Preliminary Study on the Groundwater Flow Situation of Yadanabon University and Its Environs, Mandalay Region

Khin Maung Htwe

Abstract

The proposed area is located in the Amarapura Township lying about 15 km south of Mandalay. Three test wells were drilled in the Yadanabon campus. The local drilling technique similar to the cable tool method employed for test drilling, however, all test drilling were applied in unconsolidated formations around Taungthaman area, Amarapura Township, Mandalay Region. The study area mainly deals with the activities of two rivers; Dokhtawaddy and Ayeyarwaddy. The sediments of the area are clay, silt, mud, fine to medium sand, loosely yellowish brown gravel, silty clay, sandy silt, and gravelly sand. The well logs are constructed from sampling and examination of bore holes collected at specific intervals during the drilling of test hole. The study area is susceptible to contamination from anthropogenic sources. Many of these wells also contain high hydraulic conductivity and groundwater flow with quick average linear velocities ranging from 1.76x10-2 m/day to 9.25 m/day directions predominantly towards the WNW.

Key words: Geologic Log, Hydraulic Conductivity, Water Level, Groundwater Flow

Introduction

Location

Yadanabon University is located in the heart of Dry Zone, in Mandalay Region, Central Myanmar a distinct semi-arid region within the country, lying between North Latitudes 21° 53' 25″ to 21° 53' 40″ and East Longitudes 96° 04' 08″ to 96° 04' 30″ in one inch topographic map of 93C/1 with approximately 15 km south of Mandalay (Fig; 1).

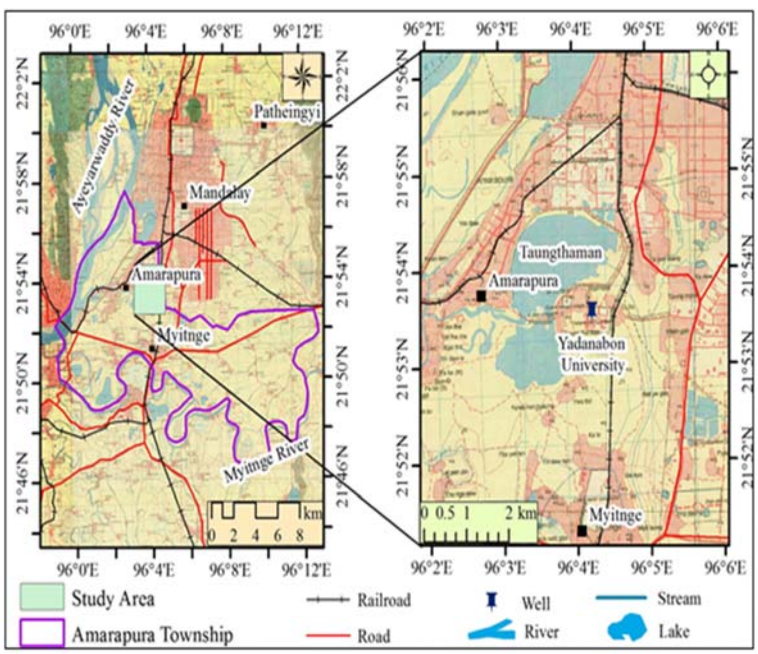

Figure (1) Location map of the study area

Lecturer, Department of Geology, Yadanabon University

Physiography

Yadanabon University falls into Mandalay-Kyaukse plain which is between the Ayeyarwaddy River in the west and Shan High Land in the east and Myitnge River in the south. In general, the topography of Yadanabon University is high in the eastern parts from which the ground surface gradually slopes towards the western and southern part of the campus (Fig; 2). The Me-O Chaung is the outlet stream connecting TTML with the Ayeyarwaddy River. The Myitnge River starts in the Shan Plateau, running east to west on the south side of the Yadanabon University.

