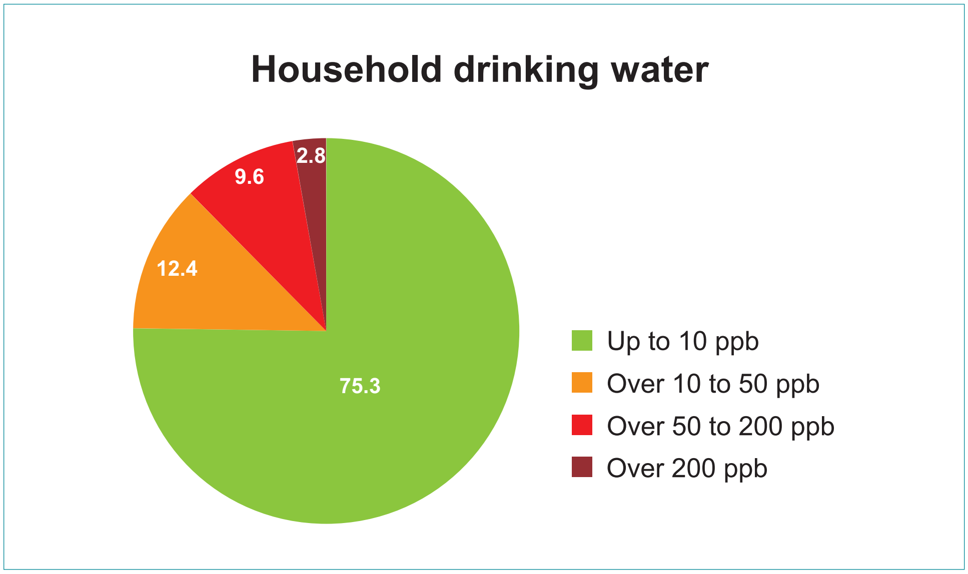


Figure 2: **Arsenic risk levels in household drinking water (in %)**



The population that is exposed to arsenic exceeding 10 and 50 ppb can be estimated using the above figures. The UN Population Division estimated the population of Bangladesh to be 156.6 million in 2013 (World Population Prospect, 2012 revision). Of these 38.8 million (24.8 per cent) drink water that exceeds the WHO provisional guideline of 10 ppb and 19.4 million (12.4 per cent) drink water that exceeded the national standard of 50 ppb.

Since there is comparatively little difference between household and source the remainder of the analysis will focus on the household water quality since there are higher numbers of tests.

4.1 Arsenic by type of drinking water source

Arsenic levels vary amongst different types of water supply (Table 10).

The majority of the population in Bangladesh (97.9 per cent) uses an improved type of drinking water source, with 70 per cent of the urban population, and 96 per cent of the rural population, using tubewells. 13.8 per cent of these people consume water above the Bangladesh standard of 50 ppb, while 26.7 per cent drink water above the WHO provisional guideline value of 10 ppb. The MICS questionnaire did not distinguish between shallow and deep tubewells, though previous surveys have shown that arsenic is almost exclusively confined to the shallow aquifer.

The next most common type of water supply is piped water, used by 28.7 per cent of the urban population, but only 1.3 per cent of the rural population. Piped water was found to be much less contaminated, with 1-2 per cent exceeding 50 ppb and approximately 10 per cent above 10 ppb. If Dhaka district is excluded, 15 per cent of the population using piped water exceeds 10 ppb, and 3.6 per cent exceeds 50 ppb.

It is likely that piped water supplies found to be contaminated are using production wells containing arsenic. Arsenic above 50 ppb was found in piped water of 12 districts, but the number of people using piped water outside of Chittagong, Dhaka, and surrounding districts was small.

Table 10: Arsenic content of household drinking water by water source type

Proportion of population by arsenic concentration in drinking water, Bangladesh 2012-2013							
	Proportion of population: Arsenic concentration in household drinking water				Total	Proportion over 50 ppb	Number of household members
	<=10 ppb	>10 - 50 ppb	>50 - <200 ppb	>=200 ppb			
Source of drinking water sample							
Piped into dwelling	91.3	7.1	0.8	0.9	100	1.7	2229
Piped into compound, yard or plot	90.1	9.0	0.7	0.2	100	0.9	2483
Public tap / standpipe	86.5	10.4	2.9	0.3	100	3.1	644
Tube well, Borehole	73.4	12.9	10.7	3.1	100	13.8	52875
Protected well	91.3	8.8	0.0	0.0	100	0.0	83
Unprotected well	80.3	19.7	0.0	0.0	100	0.0	187
Surface water (river, stream, dam, lake, pond, canal, irrigation channel)	93.0	4.2	1.2	1.7	100	2.9	822
Other	85.5	11.3	3.2	0.0	100	3.2	283
Total	75.3	12.4	9.6	2.8	100	12.4	59718
Improved/unimproved water source using JMP classification							
Unimproved water source	89.4	8.1	1.5	1.1	100	2.6	1266
Improved water source	75.0	12.5	9.8	2.8	100	12.6	58340
Total	75.3	12.4	9.6	2.8	100	12.4	59606

4.2 Arsenic by area and division

Arsenic levels were higher in rural than in urban areas, reflecting the greater use of tubewells (Table 11).

Table 11: Arsenic content of household drinking water by area and division

Proportion of population by arsenic concentration in drinking water, Bangladesh 2012-2013							
	Proportion of population: Arsenic concentration in household drinking water				Total	Proportion over 50 ppb	Number of household members
	<=10 ppb	>10 - 50 ppb	>50 - <200 ppb	>=200 ppb			
Area							
Urban	80.6	12.2	5.7	1.5	100	7.2	12230
Rural	73.9	12.4	10.6	3.1	100	13.7	47488
Total	75.3	12.4	9.6	2.8	100	12.4	59718

Proportion of population by arsenic concentration in drinking water, Bangladesh 2012-2013							
	Proportion of population						
	Arsenic concentration in household drinking water						
	<=10 ppb	>10 - 50 ppb	>50 - <200 ppb	>=200 ppb	Total	Proportion over 50 ppb	Number of household members
Division							
Barisal	94.5	5.4	0.1	0.0	100	0.1	3787
Chittagong	63.5	12.3	14.6	9.7	100	24.3	11942
Dhaka	74.1	16.4	8.2	1.3	100	9.5	18439
Khulna	62.6	18.2	16.6	2.7	100	19.2	6703
Rajshahi	88.6	7.0	3.8	0.7	100	4.5	7787
Rangpur	92.7	6.0	1.3	0.0	100	1.3	6994
Sylhet	62.3	12.8	24.0	0.9	100	24.9	4067
Total	75.3	12.4	9.6	2.8	100	12.4	59718

Chittagong, Khulna and Sylhet divisions had the highest proportion of population using water above 50 ppb, ranging from 19 to 25 percent of the population being affected. In these three divisions, approximately 37 per cent of the population consumed water above 10 ppb. The highest contamination levels were found in Chittagong, where nearly 10 per cent of the population had household water with 200 ppb or greater. The same patterns generally hold when considering rural or urban populations only (Tables 12 and 13), though contamination levels are generally higher in rural areas.

Of the 38.8 million people exposed to arsenic above 10 ppb, 6.3 million (16.2 per cent) are in urban areas, and urban areas account for 2.3 million of the 19.4 million 12 per cent consuming above 50 ppb arsenic.

Table 12: Arsenic content of household drinking water in rural areas by division

Proportion of population by arsenic concentration in drinking water, Bangladesh 2012-2013							
	Proportion of population						
	Arsenic concentration in household drinking water						
	<=10 ppb	>10 - 50 ppb	>50 - <200 ppb	>=200 ppb	Total	Proportion over 50 ppb	Number of household members
Division							
Barisal	94.4	5.5	0.1	0.0	100	0.1	3203
Chittagong	62.2	11.2	15.3	11.3	100	26.6	9187
Dhaka	69.8	18.3	10.2	1.7	100	11.9	13395
Khulna	62.3	17.4	17.3	2.9	100	20.2	5610
Rajshahi	88.9	6.9	3.9	0.3	100	4.2	6560
Rangpur	92.5	6.1	1.4	0.0	100	1.4	6110
Sylhet	58.7	12.9	27.4	1.0	100	28.4	3423
Total	73.9	12.4	10.6	3.1	100	13.7	47488

Table 13: Arsenic content of household drinking water in urban areas by division

Proportion of population by arsenic concentration in drinking water, Bangladesh 2012-2013							
	Proportion of population						
	Arsenic concentration in household drinking water						
	<=10 ppb	>10 - 50 ppb	>50 - <200 ppb	>=200 ppb	Total	Proportion over 50 ppb	Number of household members
Division							
Barisal	94.5	4.9	0.6	0.0	100	0.6	584
Chittagong	67.7	15.9	12.1	4.4	100	16.5	2755
Dhaka	85.6	11.3	2.9	0.3	100	3.1	5044
Khulna	64.1	21.9	12.7	1.4	100	14.0	1093
Rajshahi	86.9	7.3	3.2	2.6	100	5.8	1227
Rangpur	94.4	5.1	0.5	0.0	100	0.5	883
Sylhet	81.4	12.5	6.0	0.0	100	6.0	644
Total	80.6	12.2	5.7	1.5	100	7.2	12230

4.3 Arsenic by district

Some level of arsenic was detected in all 64 districts of Bangladesh, though more than 1 per cent of samples exceeded 50 ppb in only 44 districts. In 12 districts more than one in four people consume water containing over 50 ppb, while in five districts (Brahmanbaria, Chandpur, Comilla, Feni and Narail), more than one in ten people drink water having 200 ppb arsenic or more (Table 14 and Figure 3).

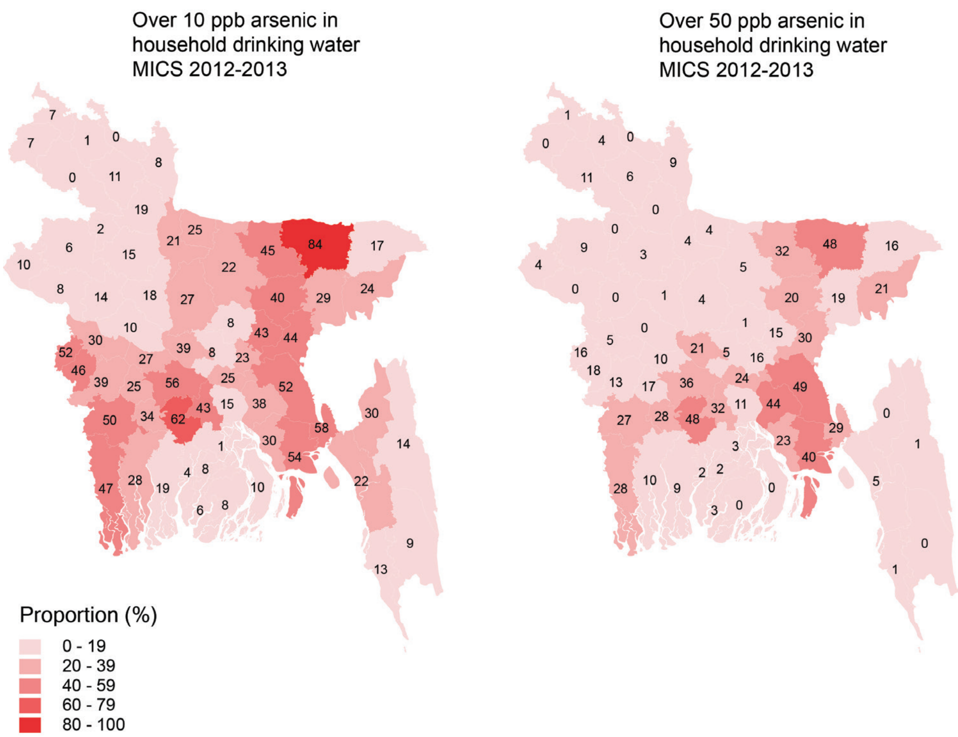
Table 14: Arsenic content of household drinking water by district

Proportion of population by arsenic concentration in drinking water, Bangladesh 2012-2013								
		Proportion of population						
		Arsenic concentration in household drinking water						
		<=10 ppb	>10 - 50 ppb	>50 - <200 ppb	>=200 ppb	Total	Proportion over 50 ppb	Number of household members
Division	**District**							
Barisal	1.Barguna	93.5	6.5	0.0	0.0	100	0.0	416
	2.Barisal	99.3	0.5	0.2	0.0	100	0.2	1086
	3.Bhola	90.4	9.6	0.0	0.0	100	0.0	818
	4.Jhalokati	92.3	7.6	0.1	0.0	100	0.1	275
	5.Patuakhali	92.0	8.0	0.0	0.0	100	0.0	711
	6. Pirojpur	96.0	3.4	0.6	0.0	100	0.6	481

Proportion of population by arsenic concentration in drinking water, Bangladesh 2012-2013								
		Proportion of population				Total	Proportion over 50 ppb	Number of household members
		Arsenic concentration in household drinking water						
		<=10 ppb	>10 - 50 ppb	>50 - <200 ppb	>=200 ppb			
Division	**District**							
Chittagong	7. Bandarban	90.7	9.4	0.0	0.0	100	0.0	182
	8.Brahmanbaria	56.3	8.0	20.4	15.3	100	35.7	1112
	9. Chandpur	61.8	0.2	10.5	27.6	100	38.0	1097
	10.Chittagong	77.8	15.1	5.6	1.6	100	7.1	3083
	11.Comilla	48.4	6.6	25.0	20.0	100	45.0	2374
	12.Cox's Bazar	87.3	12.7	0.0	0.0	100	0.0	868
	13.Feni	42.2	12.7	34.4	10.8	100	45.2	584
	14.Khagrachhari	69.6	30.4	0.0	0.0	100	0.0	261
	15.Lakshmipur	69.8	10.7	16.7	2.7	100	19.5	773
	16.Noakhali	45.8	25.9	22.3	6.0	100	28.3	1353
	17.Rangamati	85.8	14.2	0.0	0.0	100	0.0	255
Dhaka	18.Dhaka	91.9	7.1	1.1	0.0	100	1.1	3931
	19.Faridpur	44.0	26.7	25.4	4.0	100	29.3	832
	20.Gazipur	91.5	8.3	0.2	0.0	100	0.2	1196
	21.Gopalganj	38.4	16.8	35.5	9.3	100	44.7	512
	22.Jamalpur	79.2	17.3	3.6	0.0	100	3.6	1060
	23.Kishorganj	59.8	27.2	12.9	0.2	100	13.0	1263
	24.Madaripur	56.8	16.0	23.9	3.2	100	27.2	478
	25.Manikganj	61.1	23.0	12.4	3.5	100	15.9	491
	26.Munshiganj	74.5	25.5	0.0	0.0	100	0.0	509
	27.Mymensingh	78.3	14.1	6.4	1.2	100	7.6	2013
	28.Narayanganj	76.5	23.0	0.4	0.0	100	0.4	1056
	29.Narsingdi	57.1	20.9	17.8	4.2	100	22.0	971
	30.Netrakona	54.8	15.4	25.2	4.6	100	29.8	933
	31.Rajbari	72.6	20.0	6.3	1.1	100	7.5	433
	32.Shariatpur	85.3	9.2	4.5	1.1	100	5.6	561
	33.Sherpur	75.0	21.1	3.8	0.0	100	3.8	577
	34.Tangail	72.7	21.6	5.3	0.4	100	5.7	1624

Proportion of population by arsenic concentration in drinking water, Bangladesh 2012-2013								
		Proportion of population						
		Arsenic concentration in household drinking water						
		<=10 ppb	>10 - 50 ppb	>50 - <200 ppb	>=200 ppb	Total	Proportion over 50 ppb	Number of household members
Division	**District**							
Khulna	35.Bagerhat	81.0	9.7	6.9	2.4	100	9.4	635
	36.Chuadanga	54.0	26.2	18.7	1.0	100	19.8	464
	37.Jessore	49.9	17.0	31.3	1.8	100	33.1	1169
	38.Jhenaidah	60.6	22.7	13.2	3.4	100	16.7	742
	39.Khulna	71.8	19.1	7.3	1.8	100	9.1	913
	40.Kushtia	70.0	20.0	9.7	0.3	100	10.0	888
	41.Magura	74.8	11.1	12.3	1.8	100	14.1	419
	42.Meherpur	47.7	29.9	20.1	2.3	100	22.4	270
	43.Narail	66.4	9.8	13.8	10.0	100	23.8	325
	44.Satkhira	53.0	17.6	24.2	5.2	100	29.4	877
Rajshahi	45.Bogra	85.1	7.5	7.1	0.3	100	7.4	1424
	46.Joypurhat	97.6	2.1	0.3	0.0	100	0.3	383
	47.Naogaon	93.5	5.1	1.4	0.0	100	1.4	1118
	48.Natore	86.4	12.7	0.9	0.0	100	0.9	692
	49.Nawabganj	89.5	6.4	3.5	0.6	100	4.1	667
	50.Pabna	90.3	2.0	5.4	2.4	100	7.7	1074
	51.Rajshahi	92.4	6.0	1.6	0.0	100	1.6	1093
	52.Sirajganj	81.6	11.4	5.5	1.6	100	7.1	1337
Rangpur	53.Dinajpur	99.8	0.2	0.0	0.0	100	0.0	1278
	54.Gaibandha	81.4	15.4	3.1	0.1	100	3.3	1216
	55.Kurigram	92.3	6.0	1.7	0.0	100	1.7	909
	56.Lalmonirhat	99.6	0.3	0.2	0.0	100	0.2	557
	57.Nilphamari	98.9	0.7	0.4	0.0	100	0.4	803
	58.Panchagarh	93.3	6.6	0.1	0.0	100	0.1	399
	59.Rangpur	89.2	8.3	2.5	0.0	100	2.5	1222
	60.Thakurgaon	93.5	6.3	0.2	0.0	100	0.2	610
Sylhet	61.Habiganj	71.5	16.7	9.7	2.2	100	11.9	882
	62.Maulvibazar	76.0	11.4	11.9	0.7	100	12.6	758
	63.Sunamganj	15.7	16.8	66.4	1.1	100	67.5	1013
	84.Sylhet	82.5	8.4	9.1	0.0	100	9.1	1414
Total		75.3	12.4	9.6	2.8	100	12.4	59718

Figure 3: Proportion of the population (%) by district using drinking water exceeding 10 ppb As (WHO guidelines) and exceeding 50 ppb (national standard)



4.4 Arsenic by socio-economic status and education

No major trends were identified for arsenic and socio-economic status (Table 14). There was a modest trend for greater arsenic contamination among the poor in urban areas, which could reflect a greater reliance on private tubewells rather than piped supplies. A more modest trend for greater arsenic contamination among the rich in rural areas is likely not significant.

