GROUNDWATER AS A MAIN SOURCE OF DOMESTIC USE IN HINTHADA TOWN, AYEYARWADY REGION

Khin Kay Khaing[1], Wai Phyo Hlaing[2]

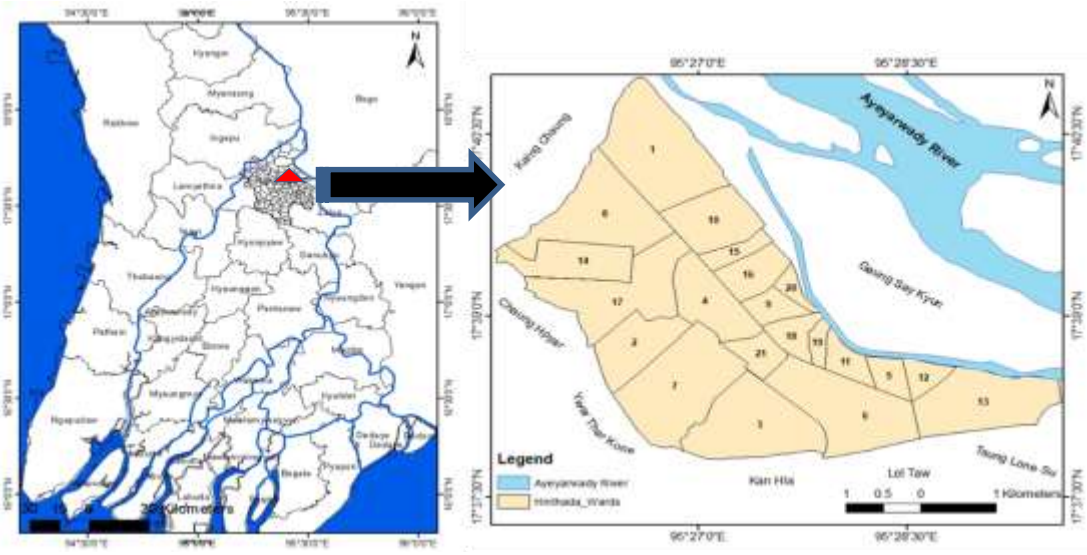
Abstract

Ayeyarwady Region is undoubtedly of great economic importance to the country by agriculture and fish productions. Hinthada Township is one of the 26 townships of Ayeyarwady Region, located on the western part of Ayeyarwady River. The total population of the Town is 80,117 in 2018. Most residents use water from groundwater source. There is no systematic water supply system. According to field survey, most of residents depend on rain water in the rainy season and ponds, opened-surface wells, shallow tube wells (hand pump) and deep tube wells and Ayeyarwady River for domestic use. Many households have their own tube wells and brick-lined wells in their houses but the water from most of them does not have good quality and is not suitable for drinking purposes. This study aims to determine the main water source for domestic and drinking uses of the residents and to make an assessment on peoples' perception on quality of their available water. Although both primary and secondary data are used, the main data from questionaries' survey and interview is used in the study. Systematic random sampling method is used to collect data. According to the result, groundwater is main water source for domestic use of residents of Hinthada Town. 97% of domestic water is from groundwater. Groundwater withdrawal is made by tube wells and hand pump wells. The chemical quality of groundwater is not exactly known well but people usually use traditional methods of at least one night keeping sedimentation with the aid of sedimentation tanks for the purpose of filtering and cleaning.

Keywords: Sources of water, groundwater, domestic use, water quality, people perception

Introduction

Ayeyarwady Region is undoubtedly of great economic importance to the country. Hinthada Township is located on the western part of Ayeyarwady River at north latitudes 17º 15′ - 17º 39′; east longitude 95º 13′ - 95º 35′. The Town area is approximately 17.82 square kilometer.



