Rural Water Supply and Sanitation Project in Western Nepal Phase II

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Tube well scheme functionality

Learning outcomes of RWSSP-WN II

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INTRODUCTION

Groundwater is the main source of drinking water in the Terai region of Nepal. Groundwater can be harvested using several technologies of which tube well is the most used. Over 90% of the Terai population use groundwater for drinking, cooking, household, and irrigation.[1] Between 2013 and 2018, RWSSP-WN II has supported the construction of 23 tube well schemes that serve in total 22,659 beneficiaries. All tube wells supported by RWSSP-WN II are public which means that several households fetch water in the same well.

Tube well scheme is a simple system. The water is typically extracted through steel and polyvinyl chloride pipeline that has a strainer and a sand trap on the bottom[2]. Hand pumps are most commonly used to extract water but it is not uncommon that a electrical pump is attached to the well temporarily for irrigation purposes. The pipeline is surrounded by concrete platform to control drainage and to protect the groundwater reservoir from surface water contamination.

Tube wells are usually divided into shallow and deep wells. Shallow wells are dug in the uppermost soil layer whereas deep wells are drilled below and impervious stratum.[2] Deep wells are generally considered safer than shallow wells as they leave less chance for bacteriological contamination. As per general understanding in Nepal, water of deep tube wells is less likely to suffer from arsenic contamination than water of shallow tube wells but late studies of RWSSP-WN II do not support this argument.

Even though tube well schemes are simple systems, their functionality is not as easy to ensure as one might think.

In recent field studies of RWSSP-WN II, several Phase II tube well schemes were found suffering from functionality challenges.

RWSSP-WN II is committed to serve the unserved which means that the Project supports people that do not yet have access to improved water supply. Most Terai inhabitants do already have an access to shallow tube wells but these are usually considered unimproved due to the risk of bacteriological and arsenic contamination.

This Brief presents findings of recent studies considering various functionality aspects of tube well schemes. The study findings question some of the general assumptions that have guided tube well construction in the Project.

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TUBEWELL SCHEME CONSTRUCTION

Tube well scheme construction differs from gravity scheme construction fundamentally. The basis for gravity scheme planning is either a spring or a stream water source of adequate water quantity, quality and reliability for the target population. In case of tube well schemes, the water is hidden underground which means there is no guarantee of any of these parameters before the scheme has actually been constructed.

The scheme construction is done manually by skilled manpower. A hole is dug to a required depth with the help of an iron pipe after which pieces of polyvinyl chloride pipeline (20 feet each) are installed to the well depth. The bottom piece has a 2 meters long strainer and a sand trap and water can enter the system only from the bottom of the well. On top of the well, a piece of iron pipe is installed to which the hand pump is attached. A lot of water is used in the drilling and instalment process and it is only after cleaning the well with diverse-pressure-water that one can tell about the water quality let alone if the well delivers any water at all (Figure 1).

Figure 1. Well construction is based on manual work and skilled labor.

It is common that no water is found on the depth that the well was designed for. In RWSSP-WN II, each tube well scheme has 20 % of the total scheme cost reserved for failures in well construction. There have been situations where even this is not enough but the users are put in a difficult situation when many wells turn up dry—this is because the skilled manpower must still be paid, no matter if the well delivers water or not. Seasonal drying of the well does not seem to be a common phenomenon but can occur as well.

Another factor of uncertainty is the water quality. It is common that during the first days, all tube wells deliver turbulent water mixed with sand and silt. It is advisable to use electrical pump to pump water continuously for a couple of first days until the water turns clear. Sometimes the water is found turbulent even after continuous pumping. This tells about silty soil conditions in the depth where the well intake is located (Figure 2).

As the examples show, tube well construction has uncertainties. In case no water or water of inadequate quality is found there is no other option than trying a new location and a new depth. The experience has shown that in Terai, there is a considerable spatial variation in soil condition.

Figure 2. The well water is usually found turbulent within the first days.

TUBEWELL SCHEME MAINTENANCE

Once tube well schemes are successfully installed, there is not much maintenance to do. Still, during our recent study in Rupandehi district, several tubewell schemes were found unfunctional due to the difficulty of lifting water. The reason was mostly found to be warn out valves. Handpump functionality is based on suction that is created when a piston moves up and down the pump cylinder. Two rubber check-valves are needed, one in the piston and one on the base plate to control water flow into the cylinder and out the spout. Check-valves are easily available in the local market. The scheme users just need to be aware of the issue and know how to change them (Figure 3).