No significant trends were found for arsenic and educational status.

Table 14: Arsenic content of household drinking water by wealth quintile and education

Proportion of population by arsenic concentration in drinking water, Bangladesh 2012-2013							
	Proportion of population						
	Arsenic concentration in household drinking water						
	<=10 ppb	>10 - 50 ppb	>50 - <200 ppb	>=200 ppb	Total	Proportion over 50 ppb	Number of household members
Wealth index quintile							
Poorest	77.6	11.3	8.9	2.2	100.0	11.1	11679
Second	76.0	12.3	9.3	2.3	100.0	11.6	11980
Middle	72.9	12.8	10.9	3.5	100.0	14.4	12161
Fourth	72.0	13.4	11.3	3.3	100.0	14.6	12032
Richest	78.0	12.0	7.6	2.5	100.0	10.1	11865
Urban wealth index quintile							
Poorest	75.7	14.3	8.0	2.0	100.0	10.0	2385
Second	76.5	13.3	8.4	1.8	100.0	10.1	2528
Middle	80.2	12.4	6.2	1.3	100.0	7.5	2525
Fourth	83.7	11.3	3.5	1.5	100.0	5.0	2391
Richest	87.2	9.5	2.5	0.9	100.0	3.3	2402
Rural wealth index quintile							
Poorest	77.3	11.0	9.4	2.4	100.0	11.8	9237
Second	76.7	12.2	9.2	1.9	100.0	11.1	9284
Middle	73.5	12.4	10.4	3.7	100.0	14.1	10007
Fourth	71.0	13.3	12.0	3.6	100.0	15.7	9677
Richest	71.0	13.2	11.8	4.1	100.0	15.8	9284
Education of household head							
None	74.2	12.8	10.1	2.9	100.0	13.0	25778
Primary incomplete	71.8	13.7	11.2	3.3	100.0	14.5	7720
Primary complete	78.0	11.2	8.8	2.0	100.0	10.8	7056
Secondary incomplete	75.5	12.0	9.4	3.0	100.0	12.5	10151
Secondary complete or higher	78.9	11.3	7.5	2.4	100.0	9.9	8989
Missing/DK	54.0	17.7	28.3	0.0	100.0	28.3	24

4.5 Comparison with previous studies

Since the recognition of the scale of arsenic contamination in Bangladesh there have been several large scale initiatives to test water quality. In this section, the findings from MICS 2012-2013 are explored in relation to earlier studies including a MICS in 2009 and the national water point mapping initiative.

MICS 2009

The MICS in 2009 included arsenic testing through an added module called the Bangladesh National Drinking Water Quality Survey of 2009.

The MICS 2009 was based on a sample of 300,000 households drawn from 15,000 clusters. In one household from each cluster a sample of drinking water was collected ("a glass of water you would give a child to drink") and analysed for arsenic in Bangladesh, using portable kits in Dhaka. The analysis of 13,423 samples revealed that 12.6 per cent contained arsenic above the Bangladesh national standard of 50 ppb, while 23.1 per cent exceeded the provisional WHO Guideline Value of 10 ppb. The proportion above 50 ppb was 0.2 percentage points lower in 2012-13, while the proportion above 10 ppb was 1.7 percentage points higher.

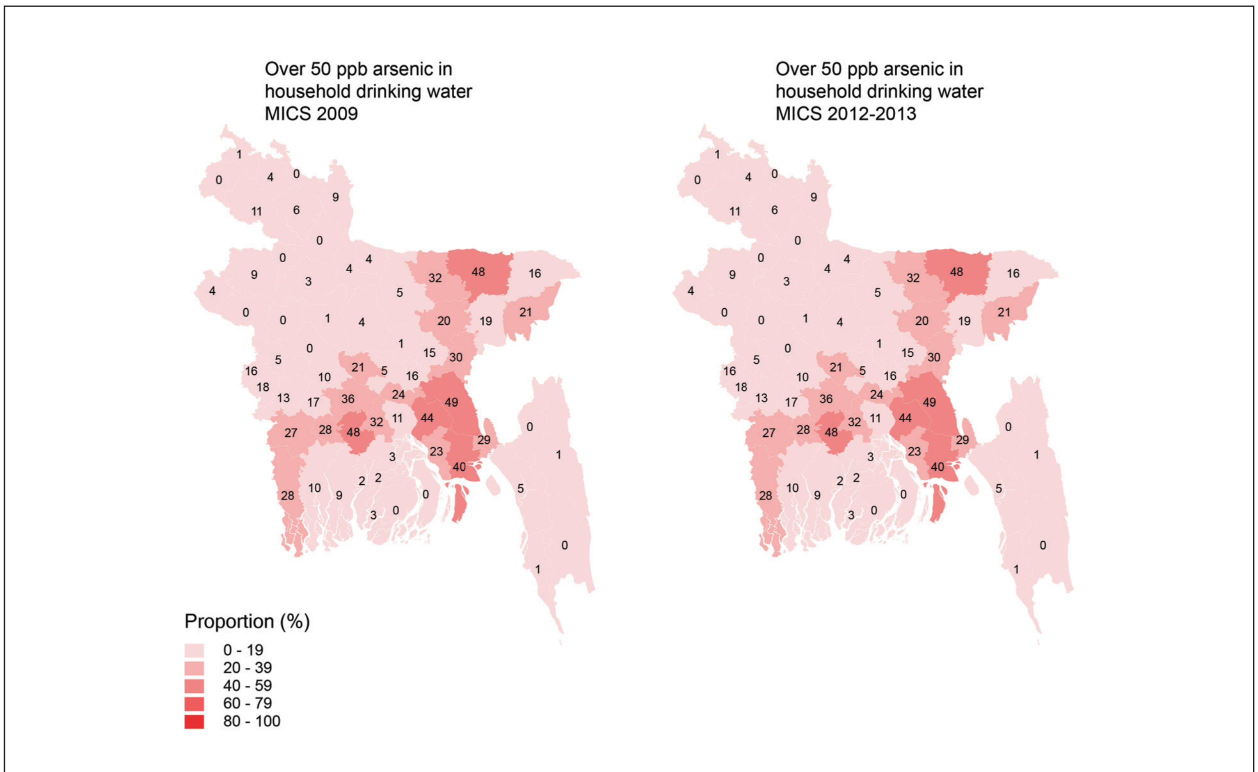
Table 15: Arsenic content of household drinking water in MICS2009 and MICS2012-2013

	Year	Arsenic content in household drinking water				Proportion over 10 ppb	Proportion over 50 ppb	Number of households
		<=10 ppb	>10 - 50 ppb	>50 - <200 ppb	>=200 ppb			
Total	**2009**	**76.9**	**10.5**	**9.5**	**3.1**	**23.1**	**12.6**	**13423**
	2012-13	**75.3**	**12.4**	**9.6**	**2.8**	**24.8**	**12.4**	**59718**
Area								
Rural	2009	74.9	11.1	10.6	3.5	25.1	14.0	11282
	2012-13	73.9	12.4	10.6	3.1	26.1	13.7	47488
Urban	2009	85.7	8.0	4.8	1.4	14.3	6.2	2141
	2012-13	80.6	12.2	5.7	1.5	19.4	7.2	12230
Division[16]								
Barisal	2009	94.5	4.1	0.9	0.6	5.5	1.5	1170
	2012-13	94.5	5.4	0.1	0.0	5.6	0.6	1283
Chittagong	2009	68.0	7.3	13.9	10.7	32.0	24.6	2615
	2012-13	63.5	12.3	14.6	9.7	36.5	13.6	2256
Dhaka	2009	76.5	11.4	9.9	2.2	23.5	12.1	3463
	2012-13	74.1	16.4	8.2	1.3	25.9	3.1	3213
Khulna	2009	66.1	17.1	14.1	2.7	33.9	16.8	1709

	Year	Arsenic content in household drinking water				Proportion over 10 ppb	Proportion over 50 ppb	Number of households
		<=10 ppb	>10 - 50 ppb	>50 - <200 ppb	>=200 ppb			
	2012-13	62.6	18.2	16.6	2.7	37.4	9.3	2031
Rajshahi	2009	88.8	7.9	3.0	0.3	11.2	3.3	3418
	2012-13	88.6	7.0	3.8	0.7	11.4	5.8	1565
Rangpur	2009	-	-	-	-		-	-
	2012-13	92.7	6.0	1.3	0.0	7.3	0.3	1718
Sylhet	2009	53.9	20.6	24.2	1.3	46.1	25.5	1048
	2012-13	62.3	12.8	24.0	0.9	37.7	2.4	886

The differences between the two surveys are mostly small at the national level, but in a few cases districts and divisions showed larger differences. However, given the smaller sample size especially at the district level (on average, approximately 200 samples per district), these differences should be interpreted with caution. Figures 4 and 5 show the spatial distribution of arsenic in the two surveys, while Figure 6 plots data from the two surveys together, with the diagonal line indicating exact agreement.

Figure 4: Proportion of the population by district using drinking water exceeding 50 ppb As (national standard) in 2009 and 2012-2013



15 Between the two survey a new division (Rangpur) was created from 8 districts formerly found in Rajshahi division.

Figure 5: **Proportion of the population by district using drinking water exceeding 10 ppb As (WHO guidelines) in 2009 and 2012-2013**

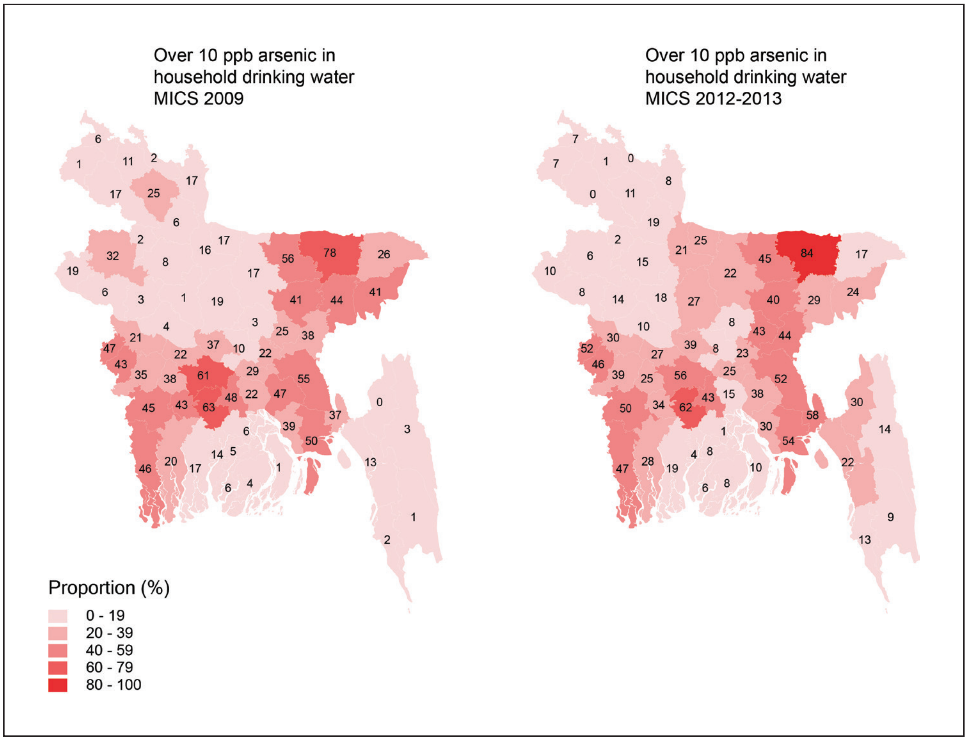
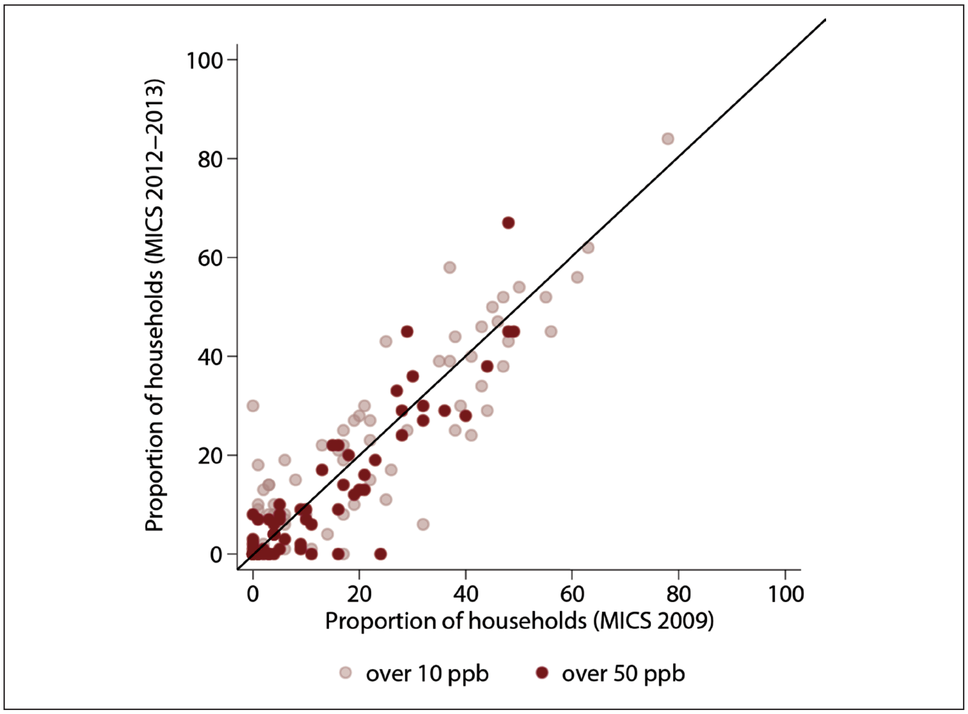


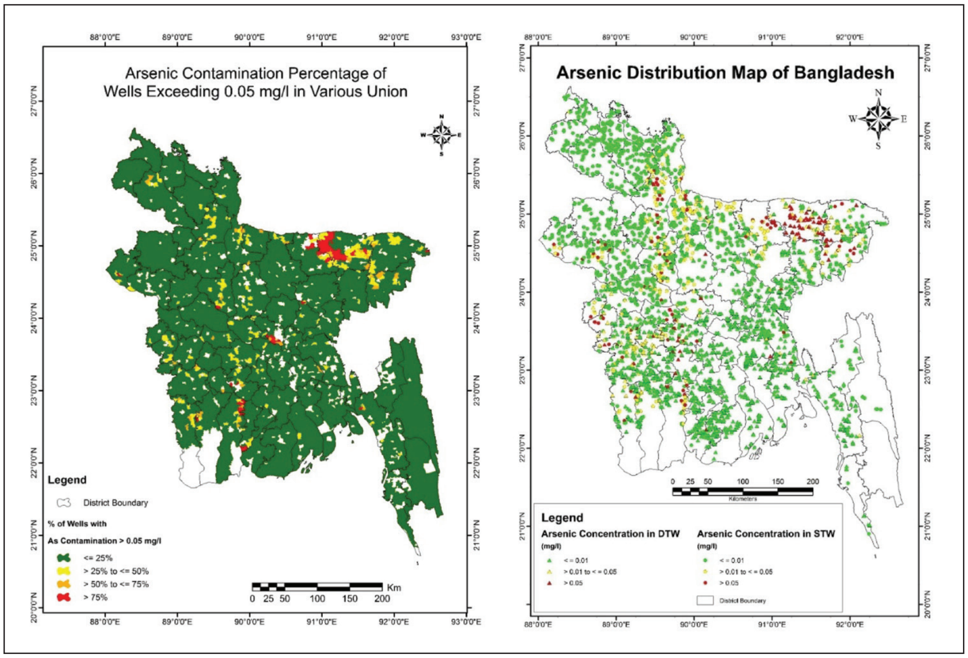
Figure 6: **Population by district using drinking water exceeding 10 ppb As (WHO guidelines) and 50 ppb (national standard) in 2009 and 2012-2013**



Water point mapping and testing

In 2013-14 a water point mapping was conducted of 150,000 water points installed by DPHE between 2006 and 2012. Selected water points were tested for arsenic and other parameters (n=125,000) and functionality was also assessed. The findings suggest that 95 per cent of newly constructed water points are free of arsenic above the national standard of 50 ppb. Contaminated water points were concentrated in a few districts, particularly Sunamganj, Dhaka and Bagerhat (Figure 7). An important distinction which could be made in the water point mapping but not in the MICS household survey was the depth of the tubewells. Most of the wells in the nationwide waterpoint mapping are deep tubewells.

Figure 7: **Arsenic distribution map from the nationwide water point mapping, 2013-2014**



Source: DPHE/UNICEF Nationwide water point mapping (2013-2014)

4.6 Quality control for arsenic

To verify the precision and accuracy of the MICS 2012-13 arsenic analyses which were made using field kits, one quality control sample from every cluster was collected (20 per cent of the households selected for arsenic testing, about 2760 samples). These samples were stocked at the UNICEF office. A subset of these quality control samples from 438 households was crosschecked in a laboratory using atomic absorption spectrophotometry. In cases where the field results in a district varied considerably with findings of previous surveys, additional stored samples would be double checked in the laboratory. This was done for 306 additional samples from ten districts. See Annex 1b for details.

5. Faecal contamination results

Test results were grouped into risk categories with reference to four key *E. coli* risk categories, shown in Table 16.