Source: Land Record Department, Hinthada, Checked Google Earth, 2019

A. Hinthada Town in Ayeyarwady Region **B. Location of wards in Hinthada Town**

Figure 1 Study area, Hinthada Town in Ayeyarwady Region

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Hinthada Town is composed of twenty-one wards. The total population of the Town is 80,117 in 2018. By the geology map of Myanmar Geoscience (2001), rocks units in Ayeyarwady Region composed of the rocks of Triassic to Holocene newer alluvial. Hinthada Town is mainly composed of Newer Alluvial. Being part of the structural basin of Central Myanmar, the relief of town is characterized by lowland plain. The old rocks of Rakhine Yoma are overlain by the younger deposits brought down by the Ayeyarwady River system. Above it are the valley-filled deposits mainly composed of sands and gravel interceded with clayey layers (Thet Thet Lwin, 2013). These sediments are found at the depth of 10 to 65 feet. According to the koppen's system of climate classification, its climate falls within Tropical Savanna (Aw) which receives heavy rain in June, July and August.

There is no water supply system distributed by Hinthada Town Development Committee. According to field survey, most of the residents depend on rain water in the rainy season and ponds, opened-surface wells, shallow tube wells (hand pump) and deep tube wells and Ayeyarwady River for domestic use. The proportions of domestic water use from these sources in Hinthada Town vary from place to place in accordance with the nature and situation of wards' location. Many households have their own tube wells and brick-lined wells in their yards but the water from most of them does not have good quality and is not suitable for drinking purposes. Majority of the residents buy bottled-water for drinking purpose and use the water from their wells for domestic use other than for drinking. Most residents use groundwater source. Although the primary sources are the same, the availability of residents vary locally and even spatially. This study intends (1) to determine the main source of water on which the residents depend high proportionately for their domestic and drinking uses and (2) to make an assessment of peoples' perception on quality of their available water.

The three main research questions for this study are

1. How many sources of water for domestic consumption are there in the study area?
2. What is the main type of water sources of residents of Hinthada Town?
3. What are the ways of local water treatment for available water quality?

Data, Methods and Methodology

Primary data is used and collected by questionnaires. Field survey and interview methods are also applied to complete investigation of sources of water, water availability, and perception on water quality. A set of questionnaires is designed after preliminary field survey to get facts and figures. By using questionnaire, the research work facilitates with fair cost for collecting a large volume of data.

Before undertaking the work of detailed questionnaire data collection, pilot survey has been carried out in different wards. Based on information obtained from pilot survey, questionnaires related to different types of water consumption are prepared. The questionnaire is arranged 27 sub-questions. After setting questionnaires, a sample size is determined by using formula devised by **Calderon and Gonzales** (1993). Systematic random sampling method is used to distribute questionnaire. Questionnaires are distributed to the wards in March to June, 2019. In the distribution of the questionnaires, the wards are stratified by street and number of questionnaires distributed in each ward is proportional to its total houses. The questionnaires are distributed by the help of ward leaders. Instead of pure random sampling, systematic stratified sampling method is mixed by which one in every 6 households is chosen. GIS software for distribution maps and descriptive and inferential statistic methods for data analysis are used.

Secondary data such as Google Earth map, various official records, research outputs, departmental reports and research papers are used for data of location, local climate, hydrogeology, population, water resource management, water related problems and sanitation.

Result and Discussion

Available types of water sources

According to the survey result, 7-types of available water sources found in Hinthada Town are R-Rain, P-Ponds, AR-Ayeyarwady River, BW- Brick lined wells, TW-Tube wells, HP-Hand pumped wells, and C-HP- Community hand pump wells. Every ward do not receive water from all these sources. Available types of sources vary spatially. Not every ward located nearby the river use river water. However, in the study area, nearly every ward has surface wells, hand pump and tube wells. Some wells belong to the private while others serve as community water source. The depth as well as quality of water varies from place to place. The following Table shows the spatial variation of available types of water sources, based on field survey records.