Figure 3. Left: Rubber check-valve of the piston. When the piston moves down, the valve opens and when up, the valve closes. Above right: New rubber valve that covers the base plate airtight. Below right: Worn-out rubber valve

Another issue that the scheme users must take care of is proper drainage of water. It is normal that when pumping, a lot of excess water flows to the platform. Often the platforms are also used for dishwashing, laundry and bathing that all produce waste water. It is important to make sure that the drainage water is safely directed to the environment. If the water stays in the platform or creates ponds nearby, it rapidly leads to unhygienic conditions and potential breeding ground for mosquitos and other insects (Figure 4).

Figure 4. Inadequate drainage design has led to flooding next by the platform. The drainage water makes the surrounding soil wet and muddy and attracts mosquitos.

ARSENIC CONTAMINATION

Arsenic (As) is a natural element, that is found in the earth's crust. Arsenic is odorless and tasteless in its elemental form. Arsenic can be toxic to humans in various forms, arsenite and arsenate being the most prevalent forms found in drinking water.[3] When groundwater moves through subsurface soil, it dissolves substances. Arsenic mobilization from soil to water depends on various conditions including pH, redox potential, adsorption, organic matter and sulfidic waters. The occurrence of the different forms of arsenic depends on the aerobic and anerobic conditions: arsenite is normally present in anaerobic conditions while arsenate is present in aerobic conditions. Arsenate is more prevalent in acidic conditions and arsenite in alkaline conditions. Still, it is possible to find both states in the same groundwater sample.[5] The World Health Organization standard for maximum arsenic level in drinking water is 10µg/l[5] whereas the Nepali standard is 50 µg/l[6].

In people, arsenic accumulates in tissues, organs, hair and nails and will gradually build up to toxic levels. The first visible symptoms are seen in the skin: dark spots on the hands, feet, neck and chest. Arsenic is believed to cause several types of cancer of the internal organs. The risk of arsenic contamination is high because the contaminated water is used for cooking, drinking and irrigation which exposes people to large volumes of arsenic in long-term[3].

In Nepal, arsenic is mostly found in Terai in the southern districts of the country. Geologically, the area is characterized by alluvial deposits.[3] Older sediments are buried by younger materials, forming a thick pile of sediments. The large volume of river flux and the basin configuration have created a variety of morphologies.[7] Large-scale arsenic blanket tests by multiple stakeholders have been conducted in the area piling up to 737,009 test results in 25 districts. As per the results, 10.2 % of the samples exceeded 10µg/l and 2.6 % exceeded 50 µg/l[5] but the spatial variation is high. There is a common belief in the sector that shallow wells are more likely to be contaminated with arsenic than deep wells but there is no consensus on this. The definition of deep wells also varies in different studies. In RWSSP-WN II, wells below 100 feet are usually considered deep and wells above 100 feet shallow. One challenge in the arsenic blanket tests is that the number of deep wells is much less than shallow ones which makes the sample biased—less deep wells give also less arsenic-contaminated result.

Arsenic is a problem also in RWSSP-WN II supported tube well schemes. The Project tests arsenic using digital Wagtech Arsenator field kit that gives results from 2µg/l to 100+ µg/l (Figure 5) . Based on arsenic tests conducted in Nawalparasi and Rupandehi districts in 2017 and 2018 it was found that arsenic is found both in schemes over 100 feet and under 100 feet. In total, 41 % of the 158 tested schemes exceeded the WHO arsenic standard and 16 % exceeded the Nepali standard .

Figure 6 shows the depth of the 65 tested wells that have arsenic exceeding the WHO standard. As seen in the figure, both shallow wells and deep wells were found contaminated and also heavily contaminated (100+ µg/l). Based on the test results, well depth seems not to guarantee water safety. In total, 35 % of the 133 over 100 feet deep wells tested were found contaminated with arsenic.

Figure 5. Yellow color indicates arsenic contamination.