Table 16: Description of *E. coli* Risk Categories

E. coli [CFU/100 ml]	Risk Level	Priority for Action
<1	Low	None
1 - 10	Medium	Low
11-100	High	Higher
>100	Very High	Urgent

Adapted from WHO drinking water quality guidelines, 4th Ed. (2011), E. coli coliform counts are divided into risk categories based on probability of infection of diarrheal disease. Note, this classification does not take account of the sanitary inspection.

Overall, 41.7 per cent of households used a water source containing *Escherichia coli (E. coli)*, evidence of faecal contamination. Drinking water in at the point of consumption was even more likely to be unsafe: 61.7 per cent of households provided a glass of drinking water that contained *E. coli* (Figure 7).

In 2013, the UN Population Division estimated that there were 156.6 million people living in Bangladesh. Using these numbers we find that 93.2 million people in Bangladesh use drinking water that is contaminated with *E. coli*.

Figure 8: *E. coli* in source and household drinking water (%)

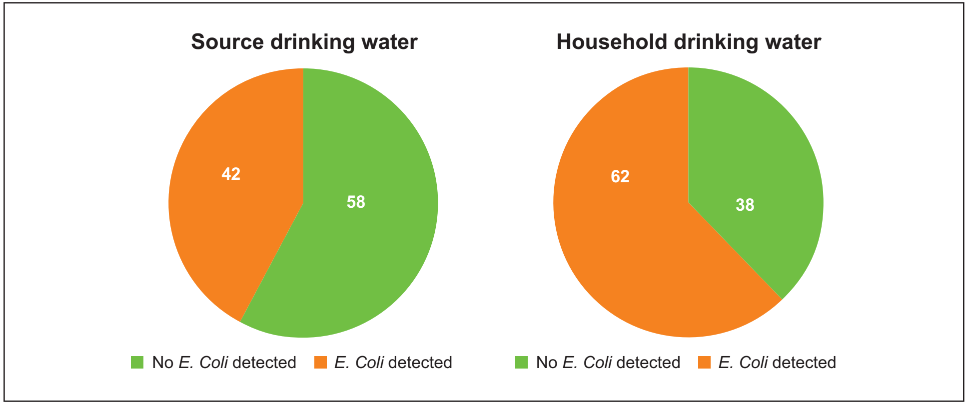
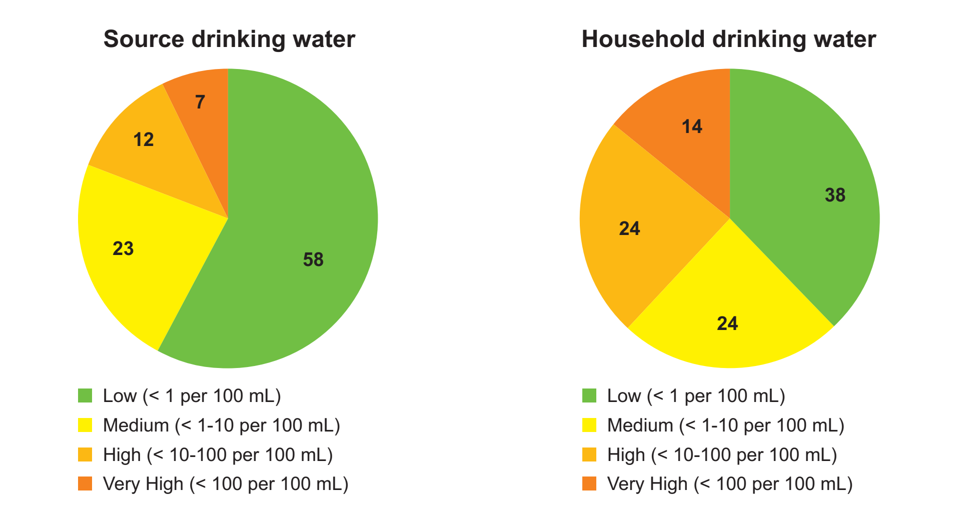


Figure 9: ***E. coli* risk levels in source and household drinking water (%)**



Although imperfect, the concentration of *E. coli* in drinking water can be used as an indicator of the level of risk presented by ingesting the water. Using the risk categories from Table 16, Figure 8 shows the risk levels of *E. coli* on a logarithmic scale from < 1 ("low risk") to >100 per 100 mL ("very high risk"). Of those with a contaminated drinking water source, the majority had medium risk sources but a large proportion (19 per cent) use either high or very high risk sources. Household drinking water was more likely to be higher risk with twice as many households in the highest risk category. An estimated 20.9 million people (13.5 per cent) used drinking water that has high levels of *E. coli* in 2012.

In this section, the factors that are associated with microbial contamination of drinking water and the level of risk as measured by levels of *E. coli* are examined.

5.1 Microbial water quality by type of drinking water source

The risk of faecal contamination varies by type of water supply (Table 17; Figure 9). The majority of the population in Bangladesh (97.9 per cent) uses an improved type of drinking water source. Whereas over three quarters of unimproved sources contained detectable *E. coli*, improved sources were free of *E. coli* in almost 60 per cent of cases. Most households primarily use water from tube wells or boreholes and these were less frequently contaminated (37.7 per cent) than piped water into dwelling (80.6 per cent) or into compound, yard or plot (78.5 per cent). A large proportion of samples from piped water systems were found to be very high risk, including 46.3 per cent of piped water into dwelling. In contrast, only 3.6 per cent of samples from tube wells and boreholes were high risk.

Table 17: *E. coli* level of source water by source type

Proportion of households by *E. coli* risk level in source water, Bangladesh 2012-2013						
	Proportion of households				Total	Number of households
	E. coli risk level in source water					
	Low	Medium	High	Very High		
Improved/unimproved water source						
Unimproved water source	24.6	17.5	22.9	35.0	100	46
Improved water source	58.9	22.8	11.4	6.9	100	2492
Source of drinking water sample						
Piped into dwelling	(19.4)	(18.7)	(15.6)	46.3	100	100
Piped into compound, yard or plot	21.5	16.9	21.7	39.9	100	137
Public tap / standpipe	(71.8)	(9.2)	(15.5)	3.6	100	31
Tube well, Borehole	62.3	23.5	10.6	3.6	100	2219
Unprotected well	(8.0)	(23.3)	(36.4)	32.3	100	11
Surface water	(15.2)	(11.2)	(27.6)	46.0	100	24
Other	(48.7)	(21.8)	(14.7)	14.9	100	16
Missing	(*)	(*)	(*)	(*)	100	5
Total	58.3	22.6	11.6	7.4	100	2543

Note: In this report results are weighted number of households for the source and number of household members for household drinking water as indicated in the far right column.
( ) Figures that are based on 25-49 unweighted cases
(*) Figures that are based on less than 25 unweighted cases

Table 18: *E. coli* level of household water by source type

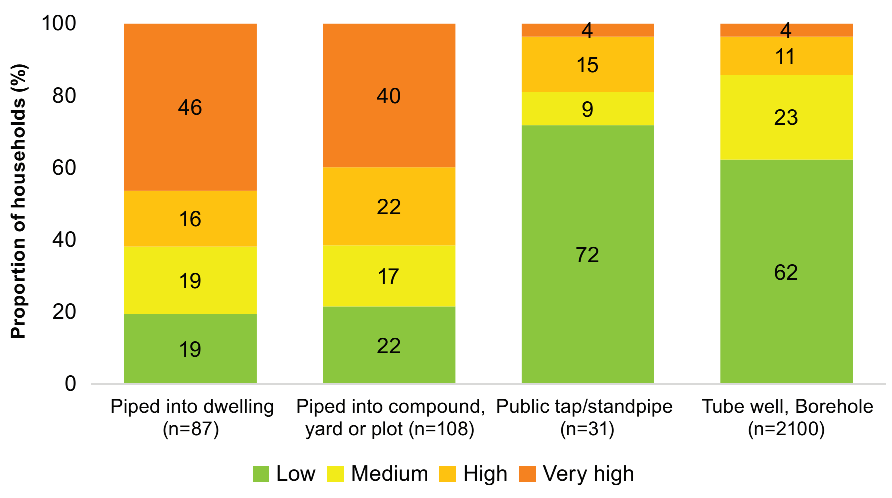
Proportion of households by *E. coli* risk level in household water, Bangladesh 2012-2013						
	Proportion of households				Total	Number of household members
	E. coli risk level in household water					
	Low	Medium	High	Very High		
Improved/unimproved water source						
Unimproved water source	11.4	25.6	39.0	24.1	100	252
Improved water source	39.0	23.7	24.1	13.2	100	11587
Total	38.3	23.7	24.4	13.5	100	11839
Source of drinking water sample						
Piped into dwelling	(41.3)	(4.3)	(43.3)	(11.1)	100	409
Piped into compound, yard or plot	14.6	16.2	31.3	37.9	100	482
Public tap / standpipe	(55.7)	(14.2)	(16.4)	(13.8)	100	140

Proportion of households by *E. coli* risk level in household water, Bangladesh 2012-2013						
	Proportion of households					
	E. coli risk level in household water					Number of household members
	Low	Medium	High	Very High	Total	
Tube well, Borehole	39.8	25.0	23.2	12.2	100	10537
Unprotected well	(31.6)	(24.7)	(14.6)	(29.2)	100	54
Surface water	4.2	23.9	48.6	23.3	100	141
Other	(22.9)	(30.0)	(28.8)	(18.4)	100	76
Missing	(*)	(*)	(*)	(*)	100	15
Total	38.3	23.8	24.4	13.5	100	11854

( ) Figures that are based on 25-49 unweighted cases
(*) Figures that are based on less than 25 unweighted cases

Risk levels in household drinking water are shown in Table 18. Similar to water quality as assessed at the water source, improved sources were less likely to have detectable *E. coli* than unimproved sources (61 per cent versus 89 per cent) and less likely to be in the very high risk level (13.2 per cent versus 24.1 per cent).

Figure 10: *E. coli* risk levels in source water by source type



5.2 Water quality source versus household

Table 19: Comparison of *E. coli* level in household and source drinking water

Proportion of households by *E. coli* risk level, Bangladesh 2012-2013				
	Proportion of households			
E. coli risk level in household water	*E. coli* risk level in source water			
	Low	Medium	High	Very High
Low	**33.0**	3.7	1.7	0.7
Medium	12.5	**8.6**	2.3	0.4
High	8.5	8.1	**5.6**	2.0
Very high	4.0	2.5	2.8	**3.7**

Reduction in contamination, source to household	10.7
No change in contamination	51.0
Increase in contamination, source to household	38.3

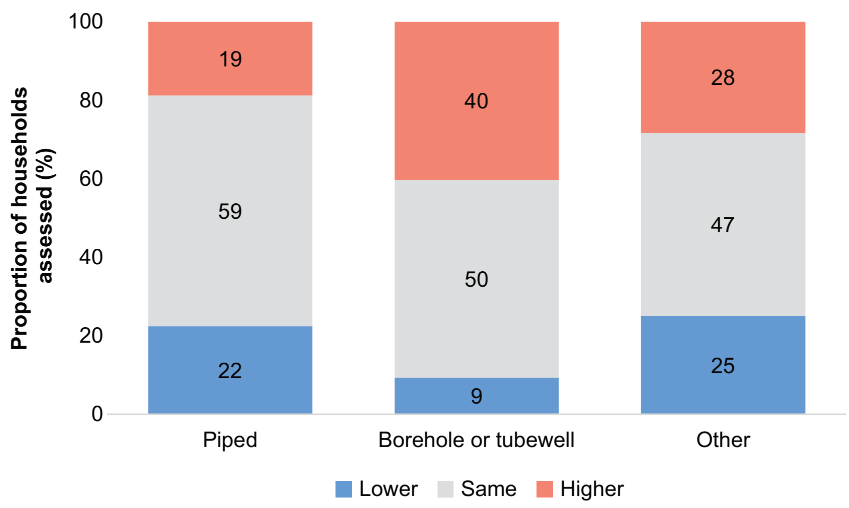
In Table 19, levels of *E. coli* measured in source and household water samples are compared for all households where samples were collected at both locations. These results show that in many cases the quality of a glass of drinking water at home does not correspond to that at the source. Water quality can deteriorate due to contamination during storage and handling or improve where households use effective water treatment practices. In only a third of households was *E. coli* found to be absent in both household and source water quality

Trends in water quality for households by source type are shown in Table 20 and Figure 10. In approximately half of the households the risk level was the same in both locations. Overall, quality deteriorated between the source and point of consumption with an increase in the risk of contamination in 38.3 per cent of households. The change was most pronounced for boreholes and tubewells which generally had lower levels of contamination at the source and for which risk level increased in 40.3 per cent of households. This is consistent with findings from a systematic review (Wright et al 2004) which noted that the degree of contamination/ deterioration tended to be greater when the source water had a low levels of contamination.

Table 20: Proportion of households by change of risk class by facility type

	Change between source and household			Total	Number of households
	Lower	Same	Higher		
Total	10.7	51.0	38.3	10,559	2292
Source of drinking water sample					
Piped	22.4	58.8	18.8	860	92
Borehole or tubewell	9.3	50.4	40.3	9,471	2093
Other	25.0	46.7	28.3	243	112
Improved/unimproved water source					
Unimproved water source	23.8	48.5	27.7	211	98
Improved water source	10.4	51.1	38.5	10,349	2194

Figure 11: Change in *E. coli* risk level between source and household by source type



5.3 *E. coli* by area and division

Source water was more likely to be contaminated in urban than rural areas (55 per cent vs 38 per cent; Figure 11), primarily the result of frequent contamination of piped supplies. There was less difference at the household level although slightly more urban households had very high risk water (18 per cent) compared to those in rural areas (12 per cent). Figure 12 shows the risk levels for tubewells or boreholes; there was no difference in household water quality between urban and rural areas for this supply type however source water was more likely to be contaminated in urban areas (44 per cent versus 36 per cent).

Figure 12: ***E. coli*** **risk levels in source water in urban and rural areas**

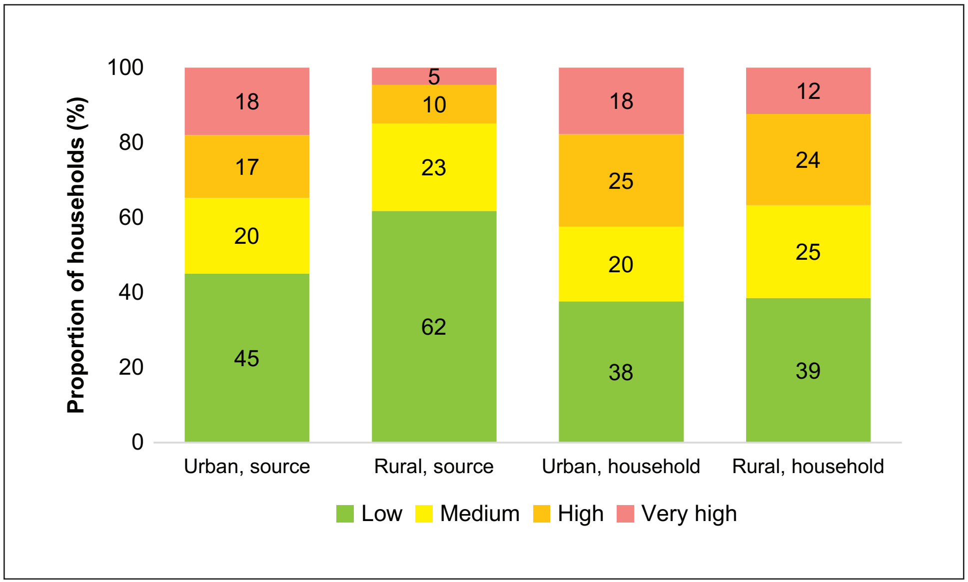
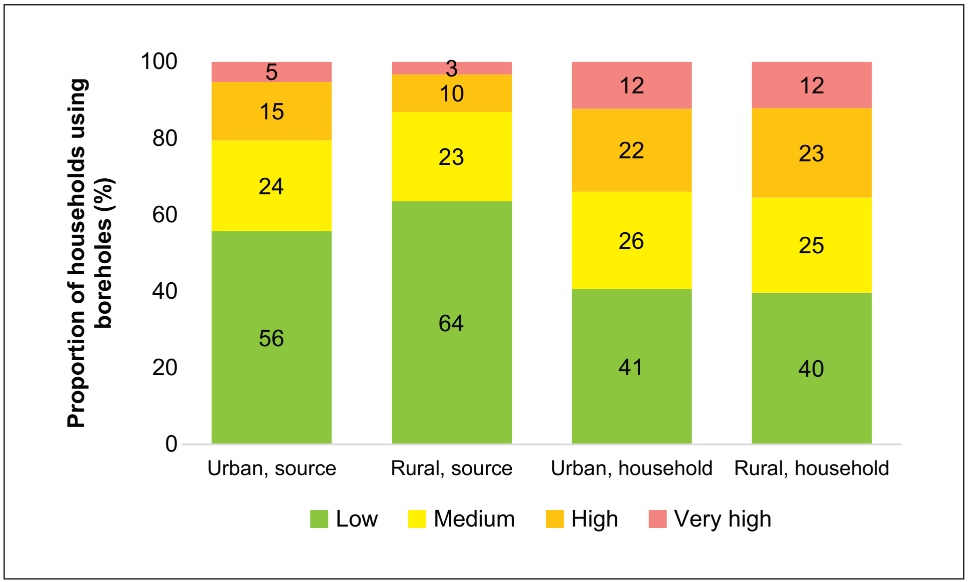


Figure 13: ***E. coli*** **risk levels in urban and rural boreholes**



In Table 21 the proportion of source and household water samples with different levels of *E. coli* are reported by area and division. Source water quality was most often free of *E. coli* in Rangpur (71.8 per cent) and Rajshahi (68.6 per cent) and least often in Sylhet (38.1 per cent). In both Dhaka and Sylhet over one in ten households use a very high risk drinking water source. In these two divisions water quality deteriorated substantially between the source and point of consumption; household water was very high risk in over one in five households. Almost three quarters (74.7 per cent) of households in Sylhet drink water that has evidence of faecal contamination.