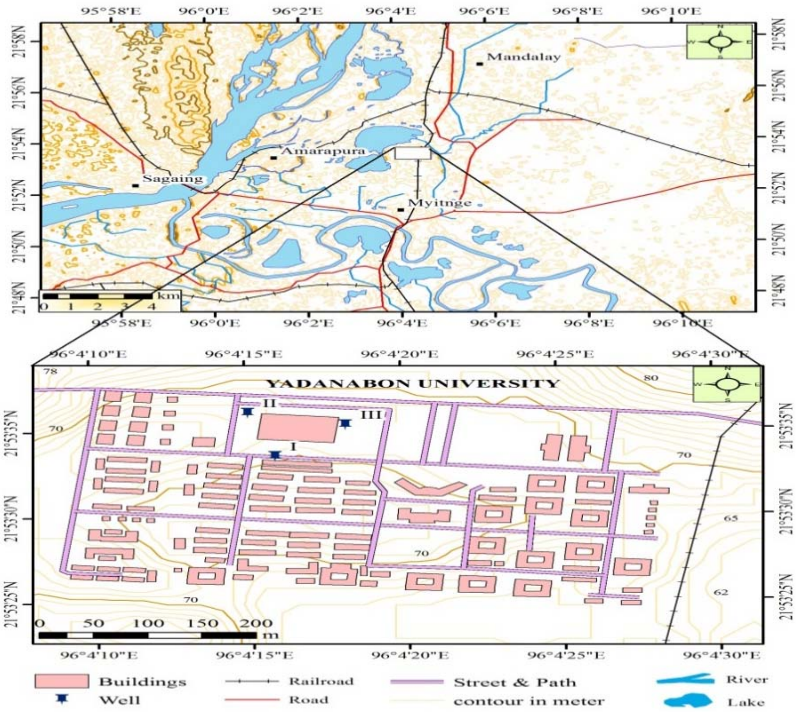

Figure (2) Topography and drainage pattern of the Yadanabon University and its environ

Regional Geologic Setting

Geologically the Yadanabon University and adjacent areas can be divided into two parts; eastern and western;

(1) **Eastern part**: In the east of the campus is represented by the west margin of the Eastern Highland which is made up of the Paleozoic carbonates and the Precambrian metasedimentary rocks of Chaung Magyi Group.

(2) **Western part**: The western part including the University campus is occupied in the Central Lowlands with the Upper Tertiary clastic sedimentary rocks peeping through the Recent Alluvium.

Objectives of Research

(1) To investigate the groundwater flow direction of Yadanabon University and adjacent areas.
(2) To support the drawing drainage plan of the campus.
(3) To prevent the contamination of domestic waste water in research area.

(4) To minimize flood damage by solving a combination of knowledge in hydrology and engineering techniques.

Method of Study

Research was mainly carried out during the dry and wet seasons in campus. The following the activities were conducted: a field survey of groundwater wells in the campus and adjacent areas, drilling for grain size analysis, hydraulic conductivity measurements, water level measurements during the wet season. During the dry season, the following activities were conducted: water level measurements and slut tests (Tube wells YDB-1, YDB-2 and YDB-3), water quality sampling and *E.coli* testing. Heron instrument150-foot water level meter tape is used to measure the depth of water level.

Drilling

Drilling was conducted to install tube well YDB-3, using a local drilling technique similar to the cable tool method. One driller used bamboo sticks to lift and drop a steel pipe repeatedly to loosen unconsolidated material. A second driller covers and uncovers the top of the steel pipe to create suction, which helps to bring the surficial material to the top. If the extra water is needed to break up aggregates stuck in the pipe, additional is poured down the pipe. Water poured down the pipe was taken from a nearby retention pond. Typically, annulus is backfilled with material taken out of the borehole or allowed to collapse around the casing.

Grain Size Analysis

Samples collected from the drilling of YDB-3 are used to determine grain sizes in the upper eight meters of surficial material. Five USA standard testing sieves was conducted to determine the type of environment the sediments were deposited in. The sieve analysis (Table; 1) of sediment from YDB-3 confirmed a predominantly medium-coarse sand and gravel material, which is in agreement with the suspected channel and bar deposits in this area. Small percentages of clay were present in the upper part, indicating thin flood plain deposits. This provides a wide range of porosities estimates from 20-35%.,the hydraulic conductivities estimates between 4.98 and 726.62 m/day by Hazen.