Table 1 Types of available water sources

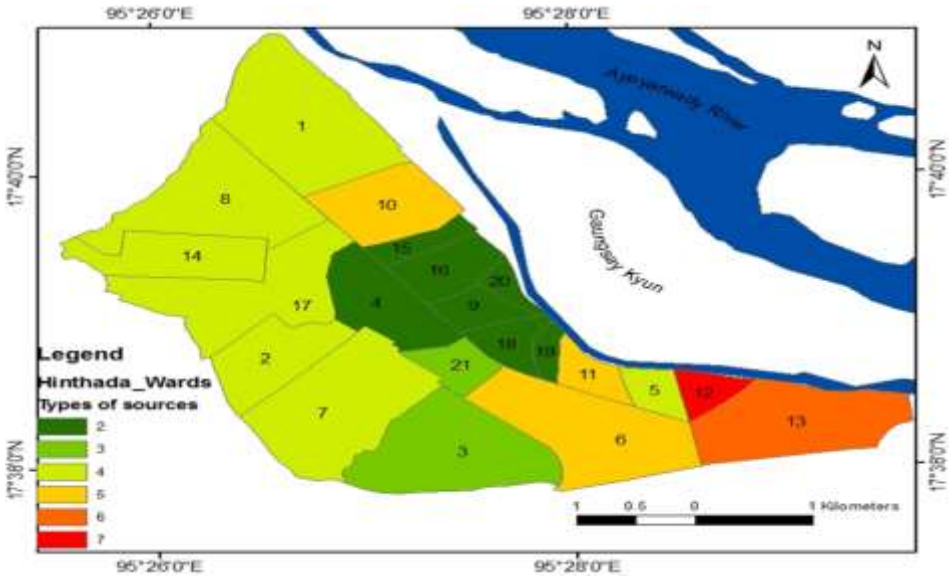
Index No. on Map	Wards Name	Types of available water sources	No. of sources
1	Pyin Ma Chaung	R, AR, TW, HP	4
2	Mya Wa Di	R, TW, HP, BW	4
3	Pan Be Dan	R,TW, HP	3
4	Pa Da Myar	R,TW	2
5	Za Kar	R, P,TW, BW	4
6	Tar Ka Lay	R, AR, TW, HP, BW	5
7	Ka Naung Su	R,TW, HP, BW	4
8	Le Ti Kwin	R,TW, HP, BW	4
9	Yone Gyi	R, TW	2
10	Nyaung Pin	R, AR, TW, HP, BW	5
11	Shwe Ku	R, AR, TW, HP, P	5
12	Kin	R, AR, TW, C-HP , HP, P, BW	7
13	Pa Khan	R, AR, TW, HP, P, BW	6
14	Aye Mya Thar Yar	R, C-HP, HP, TW	4
15	Tar Ngar Se (N)	R,TW	2
16	Tar Ngar Se (S)	R,TW	2
17	Thone Pin Kwin	R, HP, TW, BW	4
18	U-Yin (N)	R, TW	2
19	U-Yin (S)	R, TW	2
20	Let Tha Mar	R, TW	2
21	Hpa Yar gyi	R, TW, HP	3

Source: Questionnaire survey

Notes : R-Rain water, P-Ponds, AR-Ayeyarwady River water, BW- Brick line wells, TW-Tube wells, HP-Hand pumped well, C-HP- Community hand pump well

According to the respondents of Kin Ward, it was observed that they use water from 7 types of sources and also known that Pa Kham Ward with 6 types of sources and Tar Ka Lay, Nyaung Pin and Shwe Ku wards have 5 types of sources. Another 7 wards use water from 4 types of sources and 3 wards use from 3 types of water sources. 2 types of sources are used by 7 wards. Spatial variation of available type of sources can be seen in the following figure 1.

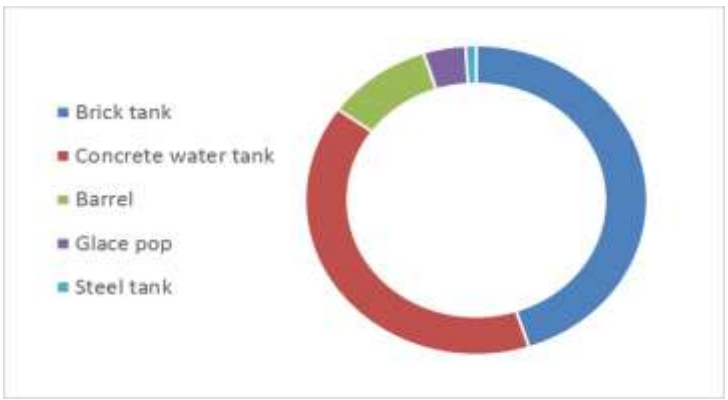
Actually the wards which used less number of water sources will possess the effective type of water sources. As they can use from only one or two sources sufficiently, they do not need to withdraw from other sources. Some wards like Kin, Pa Khan, Tar Ka Lay, Nyaung Pin, Shwe Ku cannot receive sufficient water from one or two types of sources. So they apply multi types of sources; Brick-lined wells, hand pump wells, community hand pump wells, tube wells, pond, Ayeyarwady River; by searching better types of water sources



Source: Based on table 2.1

Figure 1 Spatial variation of available types of water source.