Table 21: *E. coli* level of source and household water by area and division

Proportion of households by *E. coli* risk level in drinking water, Bangladesh 2012-2013						
	Proportion of households					
	E. coli risk level in drinking water					
	Low	Medium	High	Very High	Total	Number of households
Source water quality						
Area						
Urban	45.0	20.2	16.7	18.0	100	552
Rural	61.8	23.3	10.3	4.7	100	1991
Division						
Barisal	67.3	18.2	9.9	4.6	100	158
Chittagong	51.9	27.5	15.9	4.7	100	449
Dhaka	49.1	20.2	14.4	16.3	100	809
Khulna	65.7	23.6	6.1	4.6	100	298
Rajshahi	68.6	21.0	9.0	1.5	100	372
Rangpur	71.8	20.1	7.6	0.5	100	320
Sylhet	38.1	33.9	14.6	13.4	100	137
Total	**58.3**	**22.6**	**11.6**	**7.4**	**100**	**2543**
Household water quality						
Area						
Urban	37.63	19.92	24.7	17.75	100	2356
Rural	38.51	24.76	24.35	12.38	100	9498
Division						
Barisal	46.5	21.3	23.4	8.8	100	747
Chittagong	38.0	21.9	27.0	13.2	100	2411
Dhaka	39.0	16.7	23.7	20.7	100	3570
Khulna	30.7	32.4	27.9	8.9	100	1348
Rajshahi	41.7	31.2	20.7	6.4	100	1548
Rangpur	43.9	29.9	18.3	7.9	100	1440
Sylhet	24.3	20.3	34.0	21.4	100	790
Total	**38.3**	**23.8**	**24.4**	**13.5**	**100**	**11854**

Within each division, risk levels of household water are show in Table 22. With the exception of the proportion of households in Barisal in the “high” and “very high” risk level there are no substantial differences between rural and urban areas within each region. In Barisal, a greater proportion of household drinking water was found to be very high risk in rural areas (10.2 per cent versus 1.3 per cent).

Table 22: *E. coli* level of household water by division, urban and rural

Proportion of households by *E. coli* risk level in household water, Bangladesh 2012-2013						
	Proportion of households					
	E. coli risk level in household drinking water					
	Low	Medium	High	Very High	Total	Number of household members
Division, urban						
Barisal	(46.7)	(21.3)	(30.7)	(1.3)	100	110
Chittagong	42.0	24.7	16.6	16.7	100	549
Dhaka	30.1	9.7	33.4	26.9	100	969
Khulna	42.6	30.7	14.5	12.2	100	213
Rajshahi	(46.6)	(31.0)	(17.1)	(5.3)	100	217
Rangpur	(43.8)	(33.3)	(17.4)	(5.5)	100	192
Sylhet	(32.2)	(15.5)	(32.8)	(19.5)	100	107
Urban	**37.6**	**19.9**	**24.7**	**17.8**	**100**	**2356**
Division, rural						
Barisal	46.5	21.3	22.1	10.2	100	637
Chittagong	36.8	21.0	30.1	12.1	100	1863
Dhaka	42.5	19.5	19.8	18.2	100	2601
Khulna	28.5	32.7	30.4	8.3	100	1136
Rajshahi	40.9	31.3	21.3	6.6	100	1331
Rangpur	43.9	29.4	18.4	8.3	100	1248
Sylhet	22.9	21.2	34.2	21.7	100	682
Rural	**38.5**	**24.8**	**24.4**	**12.4**	**100**	**9498**

( ) Figures that are based on 25-49 unweighted cases
(*) Figures that are based on less than 25 unweighted cases

Table 23: *E. coli* level of drinking water source by division, urban and rural

Proportion of households by *E. coli* risk level in household water, Bangladesh 2012-2013						
	Proportion of households					
	E. coli risk level in household drinking water					
	Low	Medium	High	Very High	Total	Number of households
Division, urban						
Barisal	(68.7)	(19.5)	(11.8)	(0.0)	100	110
Chittagong	36.0	24.8	25.7	13.5	100	538
Dhaka	31.3	15.3	20.2	33.2	100	959
Khulna	69.2	27.5	0.9	2.4	100	208
Rajshahi	(59.7)	(24.4)	(15.2)	(0.8)	100	226
Rangpur	(59.9)	(23.9)	(13.6)	(2.6)	100	189
Sylhet	(*)	(*)	(*)	(*)	100	99
Urban	**44.0**	**20.6**	**18.3**	**17.1**	**100**	**2329**

Proportion of households by *E. coli* risk level in household water, Bangladesh 2012-2013						
	Proportion of households					
	***E. coli* risk level in household drinking water**					
	Low	Medium	High	Very High	Total	Number of households
Division, rural						
Barisal	66.9	18.5	8.8	5.8	100	637
Chittagong	54.2	28.7	15.2	2.0	100	1824
Dhaka	57.7	22.3	13.0	7.1	100	2566
Khulna	65.7	22.5	7.2	4.5	100	1105
Rajshahi	69.1	21.5	7.7	1.7	100	1331
Rangpur	73.3	19.0	7.7	0.1	100	1248
Sylhet	39.0	36.5	12.3	12.2	100	676
Rural	**61.2**	**23.7**	**10.8**	**4.2**	**100**	**9387**

( ) Figures that are based on 25-49 unweighted cases
(*) Figures that are based on less than 25 unweighted cases

5.4 *E. coli* by socio-economic status and education

The use of different types of water supply can be related to wealth. In Bangladesh a larger proportion of the usually more wealthy urban dwellers use - piped water on premises (14 per cent) compared to the poorest (0.2 per cent) in rural areas. Table 24 shows that there is no clear trend in levels of *E. coli* by wealth quintiles. There is a slightly higher risk of very high levels of *E. coli* contamination amongst the fourth and richest quintiles however these are also the least likely to have contaminated household water. In contrast there is a clearer, albeit gradual, trend that households whose household head has progressively higher levels of education have better microbial water quality.

Table 24: *E. coli* level of household water by wealth and education

Proportion of households by *E. coli* risk level in household water, Bangladesh 2012-2013						
	Proportion of households					
	***E. coli* risk level in household drinking water**					
	Low	Medium	High	Very High	Total	Number of households
Wealth index quintile						
Poorest	36.2	23.6	25.2	15	100	2346
Second	33.3	26.1	25.7	15	100	2424
Middle	37.5	25.9	24.8	11.8	100	2180
Fourth	42.1	21	24	12.9	100	2473
Richest	42.3	22.7	22.5	12.6	100	2432
Total	**38.3**	**23.8**	**24.4**	**13.5**	**100**	**11854**
Education of household head						
None	36.4	23.2	24	16.3	100	5107

Proportion of households by *E. coli* risk level in household water, Bangladesh 2012-2013						
	Proportion of households					
	***E. coli* risk level in household drinking water**					
	Low	Medium	High	Very High	Total	Number of households
Primary incomplete	34.2	20.8	32	13	100	1414
Primary complete	37	22.3	25.1	15.6	100	1530
Secondary incomplete	41.6	25.9	24	8.6	100	2095
Secondary complete or higher	44.9	26.5	19.2	9.4	100	1705
Total	**38.3**	**23.8**	**24.4**	**13.5**	**100**	**11854**

Note: Total include missing/DK

In Table 25, *E. coli* levels are shown by wealth quintile and educational level of the household head for rural and urban areas. There was no clear trend with wealth in urban areas but in contrast the wealthiest in rural areas were half as likely to have high risk drinking water (>100 per 100 mL). Urban dwellers with no education were at highest risk of contamination by faecal matter. Less than 70 per cent had water that was free of *E. coli* and 30 per cent had at least 100 per 100 mL. In rural areas there also appeared to be a trend with education with the more educated less likely to have contaminated drinking water and fewer with high risk levels.

Table 25: *E. coli* level of household water by wealth and education of household head, urban and rural

Proportion of households by E. coli risk level in household water, Bangladesh 2012-2013						
	Proportion of households					
	***E. coli* risk level in household drinking water**					
	Low	Medium	High	Very High	Total	Number of households
Urban wealth index quintile						
Poorest	32.6	22.9	23.8	20.7	100	409
Second	42.4	20.3	25.2	12.0	100	444
Middle	36.5	17.5	18.2	27.8	100	582
Fourth	36.5	21.3	33.0	9.2	100	508
Richest	40.0	18.6	23.8	17.6	100	413
Total	**37.6**	**19.9**	**24.7**	**17.8**	**100**	**2356**
Education level, urban						
None	29.7	16.4	23.7	30.1	100	676
Primary incomplete	(44.5)	(4.7)	(43.0)	(7.8)	100	193
Primary complete	38.5	22.0	17.7	21.8	100	336
Secondary incomplete	36.0	22.8	36.9	4.3	100	436
Secondary complete or higher	44.0	24.7	16.4	15.0	100	714
Total	**37.6**	**19.9**	**24.7**	**17.8**	**100**	**2356**
Rural wealth index quintile						
Poorest	37.3	23.1	27.1	12.5	100	1882

Proportion of households by E. coli risk level in household water, Bangladesh 2012-2013						
	Proportion of households				Total	Number of households
	E. coli risk level in household drinking water					
	Low	Medium	High	Very High		
Second	35.7	26.2	21.1	17.0	100	1875
Middle	34.3	26.0	29.5	10.3	100	1975
Fourth	37.6	22.4	23.7	16.3	100	1821
Richest	47.5	26.1	20.2	6.3	100	1945
Total	**38.5**	**24.8**	**24.4**	**12.4**	**100**	**9498**
Education level, rural						
None	37.4	24.3	24.1	14.2	100	4430
Primary incomplete	32.6	23.4	30.2	13.8	100	1220
Primary complete	36.5	22.4	27.3	13.8	100	1194
Secondary incomplete	43.1	26.7	20.5	9.8	100	1659
Secondary complete or higher	45.6	27.8	21.3	5.3	100	991
Total	**38.5**	**24.8**	**24.4**	**12.4**	**100**	**9498**

Note: otal include missing/DK
( ) Figures that are based on 25-49 unweighted cases
(*) Figures that are based on less than 25 unweighted cases

5.5 *E. coli* by number of children in a household

Children under five are most affected by water-related diseases and suffer the greatest health burden due to inadequate water, sanitation and hygiene. In Table 26, the levels of *E. coli* detected in household water are shown by the number of children under the ages of 5 and 15. Although there was no evidence that households with more children were more likely to have detectable *E. coli* in their water, the proportion with very high risk water was greater in households with more than two children under five with over one in five (20.2 per cent) in the highest risk category. Similarly, a greater number of children under fifteen was also associated with a greater likelihood of high risk drinking water. No notable differences were found at the source.

Table 26: *E. coli* level of household water by number of children

Proportion of households by *E. coli* risk level in household water, Bangladesh 2012-2013						
	Proportion of households				Total	Number of households
	E. coli risk level in household drinking water					
	Low	Medium	High	Very High		
Number of children under 5						
0	38.6	24.0	24.9	12.6	100	6392
1	38.5	24.3	23.7	13.5	100	4570
2+	35.7	19.6	24.6	20.2	100	892
Total	38.3	23.8	24.4	13.5	100	11854
Number of children under 15						
1	37.1	25.4	25.0	12.5	100	3144

Proportion of households by *E. coli* risk level in household water, Bangladesh 2012-2013						
	Proportion of households					
	***E. coli* risk level in household drinking water**					
	Low	Medium	High	Very High	Total	Number of households
2	40.5	22.7	25.5	11.4	100	3448
3	39.7	22.8	20.6	16.9	100	1828
4+	37.8	20.9	23.9	17.4	100	1253
Total	38.9	23.4	24.2	13.5	100	9673

5.6 Time to collect water and amount collected

Table 27 shows the levels of *E. coli* in household drinking water by location of the water source, time taken to collect water and amount of water collected; equivalent information for tube wells or boreholes (excluding piped water) are shown below in Table 28. There was no clear trend with time taken to collect drinking water. Households collecting only small quantities of drinking water (<5 litres) had very good quality water compared to all other households. Above five litres, there was a weak trend with households collecting more water having better water quality; this may suggest that greater quantities enable better hygiene practices including handwashing.

Table 27: *E. coli* level of household water time to collect and amount collected

Proportion of households by *E. coli* risk level in household water, Bangladesh 2012-2013						
	Proportion of households					
	***E. coli* risk level in household drinking water**					
	Low	Medium	High	Very High	Total	Number of households
Time to get water and come back						
On premises	41.2	24.1	22.7	12.0	100	8239
1-5 minutes	33.2	31.1	26.2	9.5	100	858
5-10 minutes	35.7	20.6	28.0	15.8	100	1011
11-30 minutes	28.5	22.9	30.2	18.4	100	851
31-60 minutes	28.8	17.2	48.0	6.1	100	155
>60 minutes	(*)	(*)	(*)	(*)	100	31
Total	39.0	24.3	24.3	12.5	100	11189
Amount of water collected in a day						
<5 litre	(91.8)	(5.7)	(1.4)	(1.2)	100	123
5-10 litre	53.7	16.0	12.7	17.7	100	265
10-20 litre	45.1	22.4	20.2	12.4	100	1216
20-50 litre	30.2	21.9	32.1	15.9	100	2389
50-100 litre	37.5	21.0	25.2	16.3	100	2864
100-200 litre	40.7	27.4	22.8	9.1	100	2330
>200 litre	33.8	32.3	20.8	13.1	100	1294
Total	38.3	23.8	24.4	13.5	100	11159

Note: Total include missing/DK
( ) Figures that are based on 25-49 unweighted cases
(*) Figures that are based on less than 25 unweighted cases

Table 28: *E. coli* level of household water time to collect and amount collected, tubewells or boreholes

Proportion of households by *E. coli* risk level in household water, Bangladesh 2012-2013						
	Proportion of households					
	E. coli risk level in household drinking water					
	Low	Medium	High	Very High	Total	Number of households
Time to get water and come back						
On premises	41.9	24.85	21.6	11.7	100	7752
1-5 minutes	34.8	32.6	24.7	7.9	100	815
5-10 minutes	36.7	19.3	28.6	15.4	100	939
11-30 minutes	30.1	23.3	28.7	18.0	100	748
31-60 minutes	39.2	6.1	48.7	5.9	100	111
>60 minutes	(*)	(*)	(*)	(*)	100	22
DK/Missing	(55.6)	(44.4)	(0.0)	(0.0)	100	41
Total	40.1	24.7	23.2	12.0	100	10429
Amount of water collected in a day						
<5 litre	92.5	5.4	0.9	1.2	100	125
5-10 litre	44.5	18.0	15.3	22.2	100	175
10-20 litre	46.2	22.0	19.3	12.5	100	1233
20-50 litre	32.9	23.0	29.6	14.5	100	2259
50-100 litre	41.4	23.1	21.9	13.6	100	2546
100-200 litre	40.2	28.2	23.8	7.8	100	2277
>200 litre	32.4	33.1	21.7	12.7	100	1271
dk	49.4	21.8	20.9	8.0	100	609
Missing	(20.1)	(27.6)	(0.0)	(52.3)	100	42
Total	39.8	25.0	23.2	12.2	100	10537

Note: Total include missing/DK
( ) Figures that are based on 25-49 unweighted cases
(*) Figures that are based on less than 25 unweighted cases

5.7 Treatment practices and household water quality

Implemented effectively, treating water in the home can greatly improve microbial water quality and remove harmful pathogens from drinking water. Relatively few households report treating their drinking water (8.0 per cent). Boiling (4.8 per cent) drinking water or using water filters (3.1 per cent) were the two most common methods. Table 29 shows that households that treat their water do not have substantially better water quality than those which did not; this is in part since they are more likely to use a contaminated water source (Table 30). Further analysis of changes in water quality by type of treatment was not possible due to the small number of households where water was reported as treated and water samples were collected.

Table 29: *E. coli* level of household water by household treatment

Proportion of households by *E. coli* risk level in household water, Bangladesh 2012-2013						
	Proportion of households					
	E. coli risk level in household drinking water					
	Low	Medium	High	Very High	Total	Number of households
Treat water to make safer for drinking						
Yes	28.2	19.9	30.8	21.1	100	919
No	39.3	24.1	23.8	12.8	100	10238
Missing	(*)	(*)	(*)	(*)	100	2
Total	38.3	23.8	24.4	13.5	100	11159
Water treatment method						
Other	(20.3)	(10.4)	(43.3)	(26.1)	100	135
Boil	(26.4)	(13.3)	(32.3)	(28.1)	100	548
Filter	36.3	39.2	21.0	3.5	100	272
Total	28.2	19.9	30.8	21.1	100	956

( ) Figures that are based on 25-49 unweighted cases
(*) Figures that are based on less than 25 unweighted cases

Table 30: *E. coli* level of source water by household treatment

Proportion of households by *E. coli* risk level in source water, Bangladesh 2012-2013						
	Proportion of households					
	E. coli risk level in source drinking water					
	Low	Medium	High	Very High	Total	Number of households
Treat water to make safer for drinking						
Yes	23.8	20.2	18.0	38.0	100	218
No	61.4	22.9	11.1	4.7	100	2324
Water treatment method						
Boil	(13.5)	(15.1)	(21.6)	(49.7)	100	137
Filter	48.3	31.2	14.7	5.9	100	51
Other	(23.7)	(22.2)	(9.2)	(44.9)	100	30

( ) Figures that are based on 25-49 unweighted cases
(*) Figures that are based on less than 25 unweighted cases

Reported water treatment did not substantially improve the quality of water for many households. In the subset of household for which water quality was tested at both the source and the household, the risk level stayed the same in 58 per cent of cases, decreased in 23.0 per cent and increased in 19.0 per cent (Table 31). Filtering was found to be associated with an increase in *E. coli* risk levels in 33.1 per cent of households whereas in only 16.2 per cent did the risk reduce. In contrast, boiling appears to have reduced contamination relative to other forms of treatment and relative to no treatment but the sample size is small (33 unweighted cases).

