Safe Drinking Water in Slums
From Water Coverage to Water Quality

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This article analyses the water, sanitation and hygiene situation in slum households and compares it with the non-slum urban households using data from the 2011 Census. It argues for a shift from the mere water supply coverage to an emphasis on quality water distribution. Intermittent water supply coupled with poor sanitation contributes to higher health risks. Promoting point-of-use water treatment and basic hygiene practices on safe handling and storage of water are important preventive health interventions. This article advocates for a shift from availability of infrastructure to delivery of service-level outcomes.

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The share of urban population to the total population of India has increased from 27.81% in 2001 to 31.16% in 2011. This increase has also been accompanied by rapid growth of slums in cities. The 2011 Census of India reveals that 17.4% of urban households in India live in slums. The ever mounting number of slum-dwellers pose serious challenges to provision of basic urban services. Water availability, its access by urban poor and water quality emerged as key concern for urban planners. Using data from the housing stock amenities and assets in slums, Census of India 2011, the article analyses the water, sanitation and hygiene (WASH) situation in slum households, compares it with the non-slum urban households, and argues that time has come to shift focus from mere water availability to emphasise a set of service-level benchmarks in our water distribution regime. Making safe drinking water available and accessible to the urban poor requires integrated public health action involving individual behavioural change, community action and a different approach by government agencies, whose concerns are only limited to laying pipes for water supply.

The published report on housing stock, amenities and assets in slums Census of India 2011 is the first of this kind in the country. Slums[1] have been divided into three categories[2] such as notified, recognised and identified slums. The new figures show that 13.74 million out of the 78.9 million urban households live in slums. Of this, while 4.96 million households live in the notified slums, 3.79 million live in recognised slums and 4.98 million households live in identified slums in India.

Water in Slums: Surprising Statistics

The 2011 Census household amenities data present a great surprise. The general assumption is that the slum population, being the poorest, lacks basic amenities such as drinking water and latrines. Census data, however, reveals that slum households have better access to tap water than the non-slum populace. Seventy per cent of non-slum urban households have access to tap drinking water whereas in slums this figure is 74%. This means that while almost one quarter of slum households do not have access to piped water supply, the situation in slums, in fact, is better in comparison to non-slum urban households, where 30% households do not receive any tap water. Therefore, piped water reaches a greater number of slum households than their non-slum counterparts.

Notwithstanding this encouraging data on piped water availability and access to slum households, data on piped

water supply reveals great variation. Sources of drinking water have further three parameters, i e, drinking water within the premises, near the premises and away from the premises.[3] If we analyse the census figures, the main source of drinking water within the premises is lower in slums compared to total urban households. In urban India 71% households use tap water, 54% have access to drinking water source within the premises and 16% households walk 100 metres or more to collect water. Whereas 74% of slum households use tap water, only 46% of slums households have access to tap water within the premises and 28% of slum households have to walk 100 metres or more to collect water. Therefore, the connection of tap water at home is higher in non-slum households than in their slum counterparts (Table 1).

Table 1: Households by Main Source of Drinking Water and Location
(in Percentage)

Indicators	Urban	Slum	Non-Slum
Location of source of drinking water Total			
Within the premises	71.22	56.73	74.28
Near the premises	20.74	31.89	18.38
Away from the premises	8.046	11.39	7.34
Households use tap water Total	70.63	74.00	69.92
Within the premises	54.07	45.65	55.85
Near the premises	13.22	23.00	11.16
Away from the premises	3.34	5.35	2.91
Households use well (covered and uncovered) Total	6.15	3.02	6.81
Within the premises	4.35	1.47	4.95
Near the premises	1.11	0.84	1.17
Away from the premises	0.70	0.71	0.69
Households use handpump Total	11.86	12.67	11.69
Within the premises	6.55	5.51	6.77
Near the premises	3.49	4.63	3.25
Away from the premises	1.82	2.53	1.67
Households use tube well/borewell Total	8.90	7.64	9.16
Within the premises	6.25	4.10	6.11
Near the premises	6.25	2.20	1.60
Away from the premises	1.71	1.34	0.85

Source: Census of India, 2011.