The nature of water storage containers that use in Hinthada Town also vary. The most households use brick tanks and concrete tanks (45 % and 40 % of total households) and followed by barrel (10 % of total households), glaze pops and steel tanks. Figure 2 shows the water storage containers that use in all households of Hinthada Town.



Source: Questionnaire survey, May 2019

Figure 2 Percent share of water containers used in households of Hinthada Town

Water use from different sources

According to respondents, rain water is used by all the households of the 21 wards in the rainy season. Some use throughout the year by storing it. Based on the responses during field surveys, some households want to use rainwater all year round, but they do not take effort to store the water, while some households have no large earthen jars, brick tanks, steel tanks and large plastic bucket. The households that store rainwater use it for drinking as boiled water. There are totally 31.4% of households that use rain water in rainy season for the whole township. Of which, about 3.1 % store it for dry season use. However, a few household (2.6% of total) stores rain water for the whole year use.

Surface water in Hinthada Town is acquired by two types of water sources as river and ponds. It is found that the river water is used by the residents of 6 wards. They use for cooking, washing and bathing. However, not all the households of these wards use river water. Only the households close to the river, and when they are flooded by river, they use it for domestic purposes. River water is used mainly in the rainy season. The following table 2 shows the percentage of household that use river water for domestic purpose.

Among the 21 wards, only 4 wards use pond water. Pond water is acquired by laying pipeline and pumped it with motor to get into the house. It is used mainly for cooking, cleaning and washing. Some households of Pa Khan, Kin and Shwe Ku wards use it as boiled water for drinking. Groundwater in Hinthada Town is withdrawn by two types of sources that are (1) Surface wells (or) brick-lined wells and (2) Tube wells with hand pump (hand pump wells) and tube wells with motor (tube wells)

Nearly all residents in Hinthada Town use groundwater in all season for various purposes. Therefore, it can be said that the residents of Hinthada Town depend essentially on groundwater for their daily water consumption. Generally the depth of brick wells are between 10 feet to 20 feet and the depths of hand pump wells and tube wells are between 30 to 400 feet in the Hinthada Town. Therefore water from tube wells is withdrawn from various aquifers of both shallow aquifer and deep aquifer in the study area.

There are brick-lined wells which are one type of source of domestic water in Hinthada Town. According to questionnaire survey, the distribution of brick-lined wells are found in 9 wards as shown in Table 2. In accordance with this table, brick-lined wells are widely distributed in wards of Hinthada but, their value on the use of domestic water for residents are not significant. The maximum number of households that use brick-lined wells as sources of domestic water are 7 % of total households of Za Kar Ward, followed by Nyaung Pin, Pa Khan, and Thone Pin Kwin by 4 %, and 3 % of total household respectively.

Table 2 Percentage of households using water from main different types of water sources

Index No	Wards	P%	AR%	BW%	C-HP%	HP%	TW%
1	Pyin Ma Chaung		14				100
2	Mya Wa Di			3		2	96
3	Pa Be Dan					2	97
4	Pa Da Myar						100
5	Za Kar	24		7			100
6	Tar Ka Lay		1	2			99
7	Ka Naung Su			1		1	97
8	Leti Kwin			1		1	94
9	Yone Gyi						100
10	Nyaung Pin		14	4	3	7	91
11	Shwe Ku	8	28			27	73
12	Kin	19	8	2	4	23	73
13	Pa Khan	10	13	4		10	100
14	Aye Mya Tha Yar				27	3	97
15	Tar Ngar Se (N)						100
16	Tar Ngar Se (S)						100
17	Thone Pin kwin			3	1	1	99
18	U-Yin (S)						100
19	U-Yin (N)						100
20	Let Tha Mar						100
21	Hpa Yar Gyi						100