Table 31: Change in *E. coli* risk level between source and household sample

Proportion of households by change in *E. coli* risk level between source and household water, Bangladesh 2012-2013					
	Proportion of households				
	Change in *E. coli* risk level between source and household				
	Lower	Same	Higher	Total	Number of households
Treat water to make safer for drinking					
Yes	23.0	58.0	19.0	100	193
No	9.4	51.2	39.4	100	2089
Water treatment method					
Boil	(20.1)	(67.9)	(12.1)	100	116
Filter	16.2	50.7	33.1	100	48
Other	(45.4)	(31.3)	(23.3)	100	29

( ) Figures that are based on 25-49 unweighted cases
(*) Figures that are based on less than 25 unweighted cases

5.8 Storage practices and water quality

Table 32 shows *E. coli* levels in household stored water by observed sampling location. When water was collected directly from the source either outside the home or inside the home this was less likely to be contaminated with *E. coli* compared to water provided by households from water filters and covered or uncovered storage containers. This is also shown in Figure 10 below. Storage of drinking water in an uncovered vessel was associated with a greater change in *E. coli* risk levels than obtaining water directly from the source within a home; in 45.6 per cent of households the risk level increased on storage in an uncovered vessel compared with 21.7 per cent obtaining water directly from the source within the home (Table 33). Water quality was slightly more likely to deteriorate when stored in uncovered rather than covered storage containers (45.6 per cent vs 39.5 per cent; $p= 0.0364$).

Table 32: *E. coli* level of household water by observed storage

Proportion of households by *E. coli* risk level in household water, Bangladesh 2012-2013						
	Proportion of households					
	E. coli risk level in household drinking water					
	Low	Medium	High	Very High	Total	Number of household members
Observation on source of drinking water sample						
Direct from source outside home	50.4	22.0	21.6	6.1	100	701
Direct from source inside home	54.7	20.9	17.3	7.1	100	1844
From filter inside home	(43.8)	(28.7)	(11.3)	(16.3)	100	221
From uncovered storage container	34.5	26.9	24.3	14.3	100	3591
From covered storage container	33.9	22.5	27.9	15.8	100	5393
Unable to observe	(*)	(*)	(*)	(*)	100	56
Missing	(*)	(*)	(*)	(*)	100	49
Total	38.3	23.8	24.4	13.5	100	11854

( ) Figures that are based on 25-49 unweighted cases
(*) Figures that are based on less than 25 unweighted cases

Figure 14: **Levels of *E. coli* in household drinking water by observed storage**

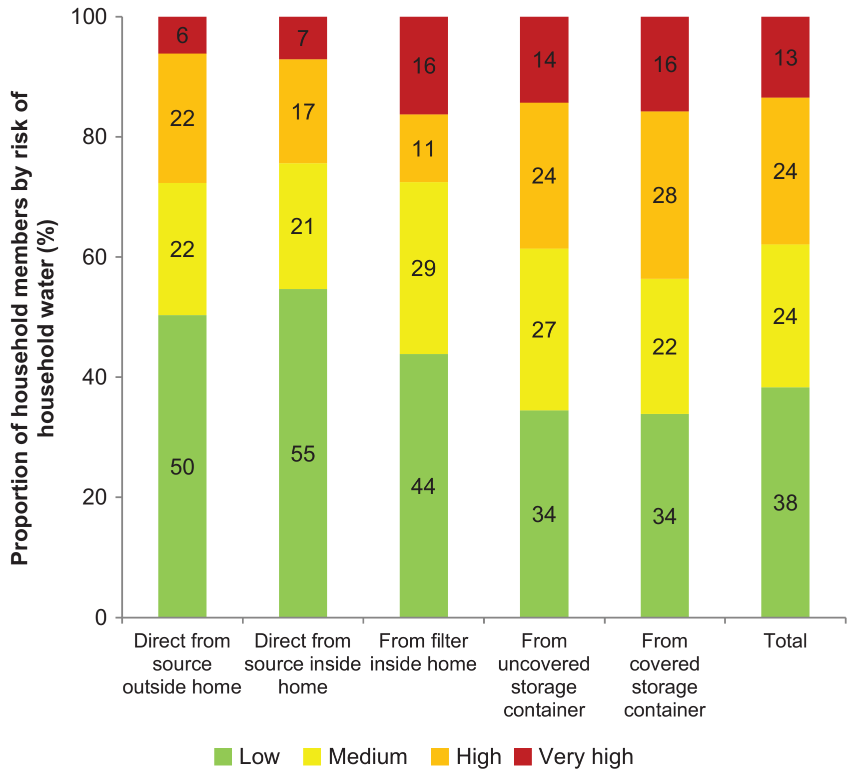


Table 33: **Change in *E. coli* risk level between source and household sample, by storage**

Proportion of households by change in *E. coli* risk level between source and household water, Bangladesh 2012-2013

	Proportion of households – Change in *E. coli* risk level between source and household: Lower	Same	Higher	Total	Number of households
Observation on source of drinking water sample					
Direct from source outside home	2.5	63.1	33.9	100	152
Direct from source inside home	13.0	63.7	21.7	100	408
From filter inside home	(20.5)	(56.4)	(21.8)	100	51
From uncovered storage container	6.7	47.2	45.6	100	778
From covered storage container	10.3	48.9	39.5	100	1122
Unable to observe	(*)	(*)	(*)	100	13
Missing	(*)	(*)	(*)	100	10
Total	9.5	51.7	37.7	100	2535

( ) Figures that are based on 25-49 unweighted cases
(*) Figures that are based on less than 25 unweighted cases

5.9 Water quality and sanitation

Groundwater quality can be strongly influenced by sanitation facilities and some forms of sanitation are more hygienic than others. In Table 34 *E. coli* levels in household drinking water are reported by sanitation facility. High risk water is common amongst those with piped sewerage (38.4 per cent) or flush to somewhere else (40.7 per cent), which is consistent with the relatively high contamination of piped water supplies. Households practising open defecation were not more likely than average to have contaminated water at home. Similarly, there was no clear trend to suggest that those sharing sanitation facilities were at higher risk of contaminated water.

Table 34: *E. coli* level of household water by sanitation facility

Proportion of households by *E. coli* risk level in household water, Bangladesh 2012-2013						
	Proportion of households				Total	Number of household members
	E. coli risk level in household drinking water					
	Low	Medium	High	Very High		
Type of toilet facility						
Flush to piped sewer system	14.8	9.9	36.9	38.4	100	378
Flush to septic tank	42.2	22.2	24.4	11.2	100	1774
Flush to pit (latrine)	35.0	26.5	26.3	12.2	100	1217
Flush to somewhere else	23.5	15.4	20.4	40.7	100	192
Flush to unknown place / Not sure / DK	(7.5)	(13.8)	(78.7)	(0.0)	100	32
Ventilated Improved Pit latrine (VIP)	49.9	14.4	26.6	9.2	100	478
Pit latrine with slab	41.1	25.8	22.4	10.8	100	5407
Pit latrine without slab / Open pit	35.7	24.0	29.1	11.2	100	1336
Composting toilet	(*)	(*)	(*)	(*)	100	6
Hanging toilet, Hanging latrine	29.5	21.3	20.5	28.8	100	556
No facility, Bush, Field	40.0	29.8	18.6	11.7	100	421
Other	0.0	12.0	28.4	59.6	100	53
Toilet facility shared						
Yes	36.2	23.0	24.6	16.2	100	3238
No	39.0	23.8	24.7	12.5	100	8188
Users of improved sanitation facilities						
Improved	38.9	23.4	26.3	11.4	100	3758
Unimproved	38.1	23.9	23.6	14.4	100	8096
Total	38.3	23.8	24.4	13.5	100	11854

( ) Figures that are based on 25-49 unweighted cases
(*) Figures that are based on less than 25 unweighted cases

5.10 Water quality and handwashing

Adequate handwashing depends on the availability of a facility and cleansing agents such as soap or ash. Where handwashing is not practised regularly or effectively there is a risk of contaminating drinking water during collection or storage. In Table 35 the levels of *E. coli* are shown by whether a facility for handwashing and soap or another cleansing agent (ash, mud or sand) where observed in the dwelling.

Households with handwashing facilities were more likely to have low risk household water (37.5 per cent) than those where facilities were not observed (29.4 per cent). Faecal contamination was also less likely where soap or another cleansing agent was observed (36.7 per cent) or shown (35.8 per cent) compared with households without soap (33.2 per cent). One in nine households where soap was observed had high risk water compared with one in five where it was not available.

Table 36 shows how *E. coli* risk levels changed between source and household depending on the availability of a handwashing facility, water and soap. In households where a handwashing facility was not observed, an increase in risk level was more likely than in households with a facility (48.1 per cent versus 36.1 per cent). The risk level did not change for approximately half (49.9 per cent) of households where a handwashing facility was observed with water and soap or another cleansing agent

Table 35: *E. coli* level of household water by availability of a handwashing facility, soap and water

Proportion of households by *E. coli* risk level in household water, Bangladesh 2012-2013						
	Proportion of households					
	E. coli risk level in household drinking water					
	Low	Medium	High	Very High	Total	Number of household members
Place for handwashing						
Observed	37.5	22.9	23.0	12.8	100	9766
Not observed	29.4	27.0	27.1	13.6	100	2088
Soap or other cleansing agent observed						
Soap or other cleansing agent observed	36.7	24.0	23.6	11.5	100	5959
Soap or other cleansing agent not observed but shown	35.8	23.0	24.4	13.7	100	5326
No soap or other cleansing agent in household	33.2	27.8	17.4	19.7	100	516
Not able/Does not want to show cleansing agent	(*)	(*)	(*)	(*)	100	34
Missing	(*)	(*)	(*)	(*)	100	20
Place for handwashing with soap and water						
Water and soap available	36.8	24.1	23.5	11.4	100	5825
Water is available, soap is not available	(29.5)	(16.7)	(29.8)	(16.8)	100	127

Proportion of households by *E. coli* risk level in household water, Bangladesh 2012-2013						
	Proportion of households				Total	Number of household members
	E. coli risk level in household drinking water					
	Low	Medium	High	Very High		
Water is not available, soap available	39.2	20.7	21.5	15.5	100	3387
Water and soap are not available	34.0	27.8	28.2	6.4	100	386
Missing	30.0	26.5	26.6	14.0	100	2130
Total	34.0	27.8	28.2	6.4	100	386

( ) Figures that are based on 25-49 unweighted cases
(*) Figures that are based on less than 25 unweighted cases

Table 36: Change in *E. coli* risk level between source and household sample, by availability of a handwashing facility, soap and water

Proportion of households by change in *E. coli* risk level between source and household water, Bangladesh 2012-2013					
	Proportion of households			Total	Number of households
	Change in *E. coli* risk level between source and household				
	Lower	Same	Higher		
Place for handwashing					
Observed	13.0	50.9	36.1	100.0	2110
Not observed	11.2	40.7	48.1	100.0	433
Soap or other cleansing agent observed					
Soap or other cleansing agent observed	13.8	49.8	36.4	100.0	1266
Soap or other cleansing agent not observed but shown	11.7	48.1	40.2	100.0	1139
No soap or other cleansing agent in household	10.6	50.2	39.3	100.0	124
Not able/Does not want to show cleansing agent	(*)	(*)	(*)	100.0	7
Missing	(*)	(*)	(*)	100.0	7
Place for handwashing with					
Water and soap available	14.0	49.9	36.1	100.0	1237
Water is available, soap is not available	(8.9)	(37.7)	(53.4)	(100.0)	26
Water is not available, soap available	11.5	53.6	35.0	100.0	751
Water and soap are not available	10.1	43.8	46.1	100.0	84
Missing	11.8	41.4	46.8	100.0	445
Total	10.1	43.8	46.1	100.0	84

( ) Figures that are based on 25-49 unweighted cases
(*) Figures that are based on less than 25 unweighted cases

5.11 Quality control for *E. coli*

A variety of quality control (QC) measures were included to assess that the quality of the information collected during the survey. These included: field blanks, field duplicates and an internal consistency check (flagged results) for the *E. coli* test.

- Of a total of 247 blank samples tested, results were recorded for 241 tests (98 per cent). Of these, six (2.5 per cent) incorrectly detected the presence of *E. coli* and this occurred less often with the 1 mL (1.2 per cent) than 100 mL (2.1 per cent) test. Of the six false positives, four were below 10 CFU per 100 mL, and two were in the 11-100 CFU per 100 mL range.
- Based on the WHO risk categories for *E. coli*, the BBS and the ICDDR,B field duplicates indicated the same level of contamination for 64 per cent of the samples. In 85 per cent of the cases the results differed by up to 1 risk category. In 15 per cent of the cases the difference was 2 or more risk categories. After comparison no adjustments were made to the results of the *E. coli* field tests.
- In total 8 per cent of samples were flagged as having potentially inconsistent results between the 100 mL and 1 mL samples. A proportion of samples (6 per cent) have been excluded from the analysis as it was unclear which risk class to assign the samples to.

Further details on quality control are provided in Annex 1a.

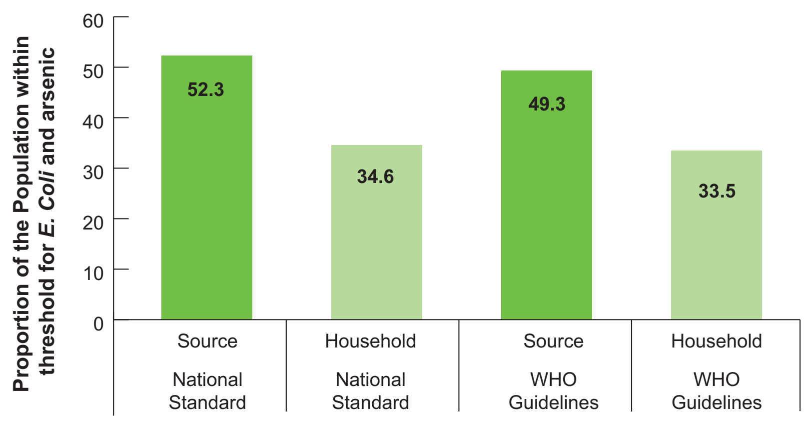
6. Combined arsenic and faecal contamination

6.1 Combined water quality: arsenic and *E. coli*

Since arsenic was measured at every household and source where *E. coli* was measured, it is possible to consider the quality of water with respect to these two parameters at the same time. It was more common for both household and source water to be contaminated with *E. coli* than with arsenic, so the combined contaminations levels are similar whether using the WHO guideline value for arsenic or the national drinking water standard.

Nationally, 52.3 per cent of households collect water from a source which meets the Bangladesh standard for both arsenic (<=50 ppb) and *E. coli* (<1 cfu/100 mL), but by the point of consumption only 34.6 per cent of the population consumes water meeting both standards (Figure 14). When the stricter WHO guideline value for arsenic is considered, trends are very similar but the proportion of the population accessing water meeting both standards drops to 49.3 per cent and 33.5 per cent at the source and household level, respectively.

Figure 15: Compliance with national standards and WHO Guidelines for Drinking Water Quality



6.2 Combined water quality by location and socio-economic status

Patterns in combined water quality are similar to those noted in Table 14 for arsenic contamination, and in Table 25 for *E. coli* contamination.

The proportion of the population meeting both standards is nearly the same in urban (35.8 per cent) and rural areas (34.3 per cent), is much higher in improved than in unimproved sources, and shows no strong trends with education or wealth.

Compliance is lowest in Sylhet division (23.0 per cent), where *E. coli* is the driving factor, and in Khulna (25.4 per cent) where arsenic is the main cause of low compliance.

Table 37: Household water quality by location and socio-economic status: arsenic and *E. coli*

Proportion of population by levels of arsenic and *E. coli* found in household drinking water, Bangladesh, 2012-2013

	Percentage of population					
	Arsenic <= 50ppb and *E. coli* < 1 cfu/100ml[1]	Arsenic <= 50ppb and *E. coli* ≥ 1 cfu/100ml	Arsenic > 50ppb and *E. coli* < 1 cfu/100ml	Arsenic > 50ppb and *E. coli* ≥ 1 cfu/100ml	Total	Number of household members
Total	34.6	52.6	3.8	9.1	100.0	11146
Division						
Barisal	46.5	53.5	0.0	0.0	100.0	738
Chittagong	29.6	44.0	8.6	17.8	100.0	2263
Dhaka	36.3	53.9	2.7	7.2	100.0	3171
Khulna	25.4	56.1	5.4	13.2	100.0	1314
Rajshahi	38.0	56.7	3.7	1.6	100.0	1526
Rangpur	43.6	56.1	0.2	0.2	100.0	1402
Sylhet	23.0	50.4	1.3	25.3	100.0	732
Area						
Urban	35.8	58.3	1.8	4.1	100.0	2253
Rural	34.3	51.1	4.3	10.4	100.0	8892
Education of household head						
None	34.0	52.9	2.4	10.7	100.0	4786
Primary incomplete	29.7	55.0	4.6	10.7	100.0	1355
Primary complete	35.8	54.0	1.2	9.0	100.0	1425
Secondary incomplete	34.4	52.5	7.1	6.0	100.0	1976
Secondary complete or higher	39.7	48.0	5.2	7.1	100.0	1601
Wealth index quintile						
Poorest	33.5	54.2	2.7	9.6	100.0	2232
Second	31.1	56.5	2.3	10.1	100.0	2250
Middle	33.4	53.3	4.1	9.2	100.0	2036
Fourth	37.8	48.0	4.3	9.9	100.0	2338
Richest	36.8	51.1	5.4	6.7	100.0	2289

( ) Figures that are based on 25-49 unweighted cases
(*) Figures that are based on less than 25 unweighted cases

Table 38: **Source water quality by location and socio-economic status: arsenic and *E. coli***

Proportion of households by levels of arsenic and *E. coli* found in household drinking water, Bangladesh, 2012-2013						
	Percentage of households				Total	Number of households
	Arsenic <= 50ppb and *E. coli* < 1 cfu/100ml[1]	Arsenic <= 50ppb and *E. coli* ≥ 1 cfu/100ml	Arsenic > 50ppb and *E. coli* < 1 cfu/100ml	Arsenic > 50ppb and *E. coli* ≥ 1 cfu/100ml		
Total	52.3	35.0	6.0	6.7	100.0	2365
Division						
Barisal	67.2	32.8	0.0	0.0	100.0	154
Chittagong	41.7	33.4	10.2	14.8	100.0	425
Dhaka	44.1	44.6	5.2	6.1	100.0	685
Khulna	51.7	27.7	13.8	6.8	100.0	291
Rajshahi	65.0	30.4	3.6	1.1	100.0	369
Rangpur	71.2	28.3	0.5	0.0	100.0	316
Sylhet	31.1	38.8	6.0	24.0	100.0	125
Area						
Urban	42.1	50.0	3.0	4.9	100.0	489
Rural	55.0	31.1	6.8	7.1	100.0	1876
Education of household head						
None	51.4	36.1	5.6	6.9	100.0	1013
Primary incomplete	58.7	27.9	5.8	7.6	100.0	287
Primary complete	54.6	33.9	3.6	7.8	100.0	293
Secondary incomplete	52.6	33.5	6.7	7.2	100.0	427
Secondary complete or higher	47.2	40.8	8.4	3.7	100.0	345
Wealth index quintile						
Poorest	56.3	31.0	4.5	8.2	100.0	509
Second	56.8	31.2	5.0	6.9	100.0	493
Middle	52.5	34.0	7.5	6.0	100.0	434
Fourth	54.4	31.6	7.1	6.9	100.0	470
Richest	40.7	48.1	6.1	5.1	100.0	459

( ) Figures that are based on 25-49 unweighted cases
(*) Figures that are based on less than 25 unweighted cases

6.3 Combined water quality by water source type and location

The percentage of households using a drinking water source in compliance with national standards for both arsenic and *E. coli* varied by type of source. Improved sources (53.2 per cent) were more than twice as likely as unimproved sources (21.3 per cent) to meet both standards.