In addition to the access to tap water, in urban areas 6.2% households depend on wells, 11.9% use handpumps, and 8.9% use tube/bore wells. Similarly 3% slum households depend on wells, 12.7% on handpump, and 7.6% on tube/bore wells for drinking water. There is no disaggregated data on access to water supply in the three categories of slums – notified, recognised and identified. Experience says slums, or scattered settlements, which are not recognised by urban local bodies (ULBs), do not have the required piped water connection. Further, there is no data on seasonal variation of water supply services, but it is noted that urban areas consistently underperform in summer.

A Distant Dream: Piped Water at Home in Slums

Some existing policies impede universal coverage of safe drinking water supply in slums. One of the major reasons for the absence of tap water within the premises of the house in slums is due to insistence on providing valid ownership certificates by the departments responsible for drinking water supply in urban areas. Since many slums are still not recognised by the governments, the slum households' application for piped water connection is rejected by the department.

Box 1: The Odisha Experience

Water supply in urban Odisha is regulated by Odisha Water Works Rules 1980. The Government of Odisha amended the Odisha Water Works Rules and launched a programme called "PIYUSH", meaning nectar, in 2010 with the objective of providing universal access to safe drinking water in urban areas. The Odisha Water Works (Urban Local Bodies) Amendment Rules, 2009 simplified the water connection and introduced the connection fee (domestic) on instalment basis to both above poverty line (APL) and below poverty line (BPL) households. Household water connection fees for BPL consumers under the new pro-poor state scheme "PIYUSH" is Rs 500 that can be paid either one-time or in five interest-free equal monthly instalments of Rs 100 each.

However, the existing procedure for new house connections requires extensive documentation, i e, up-to-date copy of holding tax or property tax payment receipt, copy of record of right over the land, site plan showing location of building vis-à-vis the existing road and line diagram of the building showing the plumbing fixtures, etc. All to be submitted by house owner along with the application for domestic water connection (Government of Odisha 2010). This restricts the Public Health Engineering Organisation to provide household connections not only to people staying in unauthorised slums but also those households staying in authorised slums without record of rights. Therefore, slum households depend more on public stand posts.

From Access to Quality: Service-Level Benchmarking

Better access to tap water in slums compared to urban households as per Census 2011 may not be taken as better service delivery for urban poor. There is a need for a shift from availability of infrastructure to delivery of service outcomes. In this context, service-level benchmarking (SLB) for the urban water supply, waste water, solid waste management and storm water drainage have been formulated in 2009 and launched by Ministry of Urban Development (MoUD), Government of India. Further the 13th Finance Commission has endorsed the principle of benchmarking and has included SLB as one of the conditions for allocation of performance-based grants to ULBs, which amounts to approximately Rs 8,000 crores over the period 2010-15. Benchmarking for the urban water and sanitation sector is well-recognised as an important mechanism for performance management and accountability in service delivery. It involves the measuring and monitoring of service provider performance on a systematic and continuous basis, resulting in better service delivery to people. The nine performance indicators of water supply include coverage, per capita supply, continuity of water supply, quality of water supply, efficiency in redressal of customer complaints, etc (GoI 2010). Public health demands the continuity and quality of water supply than mere coverage.

As per the SLB, the coverage of water supply connection is measured by the total number of households in the service area that are connected to the water supply network with direct service connections. Thus the indicator, "coverage of water supply connection" includes only direct tap water connections and water supplied through tankers, public stand posts, bore wells and open wells are not included. Census 2011 housing stock, amenities and assets data talks of tap water which includes both direct tap water connection and water supplied through public stand posts. The MoUD has completed a pilot

study of SLB in 28 cities of 14 states and one union territory, viz, Andhra Pradesh, Kerala, Tamil Nadu, Karnataka, Maharashtra, Gujarat, Madhya Pradesh, Chhattisgarh, Odisha, Jharkhand, Manipur, Punjab, Himachal Pradesh and New Delhi. The national benchmark of access to water is 135 litres per capita per day (lpcd). The average consumption of piloted cities is 126.41 lpcd. Of the 28 cities, 18 have an overall consumption of less than 135 lpcd. Of which, five cities consume less than 85 lpcd. Bokaro consumes 298 lpcd, whereas Chas consumes 37 lpcd (GoI 2010). In slum areas the consumption in terms of lpcd is considerably lower as more number of households depend on stand posts and water supply for both slum and non-slum households is intermittent.