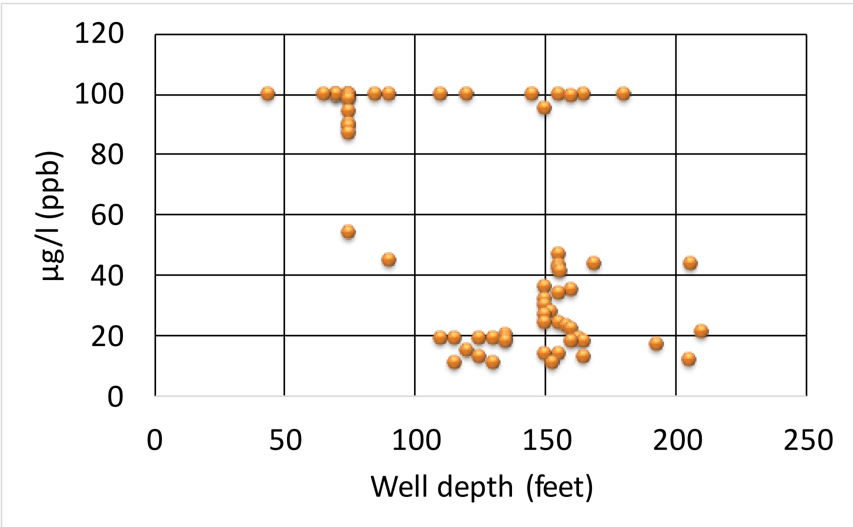

Figure 6. Depth of wells with arsenic contamination >= 10µg/l (N=65). The figure shows that both shallow and deep wells were

Arsenic is spread unevenly in soil and some areas in Nepal are especially under risk. Sarawal municipality in Nawalparasi district is one of them. In Spring 2018, RWSSP-WN II supported the construction of 27 new tubewells in Sarawal. Due to high arsenic levels found in deep wells, people were willing to dig shallow wells as some shallow wells had been found clean in the area.

This is why, only 9 of the new wells were drilled to over 100 feet depth and 18 were dug shallow. In arsenic tests conducted in spring 2018, all the 18 new shallow wells were found heavily contaminated. Out of the 9 deep wells, only two were found safe and 7 heavily contaminated ≥ 95 µg/l (Figure 7).

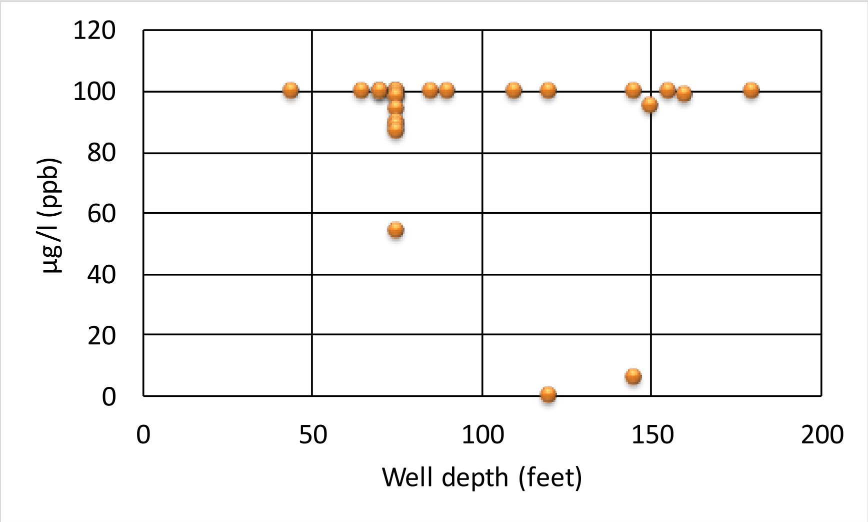

Figure 7. Only two of the 27 new tube wells in Sarawal municipality were found under =< 10µg/l while the rest were found heavily contaminated with arsenic. The result shows that deep tube wells are not a solution in these heavily contaminated hardship areas.

In an arsenic prone area such as Sarawal, a sustainable option would be a centralized overhead tank based water supply system using a deep tube well as a source. The water quality parameters of one deep well would be easily monitored compared to thousands of tube wells. The challenge is the unwillingness to pay water tariff once hand-pump schemes give unlimited access to free water. Electrical overhead tank schemes require monthly electricity fee payment whereas solar pumping is not feasible in Terai due to foggy winter climate.

BACTEROLOGICAL CONTAMINATION

Bacteriological contamination occurs usually when constructing new tube wells. This is partly due to the use of surface water but also cow dung during the drilling. If the platform is properly constructed and the well is far from risk factors such as toilet pits, tube wells seldom suffer from bacteriological contamination in long-term.