Of those households using boreholes, 55.9 per cent met both standards and 7 per cent exceeded national standards for both arsenic and *E. coli*. It was more likely for drinking water from boreholes to contain *E. coli* than arsenic concentration over 50 ppb.

Table 39: Source water quality by type and location of water source: arsenic and *E. coli*

Proportion of households by levels of arsenic and *E. coli* found in source of drinking water, Bangladesh, 2012-2013

	Percentage of households				Total	Number of households
	Arsenic <= 50ppb and *E. coli* < 1 cfu/100ml[1]	Arsenic <= 50ppb and *E. coli* ≥ 1 cfu/100ml	Arsenic > 50ppb and *E. coli* < 1 cfu/100ml	Arsenic > 50ppb and *E. coli* ≥ 1 cfu/100ml		
Total	52.3	35.0	6.0	6.7	100.0	2365
Source of drinking water for WQ sample						
Unimproved water source	21.3	73.1	2.0	3.7	100.0	44
Improved water source	52.8	34.4	6.1	6.8	100.0	2316
Source of drinking water						
Piped into dwelling	(20.3)	(79.7)	(0.0)	(0.0)	100.0	83
Piped into compound, yard or plot	21.5	77.4	0.0	1.1	100.0	108
Public tap / standpipe	(71.8)	(23.0)	(0.0)	(5.3)	100.0	31
Tube well, Borehole	55.5	30.4	6.7	7.4	100.0	2090
Dug well (protected or unprotected)	(5.7)	(94.3)	(0.0)	(0.0)	100.0	10
Surface water	12.9	79.9	0.0	7.2	100.0	22
Other	(43.9)	(50.7)	(5.5)	(0.0)	100.0	16
Location of the water source						
In own dwelling	36.7	36.7	14.4	12.2	100.0	79
In own yard / plot	54.8	32.2	6.8	6.3	100.0	1561
Elsewhere	55.9	31.7	4.0	8.4	100.0	582
Time to get water and come back						
On premises	53.9	32.4	7.1	6.6	100.0	1640
1-5 minutes	55.2	29.9	3.7	11.3	100.0	180
5-10 minutes	62.5	28.3	3.1	6.1	100.0	194
11-30 minutes	49.9	38.7	3.8	7.6	100.0	165
31-60 minutes	(44.8)	(36.9)	(8.2)	(10.1)	100.0	30

( ) Figures that are based on 25-49 unweighted cases
(*) Figures that are based on less than 25 unweighted cases

Table 40: Household water quality by water source and location of the water source: arsenic and *E. coli*

Proportion of population by levels of arsenic and *E. coli* found in household drinking water, Bangladesh, 2012-2013						
	Percentage of population					
	Arsenic <= 50ppb and *E. coli* < 1 cfu/100ml[1]	Arsenic <= 50ppb and *E. coli* ≥ 1 cfu/100ml	Arsenic > 50ppb and *E. coli* < 1 cfu/100ml	Arsenic > 50ppb and *E. coli* ≥ 1 cfu/100ml	Total	Number of household members
Total	34.6	52.5	3.8	9.1	100.0	11130
Source of drinking water for WQ sample						
Unimproved water source	10.0	86.0	1.4	2.6	100.0	250
Improved water source	35.2	51.8	3.8	9.3	100.0	10880
Source of drinking water						
Piped into dwelling	41.3	58.7	0.0	0.0	100.0	390
Piped into compound, yard or plot	14.6	83.4	0.0	2.0	100.0	471
Public tap / standpipe	(53.9)	(42.0)	(1.7)	(2.3)	100.0	139
Tube well, Borehole	35.6	50.1	4.2	10.1	100.0	9862
Dug well (protected or unprotected)	(31.6)	(68.4)	(0.0)	(0.0)	100.0	53
Surface water	4.2	91.2	0.0	4.6	100.0	139
Other	(18.3)	(77.1)	(4.5)	(0.0)	100.0	76
Location of the water source						
In own dwelling	33.5	40.1	13.9	12.5	100.0	433
In own yard / plot	37.0	50.6	3.9	8.6	100.0	7250
Elsewhere	30.0	55.8	2.9	11.4	100.0	2816
Time to get water and come back						
On premises	36.8	50.0	4.4	8.9	100.0	7683
1-5 minutes	28.0	53.5	5.2	13.3	100.0	820
5-10 minutes	33.9	54.7	1.7	9.6	100.0	958
11-30 minutes	27.5	60.3	1.0	11.2	100.0	815
31-60 minutes	24.0	56.1	4.8	15.1	100.0	155

( ) Figures that are based on 25-49 unweighted cases
(*) Figures that are based on less than 25 unweighted cases

Box 1: Safely managed drinking water

The Sustainable Development Goals (SDGs) include a goal for water and sanitation. The target for drinking water is by 2030 to "achieve universal and equitable access to safe and affordable drinking water". The target is more ambitious than during the MDGs since it is universal.

The indicator which will be used to track progress towards the SDG target at a global level is "the population using safely managed drinking water services". Safely managed drinking water is defined as a water source that is of an improved type, free of faecal and priority chemical contamination and available when needed. It is a higher service than basic drinking water (improved within 30 minutes round-trip) and addresses the Human Rights criteria of quality, availability and accessibility.

From the Bangladesh MICS 2012-2013 information is available on all but one element, the availability of drinking water when needed. In the chart below illustrative estimates are provided based on assumptions about the availability of drinking water and suggest that whilst 95 per cent of the population of Bangladesh used a basic water service in 2012-2013, only around half of the population used a safely managed drinking water source.

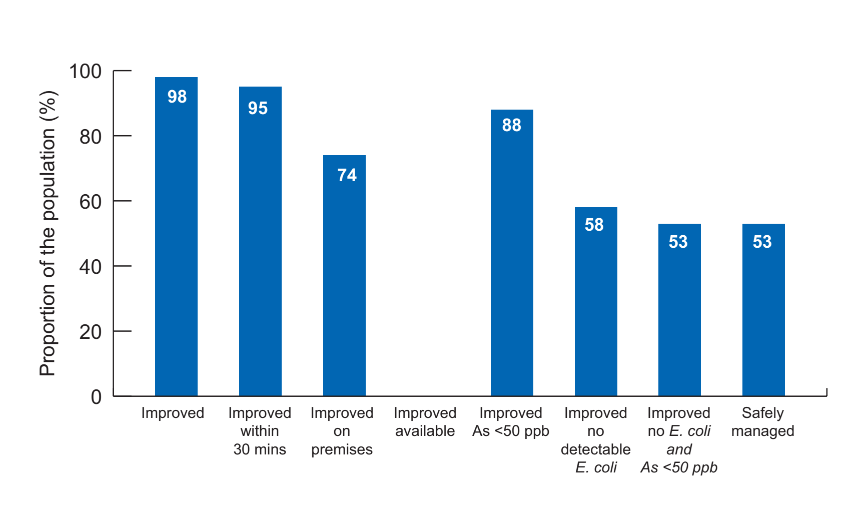


Figure B1: Illustrative example of safely managed drinking water based on data from MICS 2012-2013 in Bangladesh. Note: Example is for illustrative purposes only and based on strong assumptions about the availability of drinking water from piped water (assumed to not always be available when needed) and boreholes (assumed to be available when needed).

7. Discussion

7.1 Programme implications

Program Implications

The findings of the MICS Water Quality Thematic Report will assist the Government of Bangladesh and its development partners with prioritizing key interventions to close the gap between access to improved drinking water sources and access to safe drinking water.

Key interventions

1. **Scale up Water Safety Planning within a Drinking Water Safety Framework**

    a. Advocate for high level involvement, increased investments and sectoral focus on Water Safety Planning for point and non-point sources prioritizing Sylhet, Dhaka and Chittagong divisions.

    This is necessary as over half[16], (53.5 per cent) of households in the division that with the least *E coli* risk in drinking water used faecally contaminated water sources; affecting both urban (62.4 per cent) and rural households (61.5 per cent per cent); piped water supplies (>58.7 per cent) and tubewells[17] (60.2 per cent). Although The Government of Bangladesh has adopted the WHO Drinking Water Safety Framework Guidelines, it is not implemented by many stakeholders at national and sub-national levels. The Department of Public Health Engineering with the support of WHO and UNICEF are implementing water safety planning in 40 municipalities.

    It is important to develop a reward based performance system with high-level support which specifies water safety planning as a mandatory key performance criterion for municipalities and Union Parishads. Investments in institutional capacity building and

---

16 Except Rangpur in which almost 30 per cent of households used faecally contaminated water sources

17 Tubewells were not differentiated into shallow or deep

infrastructure development will be necessary to respond to the capacity and infrastructure assessments which is one of the three components of water safety planning.

The drinking water safety framework addresses the multiple sources of contamination by introducing water safety planning to assess and address the water safety risks within the catchment area. Consequently there is a need to:

b. Integrate water safety planning with sanitation and faecal sludge management in both rural and urban areas; especially as the survey noted (i) a relationship between open defecation and the microbiological quality of household stored water; and (ii) that piped water supplies were the worst contaminated in urban areas.

This suggests that the sanitation and sewerage risks should be assessed during water safety planning, confirmatory *E.coli* tests carried out and the data collected should form the basis of sanitation improvement planning.

c. Train communities on the use of household water treatment methods as a short-term measure to address the risks identified during the development of water safety plans

2. Advocate for the review of the Government of Bangladesh (GoB) Standard for Drinking Water from O.05mg/l to 0.01mg/l

The study results indicate that 19.7 million people are exposed to arsenic concentrations above the GoB standard through drinking water, and double that number consume water that is above the WHO guideline of 0.01mg/l.

Health Based Targeting is one of the components of the WHO drinking water quality framework adopted by the Government of Bangladesh. Consequently as various studies have documented the negative health impact of arsenic exposure from drinking water and other sources, it is important to supply drinking water that achieves the intended health benefits by adopting 0.01mg/l as the GoB standard for arsenic. Moreso as the safe water supply and sanitation policy (1998) notes that safe water and sanitation are essential for the development of public health.

Institutionalize systematic drinking water quality monitoring and surveillance within a drinking water safety framework at national and sub-national levels, prioritizing Sylhet, Dhaka and Chittagong divisions.

This recommendation is based on the survey findings that all 64 districts had a proportion of households using arsenic contaminated water sources, two out of five households in Sylhet use faecally contaminated water and the sector estimate that Bangladesh has 10 million tubewells. The Water Supply and Sanitation Sector Development Plan provides guidance on the roles and responsibilities of the tiers of government and different stakeholders. It is important to collect water quality data more frequently than two-yearly surveys allow. This will also enable Bangladesh track its progress towards the safely managed component of Drinking Water SDG targets.

3. **Adopt A Harmonized Sector-Wide Approach And Protocol For Arsenic Mitigation In Drinking Water**

The findings indicate that progress in arsenic mitigation in drinking water has been slow. A reduction of 1.0 percentage points[18] in the population exposed to arsenic above the GoB standard. One of the major reasons for the slow progress is noted in the National Policy on Safe Water Supply and Sanitation Policy 1998 i.e. the divergent approaches used by different stakeholders.

"However, many development projects have attempted to redress these inadequacies but these adopt divergent approaches and the benefits are limited to the project boundaries'. Almost two decades later, the situation has not changed.

Bangladesh recorded significant progress when the country adopted a harmonized approach to end open defecation. It is important to scale up progress by adopting a common approach/protocol for arsenic mitigation in drinking water. The Department of Public Health and UNICEF have adopted a protocol and arsenic safe village concept which resulted in the declaration of 126 villages as arsenic safe between 2014 and 2015. This is presently being scaled up to arsenic safe unions by DPHE and UNICEF. Japanese International Cooperation Agency also has an arsenic mitigation protocol. Such protocols should be identified and harmonized for sector wide adoption.

4. **Fund and Implement the National Plan on Arsenic Mitigation in Drinking Water (2016 -2025), by Developing Action Plans for Priority Areas**

The IPAM (2016-2025) has been approved by the National Council on Water Supply and Sanitation. The IPAM provides a framework for implementing arsenic mitigation projects in Bangladesh. Based on the Sector Development Plan, it prioritised areas according to top, and high priority and emergency. The Water Quality Thematic report provides more detailed information which can form the basis

18 Population growth not factored in

of developing action plans targeting and prioritizing districts for arsenic mitigation interventions. For example although all 64 districts had a proportion of households using arsenic contaminated water sources, 17 of these districts had more than one in 5 people exposed to concentrations above 0.05 mg/L. In Brahmanbaria, Chandpur, Comilla, Feni and Narail districts more than one in ten people drink water with arsenic concentrations above 0.2mg/l.

5. **Develop and Operationalize a National Communication Strategy for Water Safety**

The Communication strategy will allow the sector to (a) define the primary and secondary target audience for scaling up water safety such as policy makers, technocrats and community members (b) design methodologies to reach the specific target groups and (c) define the key messages based on the water safety issues the report identified.

Water Safety issues identified by the report include:

i. Improved water sources had better microbiological quality than the unimproved sources

ii. Microbial Water Quality worsened from source to point of consumption indicating poor water safety handling by the users

iii. Household water treatment (self-reported) was ineffective in improving microbiological quality in a third of the households

iv. Households that practiced open defecation and lacked handwashing facilities and soap had worse microbiological drinking water quality than those that did not.

v. A higher proportion of households with educated household heads had better drinking water quality at household level than those with uneducated household heads

6. **Prioritize Urban Poor, Arsenic Prone, Hard To Reach Areas For Safe Water Provision**

The report notes that there is almost universal access to improved water sources when analyzed nationally, by divisions and between the urban and rural households.

However the urban dwellers with no education were most likely to have high risk drinking water (>100 CFU/100 ml) and the poorest in rural areas were twice as likely as the richest to have faecally contaminated water. This suggests a need to include wealth ranking in both urban and rural areas as an index for prioritizing access to improved water sources.

7. **Build The Capacity Of The Private Sector To Construct Arsenic And Microbiologically Safe Water Points**

   According to the MICS report, two out of five households used sources that were faecally contaminated and about a quarter used sources that were arsenic contaminated above the World Health recommended guidelines. Majority of the wells drilled in Bangladesh is provided by private sector. It is important to regulate local driller activities by facilitating three key interventions: (a) mapping of local drillers (b) registration with the local authorities (c) training and certification.

8. **Develop and operationalize Drinking Water Supply and Sanitation management Information System.**

   Presently, the sector is unable to provide timely estimates of progress made in improving access to safe drinking water and improved sanitation. This is because projects collect data using different coding systems which are incompatible with a national database. There is a need to develop harmonized monitoring indicators and tools at national and sub-national levels, harmonize coding systems and operationalize on a national platform. The monitoring indicators will be based on the SDG indicators (level of service, quality, functionality, accessibility, utilization, availability).

   The unique coding system developed by UNICEF and adopted by DPHE and JICA, the DPHE MIS/GIS unit provide a platform for developing and operationalizing a Drinking Water supply and Sanitation Management Information System.

9. **Developing and operationalizing a National Operation and Maintenance Strategy**

   Poorly constructed and badly maintained water points impact on the water quality of the constructed water points. Relatedly non-functional improved water sources may cause households to revert to the use of unsafe and unimproved drinking water sources. There is a need to develop a National Operation and Maintenance Strategy to ensure that constructed water points remain functional and continue to provide safe drinking water.

Bridging the gap between access to improved water sources and access to safe drinking water has multidimensional implications for the WASH sector. These range from Institutional and private sector capacity building, harmonization of approaches to safe water supply, information management and operation and maintenance. Other important interventions include water safety and arsenic mitigation sector-wide planning to enhancing communication to policy makers and community members. A priority first step will be the dissemination of the Water Quality Report at National and Sub-national levels

7.2 Implications for future water quality surveillance

The Bangladesh MICS 2012-2013 demonstrated the feasibility of integrating water quality assessments in multi-topic household surveys such as MICS. Using portable kits, BBS survey teams were able to test water for faecal contamination using WHO's preferred indicator (*E. coli*) and to test for arsenic, a key priority in Bangladesh.

Water quality experts from ICCDR,B and JMP provided support for training and visited teams during the survey as part of a quality assurance. A variety of quality control measures were included and provide confidence in the results of the survey and the ability of non-specialists to conduct the water quality tests.

Integration of water testing in an existing survey such as MICS greatly reduces the costs of achieving a nationally representative sample relative to a dedicated water quality survey. The costs could be reduced over time through the use of innovative water quality tests and greater reliance on national water quality experts for training and quality control.