Source: Questionnaire survey, May 2019

Water from hand pump wells are used more or less in nearly all wards in Hinthada Town. There are community hand pump wells as well as private hand pump wells in Hinthada. The use of water from hand pump is due to two main reasons. One is its availability even when the electric power is interrupted and another is that it is not so expensive to sink it as deep tube well. There are 10 wards that use hand pump well in Hinthada Town (Table 2). Hand-pump wells were primarily developed in Hinthada long ago and later, they have been transformed to motorized tube wells by the development of electricity. At present, nearly all household has tube wells. There are also some community hand-pump wells which are used by households which cannot effort to own private wells. According to questionnaire survey, tube wells are found in all wards of Hinthada Town. But, households of 7 wards (Pa Da Myar, Yone Gyi, Tar Ngar Se (N), Tar Ngar Se (S), U-Yin (N), U-Yin (S), and Let Tha Mar) use their domestic water only from tube wells. The depth of the tube wells varies due to the variation in the depth of acquirer and the amount of money used in sinking tube wells.

The original sources of domestic water in Hinthada Town are rain water, surface water and groundwater but local people acquire water from these sources by 7 different types and they also use purified drinking water as well. Among them rain water is seasonal and availability of purified drinking water depends on the consumer choice for drinking water source and ability for purchasing. Except rain water, the dominant type of water sources with percentage of households consumed is based on 6 types of water sources. Table 3 shows ward-wise share of domestic water use from main types of water sources. Among the 6 different types of sources, water from tube well is the main source of domestic use in all wards of the town. According to responses to the

questionnaire survey, 97 % percent use water from tube wells, 4% percent from private hand pump wells. Therefore, a great majority of the urban residents of Hinthada depend mainly on the groundwater source for domestic uses. Tube wells are dominant types of available water sources as it is shown by table 3.

Table 3 percentage share of household water use

Types of water sources	Percentage of total	Original sources
using water from pond	2	Surface Water
using water from Ayeyarwady River	3	
using water from brick-line wells	1	Groundwater
using water from community hand pump wells	1	
using water from private hand pump wells	4	
using water from tube wells	97	

Source: Questionnaire survey, May 2019

Sources of drinking water in Study area

Questionnaire survey revealed that, purified bottle water is also used as drinking water in study area. Respondents of 12 wards; Pyin Ma Chaung, Pa Da Myar, Za Kar, Yone Gyi, Pa Khan, Tar Ngar Se (S), Tar Ngar Se (N), Lte Tha Mar, Hpa Yar Gyi, express that their main water source is 100 % from tube wells (Figure 3.B). But all households use purified water for drinking. As shown in Figure 4, the two main source of drinking water in Hinthada are purified bottle water and water from tube wells. For the whole town, 51% of total households drink purified bottle water and 46% drink water from tube wells and 3% from hand pump wells.

