Groundwater Quality Parameters Assessment for Sea Water Intrusion along Yangon River

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Abstract: The main purpose of this paper is to improve the sustainability of groundwater resources by identifying the problems and suggesting possible solutions to the overexploitation of groundwater in Yangon where groundwater usage is increasing due to insufficient water supply from surface water. In the study area, some of the groundwater is extracted from alluvium and valley filled deposit and some of the areas along the Yangon River are affected by saltwater intrusion due to both of over extraction and tidal effect. Ground water quality parameters of pH, EC (Electric Conductivity), TDS (Total Dissolved Solid), TH (Total Hardness), TA (Total Alkalinity), CL (Chloride), Salinity, Turbidity and Fe are accessed in this paper. Using Guidelines of WHO and IS-10500:2012 Guidelines, parameters are compared to access the quality of groundwater. For the assessment of parameters, 15 tube wells are selected at distances of 400m, 600m, 800m, 1000m and 1200m from the river. From 2015 to present, it can be seen that EC value is significantly higher especially in the buffer line of 600m, near Yangon River.

Index Terms - **Salt Water Intrusion, Groundwater quality, Buffer Lines, Over-Exploitation.**

I. INTRODUCTION

Groundwater is a renewable and invisible resource and it is needed to be sustainably managed and it plays an important role in the social and economic growth of a country. In the absence of fresh water resources, groundwater is exploited to meet the demand exerted by various sectors. As in other urban areas of the world, the development of economic activities and the growth of population in Yangon city have led to the increased exploitation of natural resources including water. The extension of the city through the development of new towns, upgrading works and new construction of infrastructures and also the establishment of industrial zones have accelerated the demand for water.

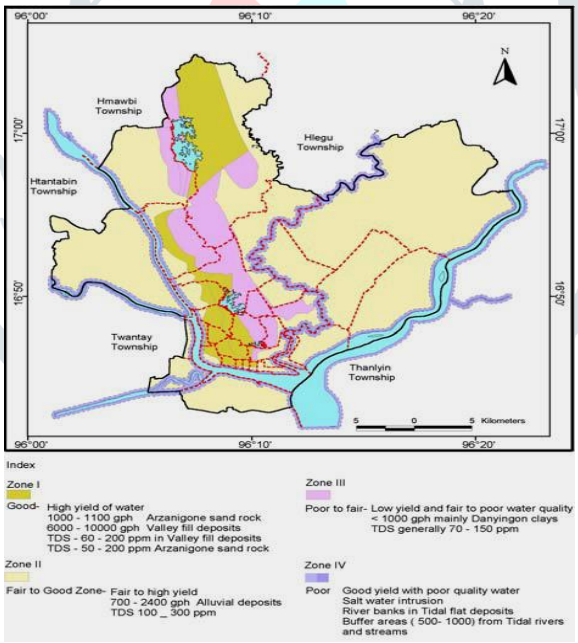


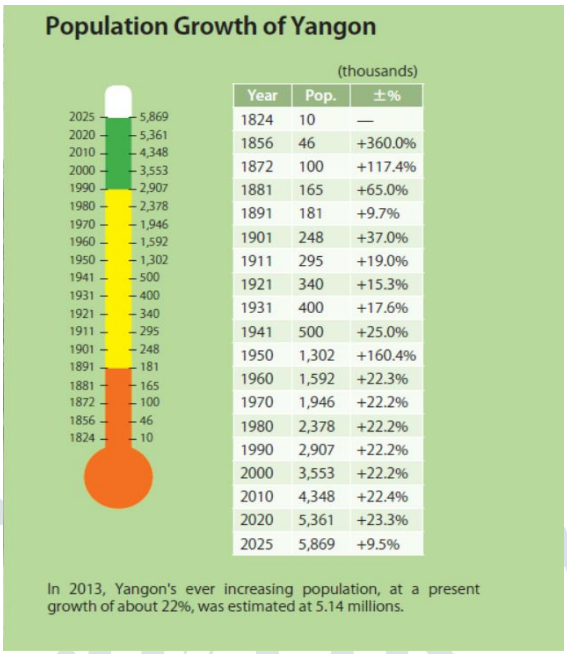
Fig.1 Groundwater potential zones in Yangon area [2]