Table (1). YDB-3 Grain Size Analysis.

	Gravels	Coarse Sand	Medium San	Fine Sand	Silts& Clays	Error	Hazen Method
Depth(m)	(%)	(%)	(%)	(%)	(%)	(%)	K(m/day)
0.31	5.68	49.5	22.52	10.08	11.23	0.98	21.6
2.13	27.25	38.65	17.26	7.65	8.72	0.47	55.3
3.05	26.16	27.47	15.47	13.98	15.21	1.72	4.98
3.66	47.95	25.22	9	7.33	9.83	0.66	33.21
4.27	41.67	25.06	10.53	8.98	12.79	0.96	8.85
4.88	42.28	27.76	9.18	8.26	11.71	0.81	15.24
5.18	29.78	23.42	13.39	18.44	12.81	2.15	12.48
5.49	34.91	36.11	14.5	7.08	6.42	0.97	86.4
6.1	25.24	27.46	20.38	14.84	11.82	0.58	17.5
6.71	46.26	24.07	12.36	7.74	8.4	1.16	55.3
7.01	26.82	35.91	24.27	6.18	5.69	1.13	124.42
7.62	0.95	74.49	21.3	1.96	0.49	0.81	381.02
8.23	3.57	80.47	13.89	1.15	0.23	0.7	726.62

Geologic log

The geologic logs were constructed from sampling and examination of well cuttings collected at specific intervals during the drilling of a well. Normally, we records at 2ˈinterval then,continuous monitoring and examining of cutting was made. The references cited for this paper are also used on MPGS Company logs data. In research area found soft, yellowish brown moist, slightly plastic, clayey silt and thickness of 3m at the top of YDB Well – 3 (Fig; 3).

Based on the above mention factor, Yadanabon and adjacent areas are directly affected by the recent flood plain deposit of Ayeyarwaddy and Dokhtawaddy rivers. The depth of 3m to 9m is composed of medium, dense, yellowish brown, moist fine-grained slightly silty sand in the upper part and medium, dense, yellowish brown, moist, fine to medium grained, gravelly sand in the lower part. The sediments may be deposited by Dokhtawady (or) Myitnge River. The study area mainly deals with the activities of above two rivers. YDB Well – 3 borehole is terminated at 14.0 m.