Intermittent to Continuous: Ensuring Water Quality

Access to safe water depends not simply on the supply of treated water, the SLB also emphasises continuity of supply. Continuous water supply plays a vital role in ensuring water quality. Intermittent water supply aids degradation of the quality of water because it results in low supply pressure and as a consequence, there is the risk of in-pipe recontamination. The risk of exposure to contaminated water is almost non-existent in continuous water supply, thereby reducing the risk of waterborne diseases. Census 2011 declared 62% households in urban areas use water from treated sources and the figure is 65.3% in case of slums. It does not mention about the continuity of the water supply services. Continuity of water supply as per the national benchmark is 24 hours (hrs), popularly known as 24×7 water supply system, which is supposed to supply water to consumers 24 hrs a day everyday of the year through a transmission and distribution system that is continuously full and under positive pressure. In developing country like India water supply is mostly intermittent.

The average duration of water supply in 18 pilot cities is 3.3 hrs, per day. Only two cities provide more than 12 hrs a day. Thiruvananthapuram has the highest duration of water supply per day at 18 hrs followed by Chandigarh 17.5 hrs. The duration of water supply in cities like Bhopal is 0.5 hr, Indore is 0.75 hr, Hyderabad is 0.3 to 2 hrs, Guntur is 1 hr, Shimla is 1.5 hrs, Bangalore is 3 hrs, Bhubaneswar is 2 hrs, Barhampur is 1 hr, Bokaro is 1.3 hrs, Delhi is 3 hrs, and Raipur is 1.5 hrs (GoI 2010). The data above shows that all the cities have intermittent water supply, the range of hours of supply is from less than an hour to 18 hours per day. Currently none of the cities in India have 24 hour water supply as prescribed by the benchmark.

In the intermittent water supply system, during non-supply hours the pressure in the pipes drops, pipes empty and water that had been leaking out of the faulty joints or holes can be sucked back in. This water could be polluted by waste water seeping from toilets, septic tanks, domestic drains, etc. Continuous water supply systems reduce contamination levels as the pipes are under positive pressure and entry of contaminations into pipes is restricted.

Moreover, the monitoring of water quality in Indian cities is haphazard, while municipal board, public health engineering organisations, public health directorate of health and family welfare department claim to conduct regular tests of supply water, but the key findings are generally not made public. Standards for drinking water that are actually enforced could have enormous positive impact on public health. But for this to occur, the procedures for water testing and data sharing have to be made regular, standard and public (McKenzie and Ray 2009).

Access to Household Latrine

As discussed, water quality is directly affected in an intermittent water supply system with widespread open defecation. In India 18.6% of urban households do not have latrine facility within the premises, in slums it is 34% (Table 2). Households have no latrine within the premises, and therefore either use public latrines or defecate in the open. Open defecation may be much more than the statistics on access to latrine facilities. The use of such facilities by each member of a household is quite questionable. Usually in urban areas household toilets are four-flush, single pit or connected with septic tanks as only a few cities have integrated sewerage lines. Considering the percentage of population that defecates in the open, slum populations are widely exposed to faecally-transmitted infections (FTIs). Children, pregnant women are more vulnerable to FTIs. The risk factor for FTI infection is due to inadequate water supply and sanitation infrastructure, lack of water linked to inadequate hygiene, poor personal and environmental hygiene and faecal-oral pathogen loads in the environment. World Health Organisation (WHO) guideline for drinking water quality 2011 suggests that, "The potential health consequences of microbial contamination are such that its control must always be of paramount importance and must never be compromised." Microbial contamination is not related only to faecal contamination. Some organisms like legionella grow in piped water distribution systems, others like guinea worm in source waters, etc.

Table 2: Households by Availability of Type of Latrine Facility, Census 2011
(in percentage)

India	Urban	Slum	Non-Slum
Households having latrine facility within the premises	81.36	66.01	84.60
Households using public latrine	6.00	15.09	4.10
Households defecating in the open	12.63	18.90	11.30