In Yangon where almost 10% of the total population of the country is living, YCDC's served population is about 39% in the year of 2015/2016 field surveys. Since the water supplied by YCDC is about 39% and the left 61% have to rely on groundwater, lakes and rivers. Most of the residents rely on their private tube wells and therefore the number of authorized or unauthorized tube wells tapping into groundwater is increasing. This would lead excessive use of groundwater which can result groundwater quality degradation through salt water/ sea water intrusion due to depletion of groundwater table. It is therefore necessary to have a detailed knowledge on the groundwater resource of Yangon city. Based on the previous researches, groundwater zone can be classified into four different types. [2] These zones are defined by rock units of geological map of Yangon city. As shown in Fig.1, the groundwater of zone IV can give fair to good yield but the quality of water is poor due to salt water intrusion and tidal action of rivers and stream and wells should not be sunk within 500ft to 1000ft of the rivers.

II. STUDY AREA

Yangon, also a part of delta region is situated at the confluence of Yangon River and Bago River and on the eastern margin of Ayeyarwaddy Delta. It is located between North latitudes of 16˚ 44′ and 17˚ 5′ and East Longitudes of 96˚ 5′ and 96˚ 24′. The city

is divided into four districts and has a total of 33 townships. Among these townships, five townships within the western district of the city along Yangon River are selected to study the water quality assessment as there is tidal river effect, extension of the built up areas and uses of groundwater from tube wells is a little bit more than the other township areas. The the population growth rate is shown in Fig.2 and the selected area is shown in Fig.3.



Year	Pop.	±%
1824	10	—
1856	46	+360.0%
1872	100	+117.4%
1881	165	+65.0%
1891	181	+9.7%
1901	248	+37.0%
1911	295	+19.0%
1921	340	+15.3%
1931	400	+17.6%
1941	500	+25.0%
1950	1,302	+160.4%
1960	1,592	+22.3%
1970	1,946	+22.2%
1980	2,378	+22.2%
1990	2,907	+22.2%
2000	3,553	+22.2%
2010	4,348	+22.4%
2020	5,361	+23.3%
2025	5,869	+9.5%

Fig.2 Population growth rate of Yangon [8]

In the study areas, the increasing of high rise buildings at least 2nd storey from 8th storey and increased impervious concrete roads not only describe lesser recharge area but also show more water need. As a result of unbalance between discharge and recharge groundwater, groundwater table depletion and water quality degradation due to salt water intrusion occurs. The quality of groundwater must be monitored and reviewed how it changed from the past years to the present as a part of sustainable groundwater management.

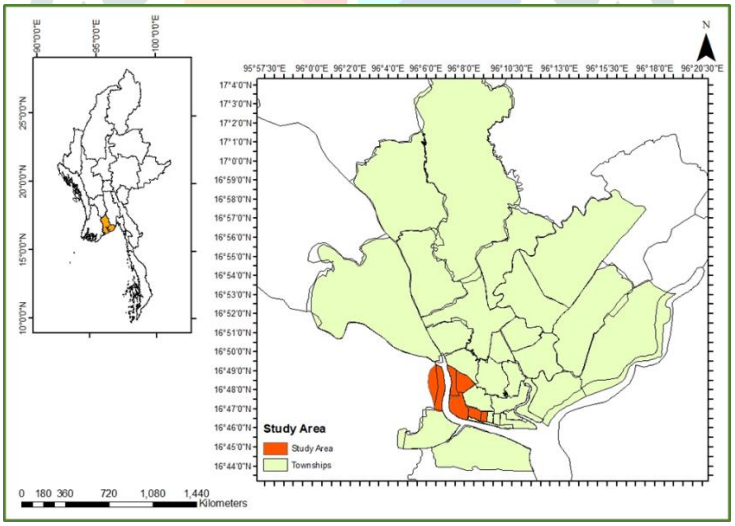


Fig.3 Location map of study area

Yangon is lying in the Ayeyarwady Delta and also in the southern spur of Bago Yoma, its geology consists of Tertiary to Quaternary deposits. Based on the geologic condition of the area, there are three types of aquifers serving considerable amount of water.

i. Groundwater from Alluvial deposits
ii. Groundwater from Valley Filled deposits
iii. Groundwater from Irrawaddy Formation

Of the eleven different types of aquifers in Myanmar as shown in Fig.3, groundwater from Alluvial and Irrawaddian aquifers are more potable for both irrigation and domestic use. [3]

The study area is underlain by Valley Filled deposits and younger Alluvium. [1] Generally the best aquifers are the valley filled deposits on the western flank of Shwedagon ridge which serve as main aquifer of groundwater. But most of the selected YCDC tube wells obtain water from the alluvium unit.