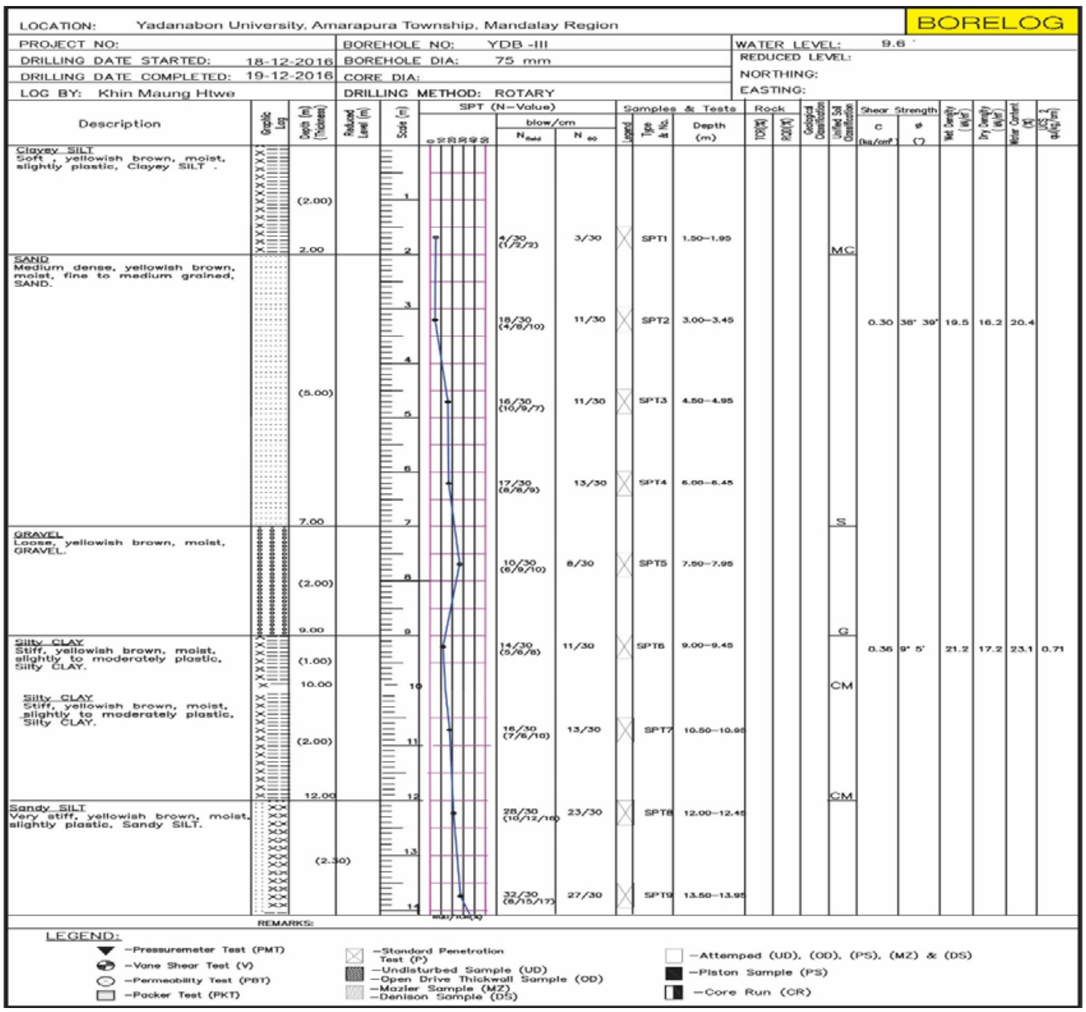

Figure (3). Showing the borelog of test YDB well-3 in Yadanabon University.

Hydraulic Conductivity Measurements (K)

Slug tests of tube wells were conducted to determine the hydraulic conductivities of YDB-1, YDB-2, and YDB-3 at Yadanabon University. High hydraulic conductivities were observed at wells with screening intervals at approximately 25 meters below ground surface. YDB-1 and YDB-2 recovered within seconds of the start of the slug tests and produced oscillating slug test curves.Hydraulic conductivity of YDB-1 has 54.86 m/day and YDB-2 has a hydraulic conductivity of 67.06 m/day. Lower hydraulic conductivities of 1.31 m/day were observed in YDB-3 at a shallower screening interval of 7-8 meters below ground surface.

The high hydraulic conductivities measured at YDB-1 and YDB-2 are assumed to be a layer of mixed sand and gravel from either the Ayeyarwaddy River or Myitnge River sediments.During drilling of YDB-3, the high hydraulic conductivities expected from the mixed sand and gravel layers. Lower hydraulic conductivities observed in YDB-3 are assumed to be from medium-coarse sand layers, such as those observed in the screening interval of YDB-3. These slug tests provide a range of values that exist across the site. Overall, these hydraulic conductivities are in agreement with the types of sediments observed from the grain size analysis of YDB-3.

Water-level Measurement

In YDB-1 and YDB-2, the long-term monitoring of water level was conducted by pressure transducer to observe changing conditions over the time frame of the study. Depth to groundwater from top of casing was measure using a Heron instrument 150-foot water level tape accurate 0.01 decimal feet in all dug well, as well as tube wells YDB-1, YDB-2 and YDB-3. Depth to water, stickup and total depth were measured in all well. Other tube wells were in use and total depths provided by their owner. Long-term monitoring showed transient conditions of water levels between seasons (Fig; 4). Water levels generally declined between the wet and dry seasons and often spiked 1-2 meters during rain events.