IRON AND MANGANESE

Iron and manganese are some of the most abundant metals in the earth's crust[8,9]. The soils of Terai contain a large amount of iron oxides, which result in iron contamination in the groundwater.[3] Taste of iron as well as stains in laundry and hardware can be noticed with concentrations above 0.3 mg/litre[7] (Figure 8). As per the Nepal national drinking water standards, the limit for iron is 0.3 mg/l[6]. Iron also promotes bacterial growth that might result in slimy coating in the piping.[8]

Manganese is usually occurring with iron. In concentrations higher than 0.05 mg/l, manganese may become noticeable by impairing color, odor, or taste to the water.[9] For manganese, the recommended concentration limit in Nepal is 0.2 mg/l[6]. Normally people’s manganese intake from drinking-water is substantially lower than its intake from food.[9] In normal conditions, despite of discoloration, odor and taste, health effects of both iron and manganese are not a concern until notably high concentrations.[8,9]

Figure 8. Iron in the groundwater has discolored the tube well platform.

CONCLUSIONS AND THE WAY FORWARD

In the tube well functionality study conducted by RWSSP-WN II in 2017—2018, overall functionality of 158 tube well schemes was monitored in Nawalparasi and Rupandehi districts. 25 % of the schemes were found unfunctional either due to poor water quality, unfunctional pump or poor drainage. In 20 % of the schemes, water quality was sub-standard due to high arsenic concentrations (>=50µg/l) in 26 (16 %) schemes and turbulent water in 6 (4 %) schemes. Pump was not fully functional in 5 schemes (3 %). It was anticipated that the difficulties in pumping water were mostly due to worn out or displaced washers. In two wells the drainage was found insufficient. The examples show that there are many issues that can influence the well functionality and service level and finally, whether the scheme will serve the beneficiaries.

Especially in hardship locations such as Sarawal, Nawalparasi, a sustainable solution would be to connect households to an overhead tank. In a centralized water supply system, the quality of water is easier to treat and monitor to ensure high quality drinking water. One functional system would also stop the uncertainty of tube well drilling—one never knows if water of good quality is found or not. The challenge is the unwillingness to pay water tariff needed to run an overhead tank scheme. Based on the field observations, people are aware and concerned about water quality but still lack motivation to connect to a centralized system. Behaviour change takes time but is needed to ensure safe water also in the hardship locations.

REFERENCES

[1] *Sadhana Pradhanang Kayastha (2015) Arsenic Contamination in the Deep and Shallow Groundwater of Bara District, Nepal. Crossing the Border: International Journal of Interdisciplinary Studies Volume 3; Number 1; 15 January 2015. Available: https://www.nepjol.info/index.php/CTBIJIS/article/view/14091*

[2] *Prasad D. (2014) Subjective Guide For Civil Engineers (2014). Innovative Education Point Pvt. Ltd.*

[3] *Halsey P. (2000) Arsenic Contamination Study of Drinking Water in Nepal. Master of Engineering in Civil and Environmental Engineering at the Massachusetts Institute of Technology. Available: http://web.mit.edu/watsan/Docs/Student%20Theses/Nepal/Halsey2000.pdf*

[4] *Pradhan B. Arsenic contaminated drinking water and nutrition status of the rural communities in Bagahi village, Rautahat district, Nepal. Available: https://www.nepjol.info/index.php/JIOM/article/view/599*

[5] *Thakur J.K et al. (2011) Arsenic Contamination of Groundwater in Nepal—An Overview. Available: www.mdpi.com/2073-4441/3/1/1/pdf*

[6] *Government of Nepal Ministry of Physical Planning and Works (2005) National Drinking Water Quality Standards. Available: http://mowss.gov.np/assets/uploads/files/NDWQS_2005_Nepal.pdf*

[7] *Gurung K. et al. Geological and geochemical examination of arsenic contamination in groundwater in the Holocene Terai Basin, Nepal*

[8] *WHO (2003) Iron in Drinking-water. Available: http://www.who.int/water_sanitation_health/dwq/chemicals/iron.pdf*

[9] *WHO (2011) Manganese in Drinking-water. Available: http://www.who.int/water_sanitation_health/dwq/chemicals/manganese.pdf*

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