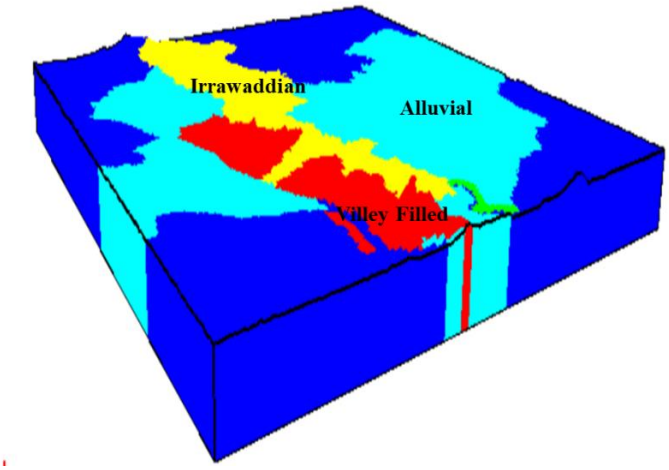


Fig.3 Groundwater aquifer and geology of study area

III. METHODOLOGY

Data Interpretation and Sample Collection

Before the sample collection of the study area, data collection about the selected townships from YCDC is carried out. All the YCDC tube wells in the study are used to fulfill the need for the water supply from the reservoir. Operating hours is twice a day from minimum 8 to maximum 9 hours. The amount of pumping water is varied according to the size of tube wells. The total number of YCDC tube wells in the study area is shown in the following Table 1.

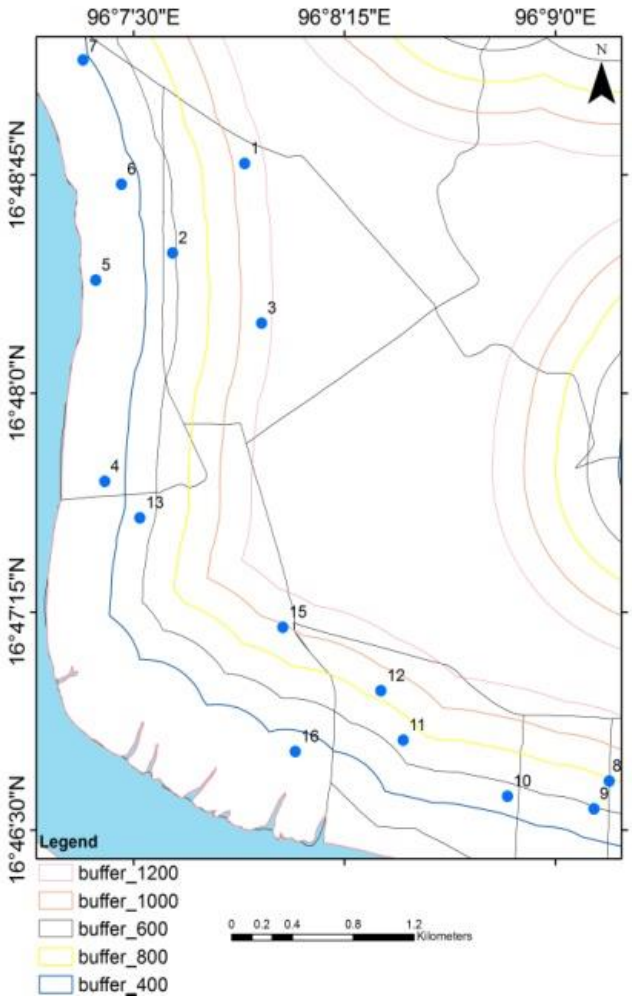


Fig.4.Location map of sample well along the buffer line

Table 3.1: Total Numbers of Tube Wells in Study Area

Township	Total No. of Tube wells (YCDC)	No. of Operating Tube Wells (YCDC)	No. of Closed Tube Wells (YCDC)
Ahlone	29	27	2
Lanmadaw	36	24	12
latha	17	16	1
Kyimyindine	21	19	2
Sanchaung	29	24	5
Total wells in the study area	132	110	22