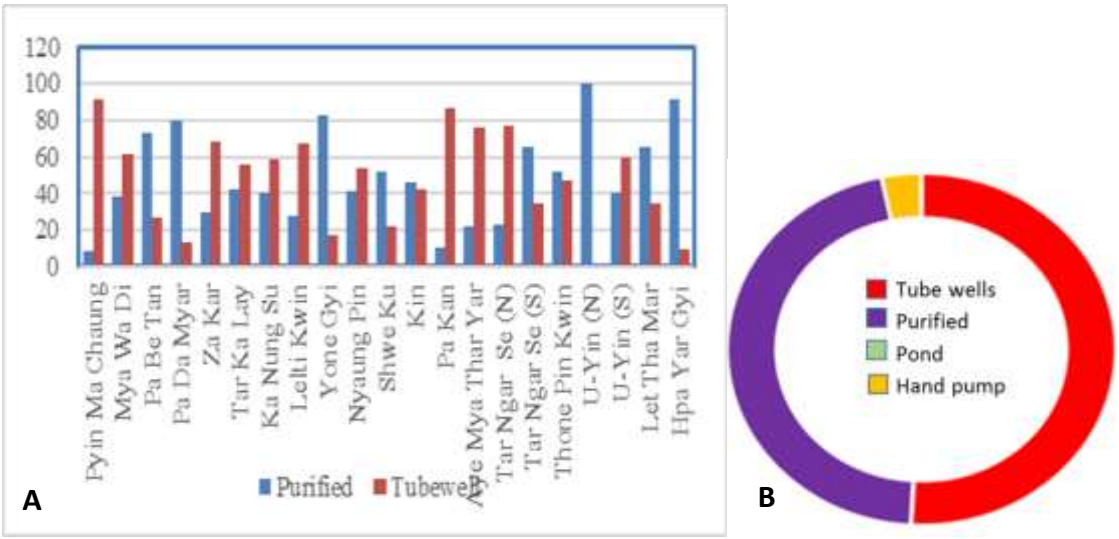
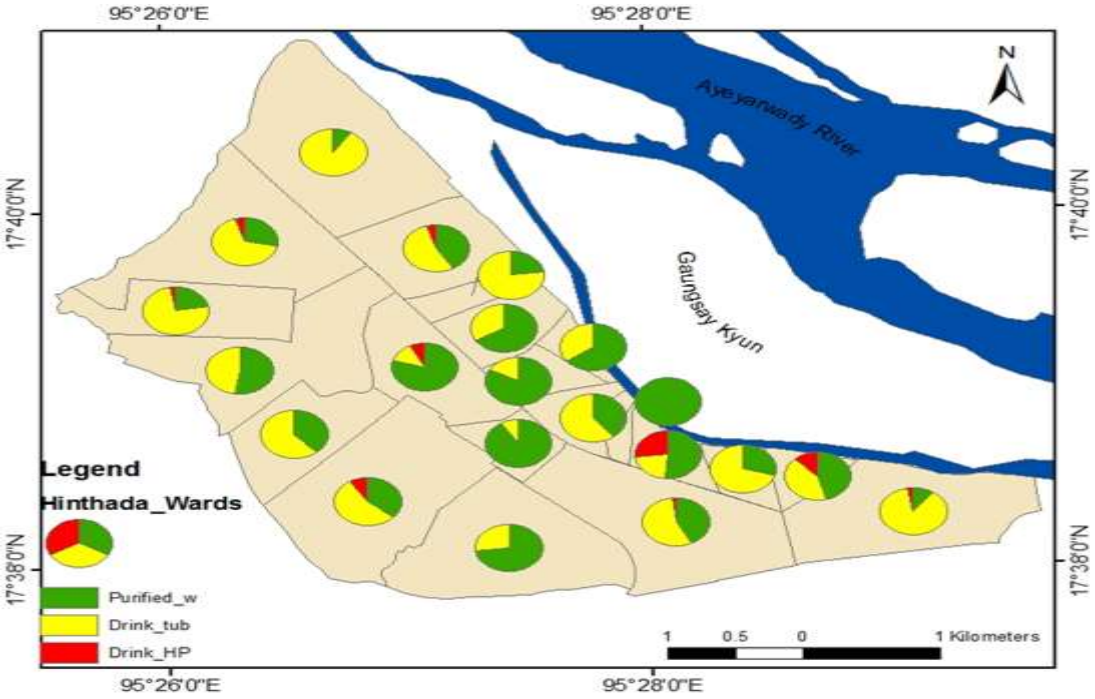


Figure 3 Ward-wise variation of sources for drinking water (result from Survey data)



Source: Questionnaire Survey

Figure 4 The ratio of drinking water sources in Hinthada Town

Groundwater situation and people's perception on water quality

The availability of groundwater varies with the changes in season. The change is more obvious between the rainy season and the dry season. According to questionnaires survey, the availability of groundwater decreases in all wards of Hinthada Town in the dry season. As most tube wells yield low amount of water in dry season, it takes more time to get sufficient water for domestic use. However the respondents of households located close to the river express as the yield of water is not different in the water. Some tube well close to the river automatically yield water without pumping as the water table rises close to the surface. Such situation is found at a household on Targyitan road in Kin Ward while is very close to the river. There has been no seasonal change in water availability from tube wells in Pyin Ma Chaung, U-Yin (North) and Hpa Yar Gyi wards. These wards are located near the Ayeyarwady River. The remaining 18 wards more or less have witnessed the seasonal variation of groundwater. These situation is learnt from questionnaires survey.