The majority of the population in Bangladesh (98 per cent) uses an improved drinking water source yet a large proportion was found to use a source contaminated with *E. coli* (41.7 per cent) or had levels of arsenic exceeding WHO Guideline value of 10 ppb (25.5 per cent) or the national standard of 50 ppb (12.5 per cent). It is clear that a greater focus is needed on the level of service provided by water sources.

Bacteriological water quality deteriorated substantially between the source and the glass of water within the home, providing further evidence of the need to extend surveillance to the point at which people are consuming water. For arsenic it would be possible to collect samples only at the household since the differences were comparatively small (12.4 per cent versus 12.5 per cent nationally).

The water quality results for arsenic were adjusted based on laboratory results for a sub-set of samples. Depending on capacity of local laboratories, for future surveys the option of laboratory testing for chemical water quality parameters should be explored.

The SDG indicator "use of safely managed drinking water services" can be monitored through nationally representative household surveys. In addition to water quality testing new questions can be included to address the availability and accessibility of water services. In Bangladesh, illustrative calculations suggest that half of the population uses a safely managed drinking water source compared with 95 per cent of the population with basic services (improved within 30 mins roundtrip collection time).

Annex

Annex 1a:

Quality control and assurance (microbiological)

A number of quality control and assurance measures were implemented during training and implementation of the survey, and during data analysis. These included:

- Supervision during training
- Field blanks
- Field visits by water quality experts
- Field duplicates by water quality experts
- Lab duplicates by water quality experts
- Post-survey data consistency checks

Supervision during training

During training of the measurers, experienced supervisors who had participated in the Bogra field pilot provided technical assistance and practical examples. Supervisors of the MICS 2012-13 survey were also oriented on the water quality testing procedure, and were responsible for day-to-day supervision in the field.

Field blanks

Field teams regularly conducted blank analyses for *E. coli*. One out of ten enumeration areas was systematically selected for blank analysis. For this enumeration area, when the measurer was at the household that was selected for additional arsenic testing, he tested bottled water for *E. coli*. Team supervisors regularly provided bottled water (Mum brand) to measurers for use in blank analysis. This resulted in one *E. coli* blank sample per twenty field samples (ten source and ten household samples in ten enumeration areas), or a blank rate of 5 per cent.

Of a total of 247 blank samples tested, results were recorded for 241 tests (98 per cent). Of these, six (2.5 per cent) incorrectly detected the presence of *E. coli* and this occurred less often with the 1 mL (1.2 per cent) than 100 mL (2.1 per cent) test. Of the six false positives, four were below 10 CFU per 100 mL, and two were in the 11-100 CFU per 100 mL range. These low levels of false positives indicate that field teams were able to conduct the test without introducing significant microbial contamination.

Field visits by water quality experts

During field work, mobile teams of laboratory technicians from ICDDR,B visited all of the 32 MICS field teams twice to monitor testing procedures and to validate field test kit results. Specifically, they:

- Observed the measurers work and provided feedback / on the job training
- Performed duplicate field test using the field team's equipment
- Collected samples for analysis by ICDDR,B in the laboratory.

Duplicate field tests

55 paired samples were tested both by MICS teams in the field and ICDDR,B teams in the field. Based on the WHO risk categories for *E. coli*, the field duplicate samples tested by both teams indicated the same level of contamination for 71 per cent of the samples. In 18 per cent of the cases the MICS team results were 1 risk category higher, and in 4 per cent of cases they were two risk classes higher. In 7 per cent of the cases the ICDDR,B test results were one risk category higher.

Laboratory cross-checks

Laboratory cross-checks were performed on duplicate samples within 24 hours of collection. In the laboratory Millipore™ membrane filters were placed in plates on modified *E. coli* agar media, and incubated at 35°C for two hours and then at 44.5°C for another 22 hours. Laboratory technicians counted red or magenta colonies as *E. coli.*

Based on the WHO risk categories for *E. coli*, the cross-checks indicated the same level of contamination in the laboratory as in the MICS field measurements for 75 per cent of the samples (Table A1). In 21 per cent of the cases the results differed by one risk category.

Agreement was highest when the ICDDR,B experts conducted both the field and laboratory tests, with 92 per cent of results in the same risk class and the remaining 8 per cent within one risk class. In all cases of disagreement, the risk class was higher in the field than in the laboratory. This could indicate some *E. coli* die-off during transport from the field to the laboratory, or differences in sensitivity due to the different analytical methods used.

After comparison no adjustments were made to the results of the *E. coli* field tests.

Table A1: *E. coli* risk class comparison						
	Number of paired samples	Proportion of paired samples (%)				
		More than one risk class lower	One risk class lower	Same risk class	One risk class higher	More than one risk class higher
Comparison						
Field MICS vs. Field ICDDR,B	55	0	7	71	18	4
Field MICS vs Lab ICDDR,B	83	1	5	75	16	4
Field ICDDR,B vs Lab ICDDR,B	59	0	0	92	8	0

Data consistency checks

During data analysis, internal consistency checks were made on *E. coli* results. Since measurers analysed both 100 mL and 1 mL samples for *E. coli*, certain unusual or inconsistent results could be identified and flagged.

As a hundred-fold smaller volume is analysed the number of *E. coli* should be correspondingly lower. In Table A2, the proportion of flagged results is given for each field team. Each "flag" represents different types of improbable result:

> ***Flag A*** - 1 mL sample count is low, 100 mL sample count is high. Results are flagged if the 100 mL test is too numerous to count (TNTC) and no colonies are recorded for the 1 mL test.
>
> ***Flag B*** - 1 mL sample is high, 100 mL sample is low. If the 100 mL test is below 10 and 1 mL has at least one colony.
>
> ***Flag C*** - 1 mL sample count greater than the 100 mL sample count provided both are non-zero and not too numerous to count (>100).

While a small number of these may be expected due purely to chance, frequent occurrences of "flags" indicate errors in the test procedure. For the purposes of this report, 5.9% of samples, Flag B and Flag C, were excluded as it was unclear which risk class to assign the samples to.

Table A2: *E. coli* level of household water by field supervisor					
Proportion of flagged results, Bangladesh 2012-2013					
	Proportion Type A flag	Proportion Type B flag	Proportion Type C flag	Proportion Excluded	Proportion Flagged
Supervisor					
1	0.9	4.5	1.3	4.5	5.4
2	1.8	1.4	0.0	1.4	3.3
3	1.2	2.9	0.8	2.9	4.1
4	1.1	1.9	0.0	1.9	3.0
5	0.7	0.0	0.0	0.0	0.7

Table A2: *E. coli* level of household water by field supervisor					
Proportion of flagged results, Bangladesh 2012-2013					
	Proportion Type A flag	Proportion Type B flag	Proportion Type C flag	Proportion Excluded	Proportion Flagged
6	2.5	0.6	0.0	0.6	3.1
7	15.0	1.5	0.0	1.5	16.4
8	5.5	3.0	0.0	3.0	8.5
9	2.9	8.8	1.3	8.8	11.7
10	11.9	4.9	0.0	4.9	16.8
11	1.0	7.5	0.0	7.5	8.5
12	0.0	29.2	17.3	29.5	29.5
13	1.9	0.0	0.0	0.0	1.9
14	1.7	5.7	3.5	5.7	7.4
15	23.2	0.7	0.5	0.7	23.9
16	0.0	8.4	0.0	8.4	8.4
17	2.6	5.3	0.0	5.3	7.9
18	7.5	32.7	23.5	32.7	40.2
19	0.0	34.2	34.5	36.6	36.6
20	3.6	2.0	1.6	2.0	5.6
21	0.0	2.8	0.0	2.8	2.8
22	6.3	1.2	0.0	1.2	7.5
23	7.2	13.3	1.6	13.3	20.5
24	1.5	0.9	0.0	0.9	2.4
25	5.9	1.6	0.6	1.6	7.5
26	2.8	1.0	0.0	1.0	3.8
27	11.0	3.0	1.3	3.0	14.0
28	7.1	2.6	0.0	2.6	9.7
29	0.0	9.2	0.0	9.2	9.2
30	0.0	1.4	0.0	1.4	1.4
31	3.6	1.4	0.0	1.4	5.0
32	15.8	0.5	0.0	0.5	16.3
Total	**5.1**	**5.8**	**2.6**	**5.9**	**11.0**

Source of water sample

In the water quality module, respondents were asked to provide the source of the particular water sample being tested. In Tables A3 and A4 this source is compared to the household's primary drinking water source as reported in the water and sanitation module. Overall 93 per cent of households reported the same type of water source and agreement was high for improved sources (93 per cent) but much lower for unimproved sources (57 per cent). These findings may reflect multiple source use especially amongst users of unimproved sources. There was also relatively high discordance for different types of piped supply.

Table A3: Comparison of main source of drinking water and source of water quality sample

	Source of drinking water sample								Number of households (unweighted)
	Piped into dwelling	Piped into compound, yard or plot	Public tap / standpipe	Tube well, Borehole	Unprotected well	Surface water[1]	Other	Missing	
Main source of drinking water									
Piped into dwelling	14	1	3	6	0	0	0	0	24
Piped into compound, yard or plot	3	19	1	7	0	0	0	1	31
Piped to neighbour	0	3	0	0	0	0	0	0	3
Public tap / standpipe	2	4	15	5	0	3	0	0	29
Tube well, Borehole	8	26	12	2306	4	1	6	4	2367
Protected well	0	0	0	3	8	0	1	0	12
Unprotected well	0	0	1	1	21	0	2	0	25
Unprotected spring	0	0	0	1	4	1	15	0	21
Rainwater collection	0	0	0	0	0	0	1	0	1
Surface water	0	0	0	6	1	50	1	0	58
Bottled water	0	0	0	0	0	1	1	0	2
Other	0	0	0	3	0	4	8	0	15
Total	27	53	32	2338	38	60	35	5	2588

Table A4: Comparison of reported main source of drinking water for the household and source of water sample, by source type

Proportion of households by *E. coli* risk level in household water, Bangladesh 2012-2013

	Proportion of households with matching response	Total	Number of households (unweighted)
Main source of drinking water			
Piped into dwelling	58.3	100.0	24
Piped into compound, yard or plot	61.3	100.0	31
Piped to neighbour	0.0	100.0	3
Public tap / standpipe	51.7	100.0	29
Tube well, Borehole	97.4	100.0	2367
Protected well	0.0	100.0	12
Unprotected well	84.0	100.0	25
Unprotected spring	0.0	100.0	21

Table A4: Comparison of reported main source of drinking water for the household and source of water sample, by source type

Proportion of households by *E. coli* risk level in household water, Bangladesh 2012-2013

	Proportion of households with matching response	Total	Number of households (unweighted)
Rainwater collection	0.0	100.0	1
Surface water	86.2	100.0	58
Bottled water	0.0	100.0	2
Other	53.3	100.0	15
Total	94.0	100.0	2588
Source of drinking water sample			
Piped into dwelling	51.9	100.0	27
Piped into compound, yard or plot	35.9	100.0	53
Public tap / standpipe	46.9	100.0	32
Tube well, Borehole	98.6	100.0	2338
Unprotected well	55.3	100.0	38
Surface water	83.3	100.0	60
Other	22.9	100.0	35
Missing	0.0	100.0	5
Total	94.0	100.0	2588

Annex 1b:

Quality control and assurance (arsenic)

As for *E. coli*, a number of quality control and assurance measures for arsenic measurements were implemented during training and implementation of the survey.

Supervision during training

During training of the measurers, experienced supervisors who had participated in the Bogra field pilot provided technical assistance and practical examples. Supervisors of the MICS 2012-13 survey were also oriented on the water quality testing procedure, and were responsible for day-to-day supervision in the field.

Field visits by water quality experts

During field work, mobile teams of laboratory technicians from ICDDR,B visited all of the 32 MICS field teams twice to monitor testing procedures and to validate field test kit results. While the focus was on *E. coli* testing, they also observed the field teams in the conducting of arsenic analysis.

Field blanks

One out of ten enumeration areas was systematically selected for blank analysis. For these enumeration areas, when the measurer was at the household that was selected for additional arsenic testing, he tested the bottled water for arsenic (and for *E. coli*, see Annex 1a). Team supervisors regularly provided bottled water (Mum brand) to measurers for use in blank analysis. This resulted in one arsenic blank sample per sixty field samples (ten source and fifty household samples in ten enumeration areas), or a blank rate of 2 per cent.

In total, 246 blank tests were conducted, and in 220 of these (89 per cent) the result was recorded as “None”. In 25 cases (10 per cent) the result was recorded as 10 ppb, and in 1 case (0.4 per cent) the result was 25 ppb. In no case did the blank test exceed the Bangladesh standard of 50 ppb.

Duplicate testing

One out of two enumeration areas was systematically selected for duplicate analysis of arsenic in laboratories. When travelling to these enumeration areas, the measurer brought two 125 mL plastic sampling bottles, supplied by laboratory partners and prefilled with 1 mL of 1:1 nitric acid as a preservative. When the measurer visited the household selected for additional water quality testing, he filled one bottle with household water and a second bottle with source water. Each bottle was then labelled with a sticker indicating the cluster and household ID. Bottles were later returned to Dhaka for storage and eventual analysis. This resulted in two laboratory samples (one source and one household sample) being collected for every twenty arsenic field tests conducted (ten sources and ten households in two enumeration areas), or a duplicate rate of 10 per cent.

The semi-quantitative data from field tests were then compared against the quantitative results from the laboratory. Results were grouped into four classes representing increasing levels of risk: <=10 ppb, 11-50 ppb, 51-200 ppb, and >200 ppb.

In all cases, when the field test recorded 0 ppb, the laboratory recorded <= 10 ppb. When the field test result was 10 ppb, the laboratory result in 89 per cent of cases was <10 ppb, with the remaining 11 per cent in the 11-50 ppb range.

Table A5: Adjustment factors for arsenic field test kits applied to all data

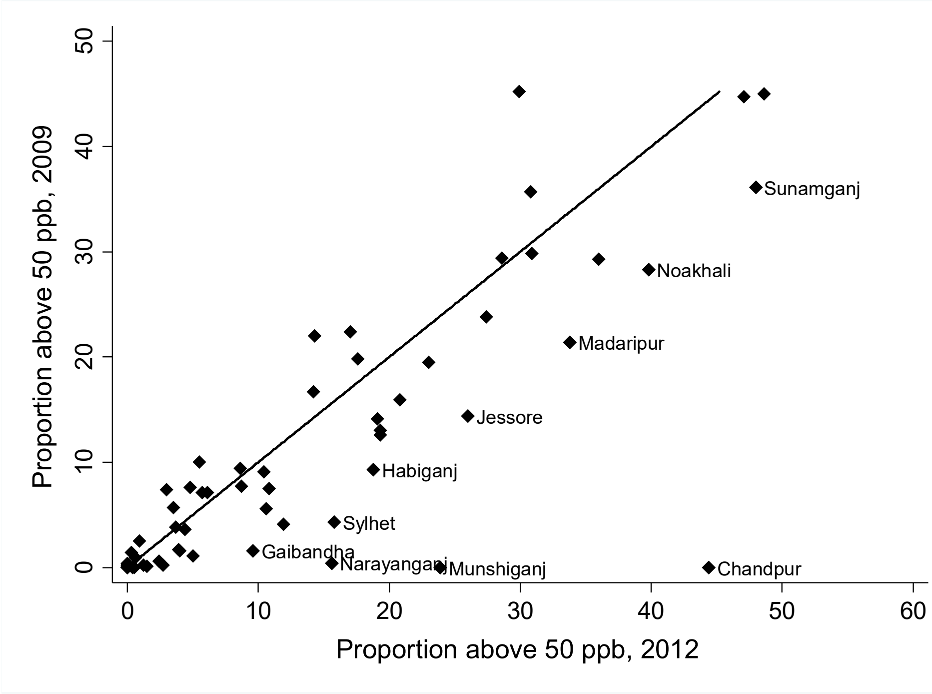
Field test kit result (ppb)	Percentage falling within laboratory range			
	<=10 ppb	11-50 ppb	51-200 ppb	>200 ppb
0	100	0	0	0
10	89	11	0	0
25	64	36	0	0
50	11	68	21	0
100	0	45	55	0
200	0	4	96	0
250	0	0	46	54
300	0	0	46	54
500	0	0	0	100
1000	0	0	0	100

Table 11 shows that field test kit results matched laboratory results well. In all cases, low contamination indicated in the kit was confirmed by laboratories. When the kit indicated at least 200 ppb, this was nearly always confirmed by laboratories. At intermediate concentrations, the kit had a slight positive bias, e.g. when the kit indicated 25 ppb, 64 per cent of results were actually <= 10 ppb. Arsenic test results were adjusted accordingly in the analysis.

Comparison with 2009 survey

Since a similar survey had been conducted three years earlier, data were compared at the district level.

Figure A1: District-wise comparison of proportion of samples exceeding Bangladesh national standard for arsenic (unadjusted)



For ten districts, labelled in Figure A1, the proportion of contaminated wells was markedly lower in the 2012 survey compared to the 2009 survey. For these districts, all available field samples which had been collected during field sampling were sent to ICDDR,B for analysis.

Approximately 35 samples, roughly evenly split between household and source samples, from each of these districts were sent to ICDDR,B for arsenic analysis, to allow a more detailed comparison with field kit data from the same districts. A total of 306 samples were analysed in the laboratory, and 295 of these could be matched with a field test kit result.