During the dry and wet seasons, heads in the Yadanabon Aquifer were relatively shallow. Heads range from 64-71 meters across the Yadanabon Aquifer and were approximately 2-6 meters higher during the wet season than the dry season. These heads are tremendously affected by heavier thunderstorm /prolonge d rain events and additional inflow of water from the Ayeyarwaddy River and other surface-water features in the region.

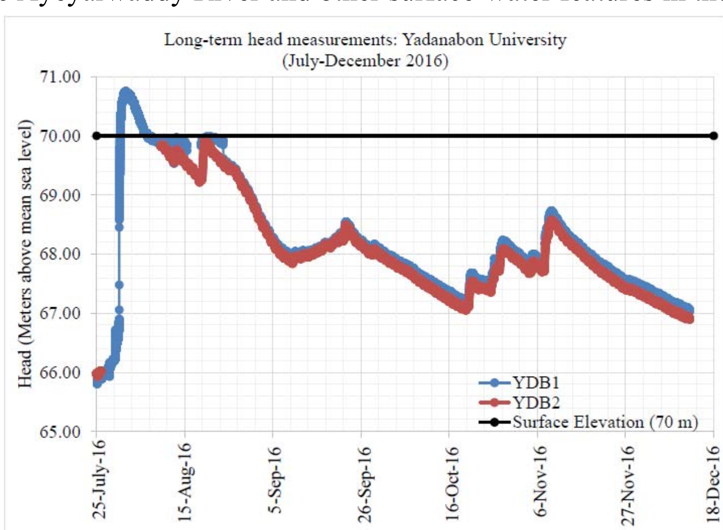

Figure (4). Long-term head monitoring (YDB1 and YDB2).

Water Quality

Geochemistry

Chlorides, nitrates, ammonium, total dissolved solids, electrical conductivities and *E. coli* are key indicators of wastewater contamination to the Amarapura Aquifer.

Electrical Conductivities

Electrical conductivity (EC) is a common measurement used to evaluate water quality. During the dry season EC values in groundwater samples ranged from 305-2,590 µS/cm and averaged 1,385 µS/cm. During the wet season EC values in groundwater samples ranged from 183-2,950 µS/cm and averaged 1,168 µS/cm. In the region between TTML and the Irrawaddy River, a divide was noticed between higher and lower values of EC. Higher values (>1200 µS/cm) were located on the west side (closer to the Shwe-Ta-Chaung canal) and lower values (<1200 µS/cm) were observed on the east side (closer to TTML). This was identified as a potential groundwater flow divide.

Total Dissolved Solids

Total dissolved solids (TDS) is a commonly used water quality parameter to describe the presence of inorganic salts in the water. The World Health Organization (2008) sets a limit on TDS of 1000 ppm as reasonable quality but specifies 300 ppm as the preferred limit for drinking water. TDS values during the dry season ranged from 59-1,039 ppm and averaged 497 ppm. TDS values during the wet season ranged from 79-1,326 ppm and averaged 467 ppm.

Chlorides

Excess chloride concentrations in groundwater have been shown to be indicators of wastewater contamination in other studies (Lawrence et al., 2000). Fetter (1999) established chlorides in excess of 100 ppm are usually associated with wastewater contamination. During the wet and dry seasons, 39% of wells exceeded 100 ppm. During the wet season, background chloride concentrations averaged 11.93 ppm and ranged from 2.66-26.00 ppm. In the wet season, 72% of groundwater samples exceeded the average, and 61% exceeded the range maximum. During the dry season, background chloride concentrations averaged 23.86 ppm and ranged from 1.43-57.46 ppm. In the dry season, 72% of groundwater samples exceed the average, and 56% exceed the range maximum.

Nitrates and Ammonium

Nitrate and ammonium contamination has been documented in a number of areas from anthropogenic sources (Fetter, 1999). Nitrates (NO3 as N) above 10 ppm and the presence of ammonium in urban areas often indicate influences from domestic wastewater (Fetter, 1999). Ammonium concentrations ranged from 0.05-3.14 ppm and averaged 0.15 ppm. Ammonium was present in 44% of wells during the wet season and 17% during the dry season. Nitrates ranged from 0.10-331.07 ppm and averaged 55.68 ppm; 56% of nitrates exceeded 10 ppm during the wet season, and 61% during the dry season.