There are 97 percent of total households that use water from tube wells and 4 percent of total households use water from hand pump wells in Hinthada Town. 51 percent of total households drink water from their own tube wells and 3.2 percent of total households drink water from their hand pump wells. These situation is interesting to test the water quality of groundwater of Hinthada Town, to analyze the situation of tube wells and to check on the perception of local people on their water by both physical and non-physical that is taste, small, hardness etc. This study tried to analyze groundwater situation of Hinthada town by collecting all available data from primary and secondary sources that can represent the general picture of groundwater of study area. During the time of field observation, some of physical quality of water such as, water colour, sediments load in water, and changing colour by boiling water were observed. Most people can detect colour above 15 true colour units (TCU) in a glass of water and levels of colour below 15 TCU are often acceptable to consumers (Tin Nilar Soe 2018). Turbidity in water is caused by suspended particles

or colloidal matter. Inorganic or organic matter or combinations of the two are sources of turbidity in water.

According to field surveys, the depth of tube-well varies from 20 to 400 feet. The variation in the depth of tube-well is related to relief, geological structure of underlying rock strata and the depth of the existence of aquifer. Not only the depth but also the quality of water varies from place to place. A household in Mya Wa Di Ward has a tube well with a depth of 240 feet, but the groundwater quality is not potable. However, the tube well cannot be sunk deeps, being underlain by hard rock layer. The experience during field survey, groundwater yield from 30 of totally 109 households at Pa Khan Ward is also not potable. These households try to get good quality water by test-drilling one place to another within their compounds but they do not success and they do not get good quality water. Usually, the sinking of tube well ceased as soon as groundwater spring out from the tube, while other sunk deeps. However, some tube well with a greater depth do not yield potable water. Therefore, the depth varies mainly with the depth of aquifer that contains good quality water. A household on Bo Saw Maung road in Yone Gyi Ward receives potable water from the tube well with a depth of only 20 feet. However, some tube wells in Pa Da Myar Ward do not yield potable water although the depth is over 200 feet. Income also affects the depth of tube well. The households on Hanpin road of Ka Naung Su had to dig down to the depth of 270 feet, although income is low. If the depth is low, the tube wells would not yield good quality water so they use more input even though they are low income.

The responses of individual household vary significantly. The lowest 20 feet tube wells and the highest 400 feet are found in the Town. However, to get general understanding of depth of tube wells and the representative for value of all individuals are grouped into 5 such as tube wells with depth under 50, between 50 to 100 feet, between 100 and 200 feet, between 200 and 300 feet, and above 300 feet. There are 28 % of tube well with depth between 100 feet and 200 feet and 41 % of tube well with depth between 200 feet and 300 feet and they are widely distributed in the Town. Town-wise share of tube wells with different depth categories is presented in Table 4 and figure 5. Some households with low income have tube well with shallow depth, resulting in low water quality, but they use it by keeping tank for sedimentation to get fairly clean water.

Table 4 Percentage of total number of tube wells with different depth categories

<50ft	**Between 50-100ft**	**Between 100-200ft**	**Between 200-300ft**	**>300ft**
6 %	17 %	28 %	41 %	9 %

Source Questionnaire Survey, May 2019

In brief, there are four factors that affect the depth of tube well, they are:

(1) Types of underlying rocks,

(2) The depth and water storage capacity of aquifer,

(3) Quality of available groundwater and

(4) Income or the amount of money spent in sinking tube well.