Table A6: Additional samples sent to ICDDR,B for cross-checking arsenic results

District	Data from ICDDR,B			Matched with Field kit database		
	Household	Source	Total	Household	Source	Total
Chandpur	17	17	34	17	17	34
Gaibandha	16	16	32	15	16	31
Habiganj	17	16	33	17	16	33
Jessore	15	18	33	15	16	31
Madaripur	17	17	34	17	17	34
Munshiganj	14	17	31	14	17	31
Narayanganj	10	11	21	10	10	20
Noakhali	13	12	25	12	11	23
Sunamganj	11	13	24	10	11	21
Sylhet	20	19	39	19	18	37
Total	150	156	306	146	149	295

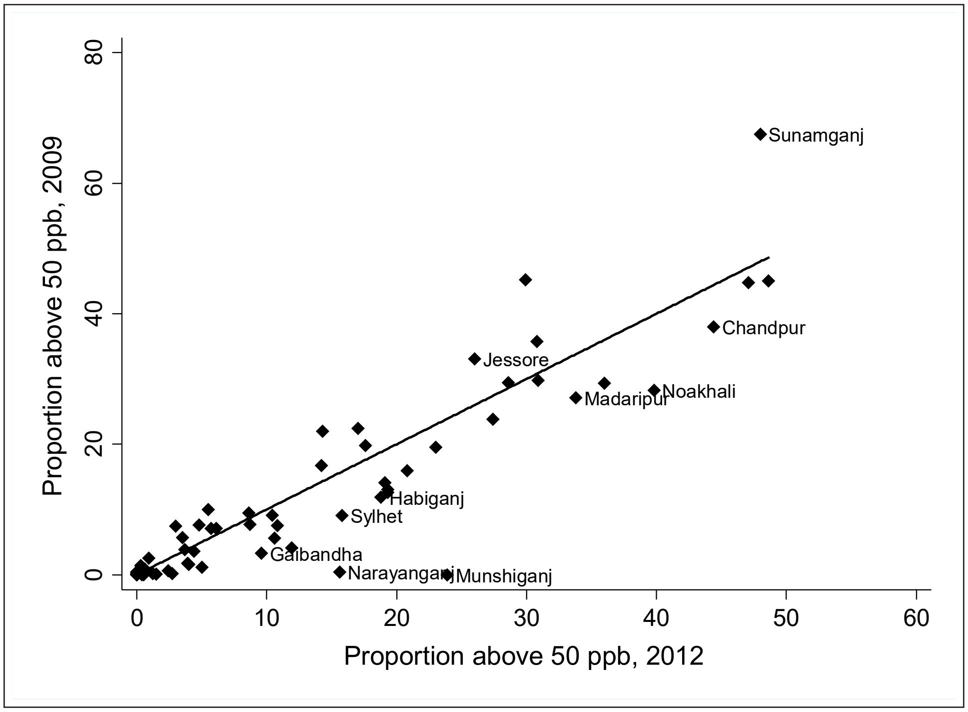
Resulting adjustment

When at least five field test samples in a district resulted in the same result, the distribution of arsenic in laboratory tests from those samples was taken to adjust all field samples from that district, as shown in Table A7. For example, in Munshiganj, 83 per cent of the samples recorded as '0' with the field test were classified as <=10 ppb on the basis of the laboratory comparison, with the remaining 17 per cent classified as in the 11-50 ppb range. This had no impact on the proportion of samples exceeding the Bangladesh standard of 50 ppb.

Table A7: Adjustment factors for arsenic field test kits applied to specific districts and field test kit results

District	Field test kit result (ppb)	Percentage falling within laboratory range			
		<=10 ppb	11-50 ppb	51-200 ppb	>200 ppb
Chandpur	0	80	0	0	20
Chandpur	10	43	0	21	36
Gaibandha	0	87	4	9	0
Habiganj	10	89	0	11	0
Jessore	0	63	0	37	0
Jessore	10	75	4	13	8
Madaripur	10	71	18	12	0
Madaripur	100	0	17	83	0
Munshiganj	0	83	17	0	0
Munshiganj	10	71	29	0	0
Munshiganj	25	50	17	33	0
Narayanganj	10	71	29	0	0
Noakhali	0	75	25	0	0
Noakhali	10	71	29	0	0
Sunamganj	50	0	33	67	0
Sylhet	10	95	5	0	0
Sylhet	25	63	0	37	0

Figure A2: **District-wise comparison of proportion of samples exceeding Bangladesh national standard for arsenic (adjusted)**



Annex 2:

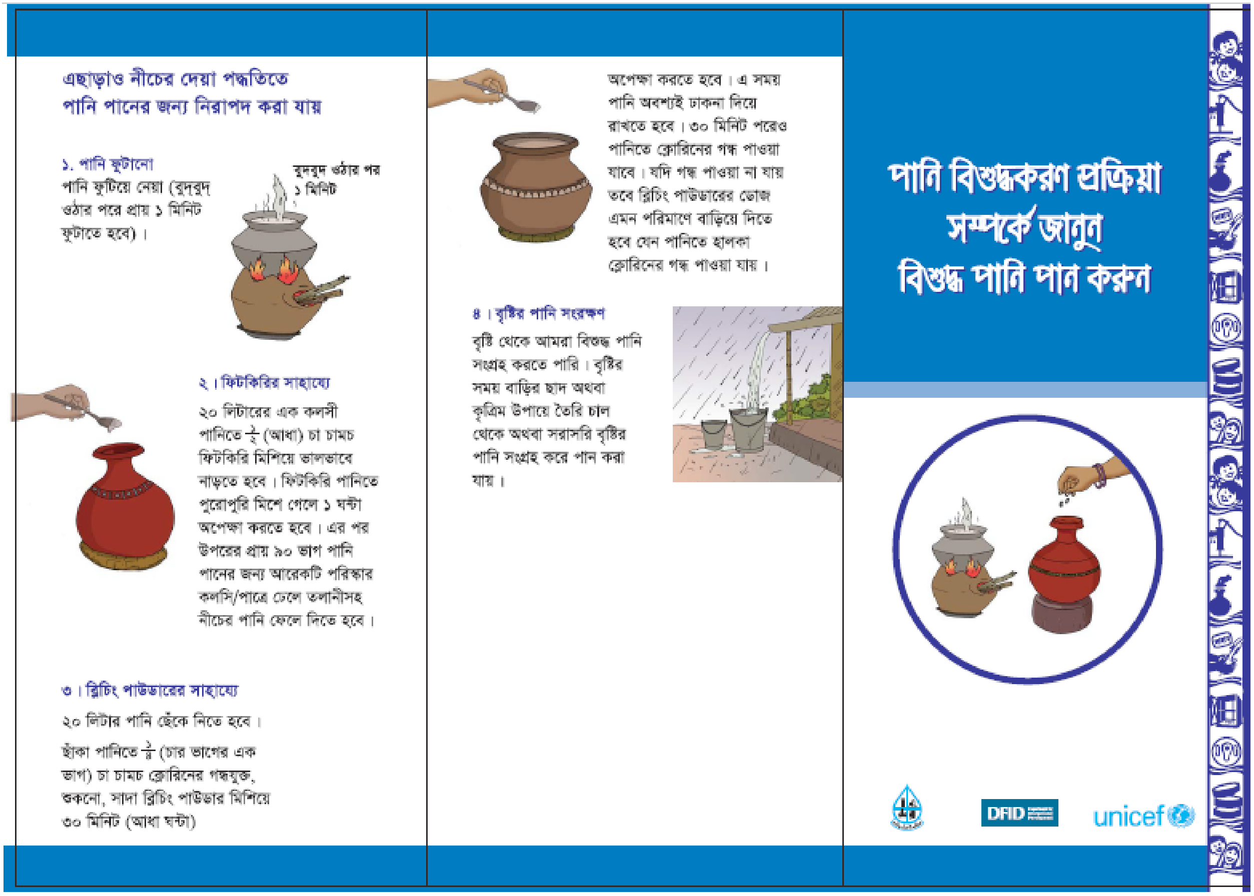
Cost of assessment

Inclusion of water quality testing in Bangladesh MICS 2012-2013 required the procurement of water testing equipment through UNICEF's Supply Division (international) as well as items purchased in Bangladesh (Table A8). The total cost of these items was approximately US$65,000 including freight. On a per test basis the *E. coli* test was $830 for the equipment and US$3.80 per test for the consumables, overall around US$7 per test. The arsenic test was US$50 for 300 tests (<US$0.20 per test). In addition the cost of the assessment included the role of ICDDR,B quality assurance and quality control (US$26,000) and support from an international water quality expert to lead the training of field teams (US$10,000). In total the additional cost of integrating the water quality module in the Bangladesh MICS 2012-2013 was approximately US$100,000.

Table A8: Cost of water testing equipment used in Bangladesh MICS 2012-2013

Item Description	Quantity	Unit	Unit Price USD	Amount USD
International procurement				
Nissui compact dry EC plates	16	Box of 920	1,065.42	17,047
Millipore Microfil funnels and membrane	47	Pack of 150	223.94	10,525
Millipore Microfil 1-place manifold	28	each	818.53	22,919
Econo-Quick Arsenic Test Kit	90	300 tests	48.08	4,327
Sterile disposable 1 mL syringe	70	Box of 100	3.79	266
100 mL syringe for creating a vacuum	50	Box of 25	1.00	50
Isopropyl alcohol swabs	70	Box of 100	2.00	140
Sample bottles (100 ml) for arsenic QA	6000	each	1.00	6,000
Forceps used for transferring filter paper.	50	each	1.00	50
Silicon tubing to connect syringe	5	meters	1.00	5
Cost of Freight	-	-	-	2,000
Procurement in Bangladesh				**63,328**
Incubation bags	35	each	0.95	33
Hand sanitizer	142	250 ml bottle	1.33	189
Trash bags	36	Roll of 30	1.52	55
Clear tape	35	each	1.01	35
Permanent marker	35	each	0.41	14
Water Quality Testing bag	32	each	8.35	267
Labels for arsenic sample bottles	3000	each	0.03	101
E. coli brochures	10000	each	0.06	563
Arsenic brochures	10000	each	0.03	259
Total Amount				**64,845**

Brochure on microbiological water safety



এছাড়াও নীচের দেয়া পদ্ধতিতে
পানি পানের জন্য নিরাপদ করা যায়

১. পানি ফুটানো
পানি ফুটিয়ে নেয়া (বুদবুদ ওঠার পরে প্রায় ১ মিনিট ফুটাতে হবে)।

বুদবুদ ওঠার পর
১ মিনিট

২। ফিটকিরির সাহায্যে
২০ লিটারের এক কলসী পানিতে ½ (আধা) চা চামচ ফিটকিরি মিশিয়ে ভালভাবে নাড়তে হবে। ফিটকিরি পানিতে পুরোপুরি মিশে গেলে ১ ঘন্টা অপেক্ষা করতে হবে। এর পর উপরের প্রায় ৯০ ভাগ পানি পানের জন্য আরেকটি পরিস্কার কলসি/পাত্রে ঢেলে তলানীসহ নীচের পানি ফেলে দিতে হবে।

৩। ব্লিচিং পাউডারের সাহায্যে
২০ লিটার পানি ছেঁকে নিতে হবে।
ছাঁকা পানিতে ¼ (চার ভাগের এক ভাগ) চা চামচ ক্লোরিনের গন্ধযুক্ত, শুকনো, সাদা ব্লিচিং পাউডার মিশিয়ে ৩০ মিনিট (আধা ঘন্টা) অপেক্ষা করতে হবে। এ সময় পানি অবশ্যই ঢাকনা দিয়ে রাখতে হবে। ৩০ মিনিট পরেও পানিতে ক্লোরিনের গন্ধ পাওয়া যাবে। যদি গন্ধ পাওয়া না যায় তবে ব্লিচিং পাউডারের ডোজ এমন পরিমাণে বাড়িয়ে দিতে হবে যেন পানিতে হালকা ক্লোরিনের গন্ধ পাওয়া যায়।

৪। বৃষ্টির পানি সংরক্ষণ
বৃষ্টি থেকে আমরা বিশুদ্ধ পানি সংগ্রহ করতে পারি। বৃষ্টির সময় বাড়ির ছাদ অথবা কৃত্রিম উপায়ে তৈরি চাল থেকে অথবা সরাসরি বৃষ্টির পানি সংগ্রহ করে পান করা যায়।

পানি বিশুদ্ধকরণ প্রক্রিয়া
সম্পর্কে জানুন
বিশুদ্ধ পানি পান করুন

DFID
unicef

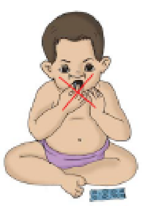
পানি বিশুদ্ধকরণ ট্যাবলেট কি?

যেকোন প্রাকৃতিক দূর্যোগ বা বন্যার পর নিরাপদ পানির সংকট দেখা দেয়। অনেক সময় বন্যার পানিতে নলকূপের পানিও দূষিত হয়ে পড়ে। তখন মানুষ নির্ভরশীল হয়ে পড়ে পুকুর বা নদীর পানির উপর যা কোনভাবেই পানের যোগ্য নয়।

তবে বিশুদ্ধকরণ প্রক্রিয়ার মাধ্যমে দূষিত পানির জীবানু ধ্বংস করে পানের জন্য নিরাপদ করা যায়। এর একটি সহজ পদ্ধতি হল

ক্লোরিন ট্যাবলেট দূষিত পানিতে মিশিয়ে পানি নিরাপদ করা

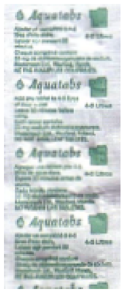
বাজারে বিভিন্ন ক্ষমতাসম্পন্ন ক্লোরিন ট্যাবলেট পাওয়া যায়। কাজেই ব্যবহারের আগেই প্যাকেটের গায়ে লেখা নির্দেশাবলী অনুসরণ করতে হবে বা স্বাস্থ্য কর্মীর পরামর্শ নিতে হবে।



বিঃ দ্রঃ

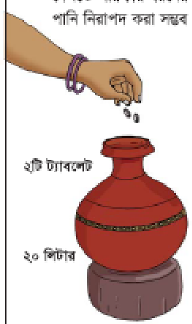
- *এই ট্যাবলেট কোনভাবেই খাওয়া যাবে না।*
- *ট্যাবলেট শিশুদের নাগালের বাইরে রাখতে হবে।*
- *ট্যাবলেটগুলো অবশ্যই শুষ্ক ও আলোবাতাসপূর্ণ স্থানে রাখতে হবে।*

জনস্বাস্থ্য প্রকৌশল অধিদপ্তর কর্তৃক সরবরাহকৃত ক্লোরিন ট্যাবলেট



জনস্বাস্থ্য প্রকৌশল অধিদপ্তর/ইউনিসেফ কর্তৃক সরবরাহকৃত ক্লোরিন ট্যাবলেটের নাম হল একোয়াটেব। এর একটি প্যাকেটে ১০ টি ট্যাবলেট থাকে।

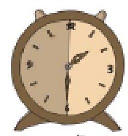
একটি ট্যাবলেটের মাধ্যমে ১০ লিটার দূষিত কিন্তু দেখতে পরিষ্কার ধরনের পানি নিরাপদ করা সম্ভব।



- সাধারণ মাপের একটি কলসী ২০ লিটার পানি ধারন করতে পারে। সেই ক্ষেত্রে এক কলসী পানি নিরাপদ করতে ২টি ট্যাবলেট ব্যবহার করতে হবে।

বিঃদ্রঃ

পানি যদি অপরিষ্কার এবং নোংরা, ঘোলা হয় তবে সেই ক্ষেত্রে ক্লোরিন ট্যাবলেট ব্যবহারের আগে ফিটকিরির মাধ্যমে বা কয়েক পরতা ভাঁজ করা পরিষ্কার সুতির কাপড় দিয়ে ছেঁকে নিতে হবে এবং এধরনের ২০ লিটার পানিতে ৪টি ট্যাবলেট ব্যবহার করতে হবে।



ট্যাবলেট পানিতে দেওয়ার পর আধাঘন্টা (৩০ মিনিট) অপেক্ষা করতে হবে। যদি ক্লোরিনের গন্ধ পাওয়া যায় তবে পানি পান করা যাবে। গন্ধ না পেলে আবারও ১টি ট্যাবলেট পানিতে দিয়ে আধাঘন্টা অপেক্ষা করতে হবে। তারপরও দেখতে হবে পানিতে ক্লোরিনের গন্ধ আছে কি না।

- বালতি অথবা জারিকেন এর ভিতর ট্যাবলেট দিয়েও পানি নিরাপদ করা যাবে। জনস্বাস্থ্য প্রকৌশল অধিদপ্তর ১০ লিটার পানি ধারন ক্ষমতা সম্পন্ন জারিকেন সরবরাহ করছে। সুতরাং এই এক জারিকেনের পানি নিরাপদ করার জন্য ১টি ট্যাবলেট প্রয়োজন।

একই নিয়মে আবারও ট্যাবলেট পানিতে দেওয়ার পর আধাঘন্টা অপেক্ষা করতে হবে। যদি ক্লোরিনের গন্ধ পাওয়া যায় তবে পানি পান করা যাবে। গন্ধ না পেলে আবারও ১টি ট্যাবলেট পানিতে দিয়ে আধাঘন্টা অপেক্ষা করতে হবে। তারপরও দেখতে হবে পানিতে ক্লোরিনের গন্ধ আছে কিনা।

ACKNOWLEDGEMENTS

We express our sincere appreciation to the following people without which this this work would not have been possible.

Rick Johnston, Technical Officer, Joint Monitoring Programme for Water Supply and Sanitation (JMP), World Health Organization, Geneva, Switzerland

Robert Bain, Statistics and Monitoring Specialist (WASH), UNICEF, New York

Boluwaji Onabolu, Water Quality and Water Supply Specialist, WASH Section, UNICEF Bangladesh

Hyrachya Sargsyan, Former Chief, WASH Section, UNICEF Bangladesh

Carlos Acosta, Chief, SPEAR Section, UNICEF Bangladesh

Dara Johnston Chief, WASH Section, UNICEF Bangladesh

Dipankar Roy, Project Director, MSCW Project, Bangladesh Bureau of Statistics

Shantanu Gupta, Statistics and Monitoring Specialist, SPEAR Section, UNICEF Bangladesh

Mashiur Rahman Khan, Statistics and Monitoring Officer, SPEAR Section, UNICEF Bangladesh

unicef

UNICEF Bangladesh
BSL Ofce Complex
1, Minto Road, Dhaka 1000
Bangladesh

Telephone: (880-2) 55668088
Email: infobangladesh@unicef.org

www.unicef.org