Chart 1: Percentage of Households That Defecate in the Open

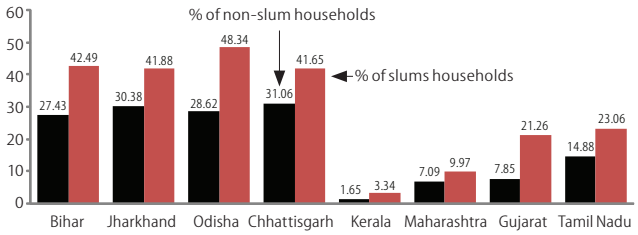


Chart 1 compares the households' open defecation in non-slum and slums between most-urbanised and least-urbanised states as per Census 2011. There seems to be an inverse relationship between level of urbanisation and open defecation in states of India. The states with low levels of urbanisation

have higher levels of open defecation. For example, highly urbanised states such as Kerala, Maharashtra, Tamil Nadu and Gujarat have low levels of open defecation. This difference can be attributed to haphazard, rather than planned urbanisation in least-urbanised states. More-urbanised states have focused their attention on developing sanitation infrastructure. People have also developed a culture of shanties by installing individual toilets at their premises. Further there is a sharp difference between non-slum and slum households both in most-urbanised and least-urbanised states so far as open defecation is concerned. In Odisha, for example, 28.62% of the non-slum populace defecates in the open, while the corresponding figure in slum almost touches 50%. Odisha is the worst-performing state with 48.34% of slum households defecating in the open, followed by Bihar (42.49%), Chhattisgarh (41.68%) and Jharkhand (41.88%).

High urban population growth in least-urbanised states would be a serious concern of state government and ULBs for provision of basic services. An integrated and planned water, sanitation and environmental public health intervention is needed in the least-urbanised state with high urban growth potential.

Improper Sanitation and Water Contamination

Water-related diseases are caused by intermittent water supply systems coupled with poor sanitation and hygiene practices. Inconvenient supply hours in an intermittent water supply system in India affect the poor the most. Large storage facilities are required to address daily requirements; it is difficult for slum-dwellers to store more water to meet their requirements. It results in poor sanitation and hygiene practices leading to increase in health risks and mortality. Moreover, household storage may lead to an increase in the risk of contamination during such storage and associated handling. Hygiene practices include hand washing at critical times – after defecation, before eating and while handling food – proper storage of water and its handling and other personal and environmental hygiene. People in some slums have knowledge of and realise the need for proper hand washing at critical times, cleaning face, feet, brushing teeth, rinsing mouth after eating food, etc, but they cannot adopt these practices because there is no facility to drain out the minimum water required for these practices at the household level. Adoption of these practices will result in water logging and hence hygiene practices are avoided by them.

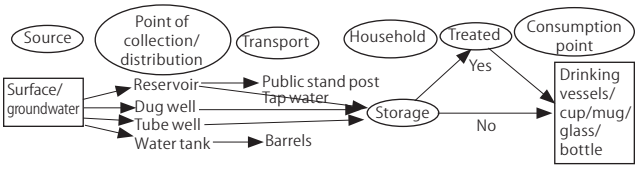
Principally, diarrhoeal diseases are the outcome of unsafe WASH. An estimated 94% of the diarrhoeal burden of diseases is attributable to the environment and associated with risk factors such as unsafe drinking water, lack of sanitation and poor hygiene (Pruss-Ustun and Corvalan 2006). Diarrhoea remains the second leading cause of death among children under five years globally. Nearly one in five child deaths – about 1.5 million each year – are due to diarrhoea. It kills more than AIDS, malaria and measles combined (UNICEF/WHO 2009).

Causes of death since January 1992 were recorded in 1995 in all the anganwadi centres in urban Lucknow. Beyond neonatal period; pneumonia (23.4%), diarrhoeal disease (20.9%), malnutrition and anaemia (11.4%) were the major causes of death and disease burden (Awasthi and Agarwal 2003). Esrey's (1996) study suggests that for the high faecal-oral pathogen exposure group, a mean reduction in diarrhoea of 37.5% is possible following the introduction of improved water supply and sanitation in a developing country environment. Further, water, sanitation and unhygienic conditions are also important determinants in a number of additional diseases like schistosomiasis, trachoma, hookworm, malaria, yellow fever, filariasis, dengue, hepatitis A, hepatitis E, typhoid, etc. Infants and young children, the elderly, pregnant women and people living in unsanitary conditions like slums are the most vulnerable.

Multiple Contamination Possibilities and Remedies

The potential contamination pathway of drinking water from water source to the consumption point includes at the main water source, the point of collection or distribution, during transportation, storage point at the household and at the consumption point such as drinking vessels, cup, glass, mug, bottle, etc. Figure 1 shows the quality of water at all stages of potential contamination pathway from the source of water to the consumption point.