Cl/Br Ratios

Cl/Br ratios from domestic wastewater are greater than 400 and 150 for groundwater contaminated with domestic wastewater (Vengosh and Pankratov, 1998). During the wet and dry seasons, 70% of dug wells exceeded the Cl/Br ratio for groundwater. In tube wells, 38% and 63% exceeded this ratio during the wet and dry seasons.

E. coli

E. coli is measured in "most probable number" (MPN) per 100 mL, and detection of *E. coli* at any level is considered unsafe for drinking water. During the wet season, 100% of dug wells and 33% of tube wells sampled contained unsafe levels of *E. coli* for drinking water. During the dry season, 86% of dug wells and 11% of tube wells sampled contained unsafe levels of *E. coli* for drinking water. *E. coli* counts in most dug wells (>55%) exceeded 100 MPN/ 100 mL during both seasons, which is the United States Environmental Protection Agency (2012) recreational limit.

Groundwater Flow

Groundwater flows under the influence of gravity and it moves at an exceedingly slow rate usually measured in feet or inches per day. However, a more appropriate view is that groundwater flows from locations of high gravitational potential to locations of low gravitational potential. The direction and degree of the slope of the water table is the driving "force" that causes groundwater to move YDB Well-2 is locating at the distance of 485.3' in the north-west of YDB Well-1 and the northeast, 381' away is situating YDB Well-3. By determining the direction and degree of the slope of the water table, the groundwater is flowing to YDB Well # 1 in WNW.

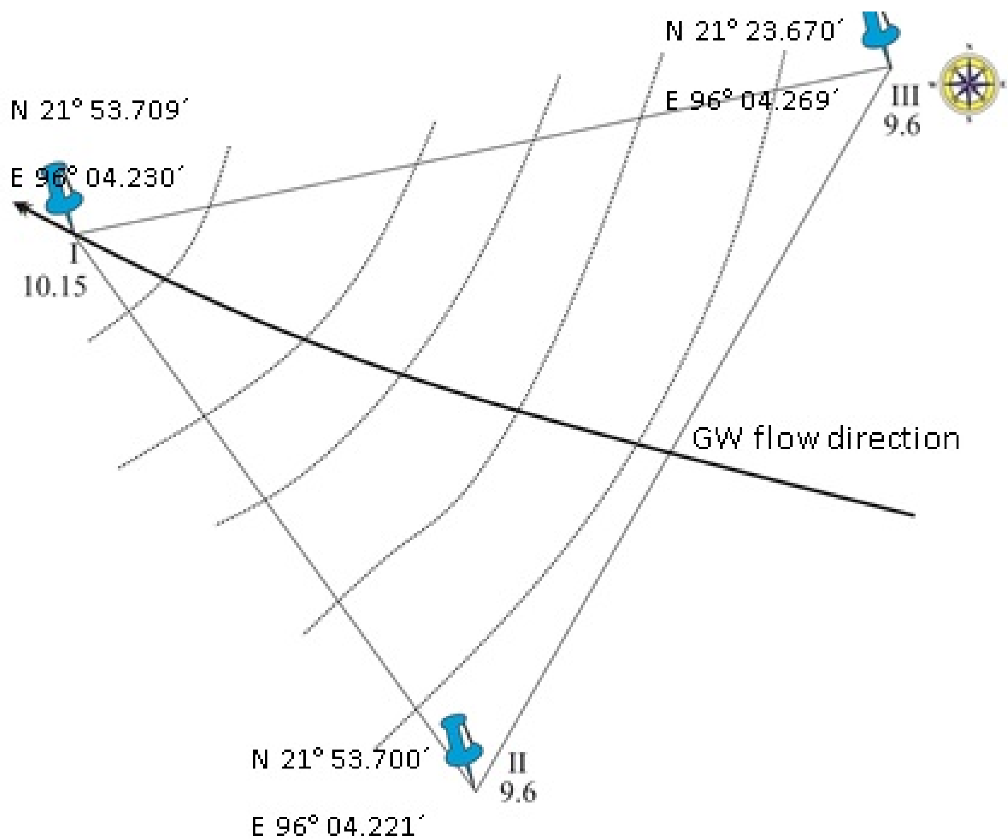

Figure (5). Groundwater flow direction of Yadanabon University.