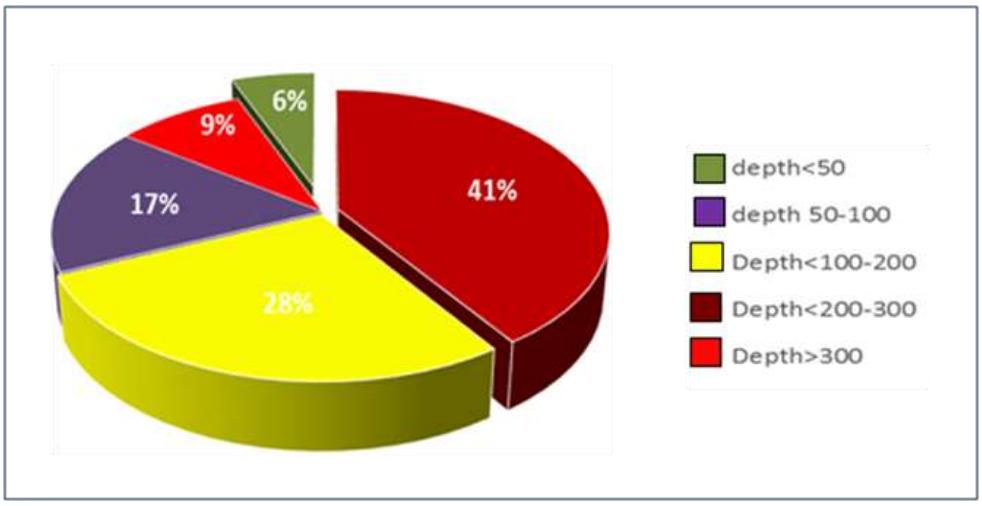


Figure 5 Town-wise share of tube wells with different depth categories

The different perceptions on the quality of available water are identified by the sample households. Some households on Kyawk Kone road of Pyin Ma Chaung Ward do not like the water they are using because of its yellowish colour. Likewise, some households on Khayay road in Mya Wa Di Ward do not satisfy the water being used as it turns to black colour although it is clean at the beginning. The depth of their tube well is 240 feet, but they have to keep sedimentation tank to get fairly clean water. Households on Thiri-8 road like the water that yields from shallow tube-well because of good quality water. According to talking with owner household, it can be drank just by keeping one night for sedimentation. A household on Shwe Myin Tin road does not like their water because sediments appear in several days. Some households do not like their water as it turns to rusty colour in a few days and the layer of calcium encrusted the cup and utensil used with this water. Water from some tube wells turned into red colour if it is boiled. Anaerobic groundwater may contain ferrous iron at concentrations up to several milligrams per liter without discoloration or turbidity in the water when directly pumped from a well. On exposure to the atmosphere, however, the ferrous iron oxidizes to ferric iron, giving an objectionable reddish-brown colour to the water. Iron also promotes the growth of "iron bacteria", which derive their energy from the oxidation of ferrous iron to ferric iron and in the process deposit a slimy coating on the piping. At levels above 0.3 mg/l, iron stains laundry and plumbing fixtures. There is usually no noticeable taste at iron concentrations below 0.3 mg/l. No health-based guideline value is also proposed for iron (WHO, 2011). In brief, the perception of users on the available water depends on the quality of water. The water users or the sample households dislike if the water they receive has the undesirable qualities. According to the open talk and interviews with residents, quality of groundwater in study area can be highlighted by following points.

(1) Having yellowish colour
(2) Having large content of sediments on solid particles
(3) Turning red when it is boiled
(4) Turning into black colour some time later after the withdrawal
(5) Turning yellowish colour in cooking rice
(6) Encrusting of calcium in the cup or utensil
(7) Having rest colour and rusty smell

In brief, water shortage problem occurs in wards which are located outside the embankment and due to floodwater that causes all the existing groundwater sources in these areas leading to

water shortage problem both for domestic uses and drinking. Some areas with remarkably low quality water and for some households that cannot effort to have own tube wells have to face with water shortage problem. Almost all households in Hinthada Town use sedimentation tanks for the purpose of filtering and cleaning. The following plates show such water sedimentation tanks of households as examples.

Plates showing the examples of sedimentation tanks that usually use for the purposes of sedimentation, filtering, and cleaning. Source: Photo© taken by Wai Phyo Hlaing

Conclusion

The climate of Hinthada Town in Ayeyarwady Region is monsoonal with the rainfall of nearly 2000 millimeter. Rain water is seasonal. Rain water collection ponds are not well developed. There is no water supply system distributed by Hinthada Town Development Committee. The residents prefer water from groundwater sources which can access easily when they can effort to sink tube wells. According to field survey, most of the residents depend on rain water in the rainy season and ponds, opened-surface wells, shallow tube wells (hand pump) and deep tube wells and Ayeyarwady River for domestic use. The proportions of sources of domestic water use in Hinthada Town from these sources vary from place to place in accordance with the nature of and situation of that area. The household water use in Hinthada Town comes from tube wells mostly private and lesser amount from hand pump wells. The depth of tube wells are different mostly (70 per cent of total tube wells) between 100 and 300 inches. About 97% of domestic water use is from groundwater source. Tube well is the main type of available water sources in Hinthada Town. According to survey results, the residents do not know well about the chemical quality of groundwater which they use. They know the water colour and sediments in water. But, as the traditional way whatever used by ancestors they treat one night keeping sedimentation and some people try to get good quality water by boiling.

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