Figure 1: Potential Contamination Pathway from the Source to Consumption Point



Source: Adapted from Rufener et al (2010).

Faecal contamination is usually low at the water source but increasingly deteriorates throughout storage, handling and treatment within the household. For securing the microbial safety drinking water the supply of water is based on the use of multiple barriers from the source to the consumer. Safety will be amplified by putting multiple barriers in place, it includes the protection of water resources, proper selection and operation of a series of treatment steps, management of distribution systems, maintenance and protection of treated water quality, and home-based management and treatment of drinking water at household level and practice of hygiene by the consumer.

In-household Contamination and Its Prevention

In-house contamination of drinking water is a constant problem in developing countries like India. Dependence of households on public stand posts, tube well, without access to running tap water at home, a major cause of contamination at the point of use is bacteriological. Contamination happens in different stages due to improper handling of water from collection point to user point. Most slum households collect water and consume it without treatment. The treatment of water is found to be occasional and for specific targeted members of the household. Usually water is boiled to feed babies and for patient

with diarrhoea, beyond these occasions water is mostly not treated before use. The point-of-use approach towards safe drinking water is a preventive health intervention that requires individuals, especially vulnerable populations living in slums to use water treatment methods at household level – correctly and consistently – for safe water.

Promotion of hand washing with soap at critical times – before eating, after defecating and before handling food – improved sanitation and point of use water treatment are three most effective interventions to reduce diarrhoea. A meta analysis (Waddington et al 2009) have shown that hand washing with soap can reduce the incidence of diarrhoea in children under five years by 37%, improved sanitation 34% and point-of-use water treatment 29%. A seven-point plan for comprehensive diarrhoea control was suggested jointly by United Nations Children's Fund (UNICEF) and WHO to focus on both treatment and preventive packages. Five elements of preventive packages include promotion of hand washing with soap, improved water supply quantity and quality, including treatment and safe storage of household water and community-wise sanitation promotion (UNICEF/WHO 2009).

Point-of-Use Water Disinfection Training

The experience of Health of the Urban Poor Programme in four cities of India – Delhi, Bhubaneswar, Jaipur and Pune – on point-of-use water disinfection training programme witnessed the fact that bacteriological contamination of water at point-of-use is quite higher than the water sample collected at point of source in slums of respective cities. Health of the Urban Poor organised training programmes on points of use water disinfection for its partner non-governmental organisations (NGOs) in 2011. Water sample collection, water testing, and sharing of the water test result with the community was one of the key strategies under the promotion of point-of-use water disinfection methods.

Methods of Sample Collection

Hydrogen sulphide (H2S) tests strip was used for assessing water quality. As per the design of the programme, two water samples – one from the drinking water source and one from the point of storage at household (point-of-use) – were collected from every 10th sample households of the selected slum location in H2S vials. Thus in each slum location of four cities, around 40 samples each – 20 from source and 20 from point of use water storage – were collected.[4] The sample water collected from point of use was water stored by members of households in containers like bottles, buckets, pitchers, etc. Water collected in H2S vials incubated for 24 hours at room temperature (25 to 35 degree centigrade) and were checked for the presence/absence of colour change. The test was considered positive if the colour changed from clear to black (HUP-PFI 2012).

Water Test Results

Thus water contamination is reported from source as well as user point. Table 3 describes the level of contamination in the sample water collected from source and at point of use by households (ibid).

Table 3: Summarised Water Testing Results of Four Cities

Reported Contamination (% of sample collected)	Delhi	Jaipur	Bhubaneswar	Pune
At source	45	40	43	11
At point-of-use	65	55	65	42

In Delhi 45% of water samples collected from source were contaminated and at point-of-use the contamination was higher with 65%, while in Pune 11% of water samples were contaminated at source and 42% at point-of-use. The mean calculation of water contamination in above mentioned four cities is 35%, whereas the contamination at point of use is 57%. On an average the water contamination at point of use was higher by 22% compared to source contamination. The result shows that despite several protection methods, the source can also be contaminated for various reasons. The result also indicated that even if the water is safe at the source, the possibility of it being contaminated by the time it reaches the intended user is quite high.

A model of water treatment, safe storage and safe handling intervention at point of use can be adopted to improve microbial water quality to significantly reduce diarrhoea, and may be an effective public health intervention. WHO and UNICEF have announced a seven-point strategy for the treatment and prevention of diarrhoea among children that highlights the importance of household water treatment and safe storage as a preventive intervention (UNICEF/WHO 2009).