Conclusions

Yadanabon University is located between Latitudes 21° 53'N and Longitudes 96° 04'E in one inch topographic map of 93 C/1. It is situated in the Amarapura Township lying about 15 km south of Mandalay. Three test wells were drilled in the Yadanabon campus. The local drilling technique similar to the cable tool method employed for test drilling, however, all test drilling were applied in unconsolidated formations around Taungthaman area, Amarapura Township, Mandalay Region. The study area mainly deals with the activities of two rivers; Dokhtawaddy and Ayeyarwaddy. The sediments of the area are clay, silt, mud, fine to medium sand, loosely yellowish brown gravel, silty clay, sandy silt, and gravelly sand. The Yadanabon Aquifer's high hydraulic conductivity (50-70 m/day) allows water to flow in and out of the aquifer with higher average linear velocities (9.25 m/day) causing quick water level fluctuations during rain events. This means water levels in this alluvial aquifer are susceptible to changing weather conditions.

A few groundwater well had different water types between seasons and are likely due to contamination from other anthropogenic sources because of improper well construction. YDB-1 changed water types between seasons from $Na\text{-}SO_4$ during the wet season to $Ca\text{-}CO_3$ during the dry season.

Groundwater flow direction of the Yadanabon University and adjacent areas are WNW. Contamination of shallow aquifer system can have a negative impact on the health of those using water from dug and tube wells in the Amarapura Township. It is possible that many of these health effects have gone unnoticed because health surveys haven't been conducted. Local infrastructure is needed to build lined wastewater canals or underground sewers to protect water sources and treatment plants are needed. This preliminary investigation of groundwater flow in Yadanabon University and adjacent areas is very important because Yadanabon campus is facing with the problem of flood hazard in almost every 3 or 4 years. From an environmental point of view, the realistic solution to minimize flood damage involves a combination of knowledge in hydrogeology together with flood plain regulation and engineering techniques.

Acknowledgements

We are greatly indebted to Rector Dr. Maung Maung Naing, Pro-rectors Dr. Si Si Khin and Dr. Tin Moe Thuzar, Yadanabon University, for their permission to carry out this research and for paying attention to this works. We wish to express my sincere gratitude to Dr. Htay Win, Professor and Head, Dr. Khaine Khaine San, Professor and Dr. Min Nyo Oo, Associate Professor of Geology Department in Yadanabon University for allowing to do this research

References

Freeze, R. A. & J. A. Cherry, 1979. Groundwater, PRINTICE HALL, Englewood Cliffs, N.J. 07632

Hudak, P.F., 2001. *Principle of Hydrology*, Boca Raton, CRC Press LLC

Michael Grzybowski, 2017. Water quality and physical hydrology of the Amarapura Township, Mandalay, Myanmar.

Moe, U Aung Khaing., 2013,Sustainable Development and Management of Groundwater in Myanmar: Water Resources Utilization Department.

Sterrett, R.J., *Groundwater & Well,* 3rd edition, Johnson screens, A Weatherford Company

Todct D.K. & L.W. Mays, , *Groundwater Hydrology,* 3rd edition, John Wiley & Sons, Inc.

Vengosh,Avner and Pankratov, Irena, 1998, Chloride/Bromide and Chlorite/Fluoride Ratios of Domestic Sewage Effluents and Associated Contaminated Ground Water; Groundwater,v.36, no.5,p.815-824

Win Win Kyi, 2007, Preliminary Report for Sediment Distribution Pattern of Taungthaman Lake, Amarapura Township, Myanmar, *Unpublished Report*, Yadanabon University, Myanmar

Zreda, M. 2007. *Hydrology,* University of Arizona www.myanmargeosciences.org