Point-of-Use Water Treatment Methods

The point-of-use water treatment methods include filtration, chemical disinfection, boiling and solar disinfection (SODIS). For filtration there are different types of household filters which remove a high proportion of solids and silts. Most household filter technologies operate by gravity flow or by water pressure provided from piped supply. Some filters used for ultra-filtration, nano-filtration and reverse osmosis filtration by households require electricity. Chemical disinfection includes chlorine-based technology. Mostly disinfection of drinking water in developing countries is done primarily with free chlorine, either in liquid or dry form. Boiling is a simple way whereby water is heated until it comes to a "rolling boil", which means large bubbles continuously coming to the surface of the water which is maintained for one minute. In the SODIS method, water is collected in clear plastic bottles with half a side coated in black colour. The bottle is exposed to solar radiation for six to eight hours. A combination of these methods may also be used for increasing the efficacy of the treatment.

Although home-based water treatment improved the quality of water immediately, the quality frequently worsened in the cups used for drinking, thereby causing a recontamination just before drinking (Rufener et al 2010). In this context it is important to practise hygiene while handling water at each point of potential contamination. Hygiene practices include cleaning the container used for transportation from water collection point to household storage, cleaning of drinking vessels such as cups, glasses and mugs before it is consumed,

always handling water with clean hands. Point of use water treatment along with safe storage and proper handling of water minimise the contamination at the household.

A Shift from 'Silo' Approaches

Conventionally, public health interventions have been implemented as vertical programmes. Each programme follows a "silo" approach, with separate planning, funding, staffing, programme monitoring, supervision, reporting, etc. This silo approach may help in achieving the specific programme's objectives but does not necessarily bring a change in the quality of public health, especially in the case of marginalised people staying in slums and slum-like conditions. There is a need for a shift from a silo approach in public health interventions to one that is integrated, coordinated, and convergent in action. There is a lot of evidence of integrated programme interventions for public health across the globe. One such example is in Malawi, which combined the provision of hygiene kits with antenatal care and resulted in a nearly 30-fold increase in household water treatment practices three years after the intervention. It also achieved a 15% increase in health facility deliveries and post-natal check-ups (WHO and UNICEF 2013).

It is more appropriate in urban areas considering the complexity of provisioning water supply, sanitation and public health services by multiple agencies, viz, government departments, ULBs, corporations, etc. An integrated approach will create a positive environment for change, save costs, save effort and will lead to savings on healthcare. The effort should not only involve WASH sector but also promote linkages with associated sectors like health and nutrition. The same principles apply to the health sector, which need to give equal importance to preventive healthcare interventions like access to safe water, proper sanitation and promotion of safe hygiene practices. For such an integrated approach it is important to understand the situation, context, risks, and to formulate a realistic convergent action plan. Integrated public health action for ensuring quality services and its impact can involve "integrated convergent bottom up action plan[s]", "integrated logistics", "integrated service delivery", "integrated capacity building programmes", "integrated behavioural communication programmes", and "integrated programme review and supervision".

NOTES

1 For the purpose of Census of India, slums have been defined as residential areas where dwellings are unfit for human habitation by reasons of dilapidation, overcrowding, faulty arrangements and design of such buildings, narrowness or faulty arrangement of street, lack of ventilation, light, or sanitation facilities or any combination of these factors which are detrimental to safety and health.

2 A notified slum is an area in a town or city notified as "slum" by state, union territory (UT) administration or local government under any Act including a "Slum Act". Recognised slums are all areas recognised as "slum" by state, UT Administration or local government, housing and slum boards, which may have not been formally notified as slum under any Act. An identified slum is a compact area of a population of at least 300 or about 60-70 households of poorly built congested tenements, in unhygienic environment usually with inadequate infrastructure and lacking in proper sanitary and drinking water facilities.

3 Within the premises refers to the source located within the premises, where households live; near the premises is within a range of 100 metres from the premises in urban areas; and away from premises is the water source was located beyond 100 metres from the premises in urban areas.

4 Water samples collected from sources were tube/bore wells, public stand posts, house tap collection and in some cases water collected from bore wells and stored at overhead tanks and supplied to households through piped connections.

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