Among the YCDC tube wells, 15 tube wells are selected according to the Yangon River which has a tidal effect. The distance from the river can be grouped into five buffer lines: 400,600, 800, 1000 and 1200 Buffer from the river. The location of the selected well is shown in above Fig.4.

Fence Diagram

Based on the well log data from YCDC, lithology of the study area is detected by drawing Fence diagram. Fig.5 shows the litho logic characteristics of the study area in order to know its aquifer type. According to the Fence diagram, the study area is mostly underlain by sediments of various grain sizes of sand and gravels and a thick sequence of loose, highly pervious, inter bedded with white or yellowish sand and fine to coarse gravels. White or yellow coarse sand, gravels are found near the bottom and white silt or fine sand and yellowish grey, bluish grey, brownish grey silts and clay are seen at the top. According to the well log data, the aquifer type is confined. [5]

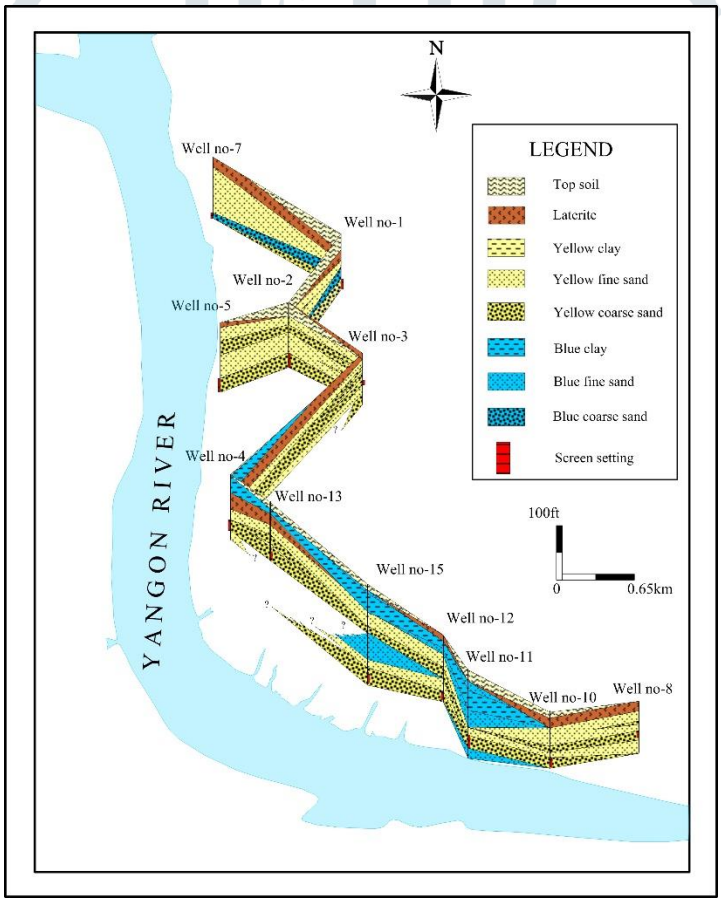


Fig.5.Fence diagram of the study area

Hydrochemistry

The quality analysis has been carried out for the parameters of temperature, pH, Electric Conductivity, Total Dissolved Solids, Salinity, Total Alkalinity, Total Hardness, Chloride, Iron and Turbidity and samples are collected before the start of rainy season (start of June) and during the rainy season (start of August). The parameter pH is measured by using pH meter at the field and temperature EC, TDS and Salinity are also measured at the field by using GMH device. TH and Cl are measured with standard titration method and Iron is measured with standard method and color comparison method. Photometer is used to measure turbidity. The results were compared with the values of Indian Standard (IS-10500:2012) guideline in order to find out the quality criteria.

IV. Results and Discussions

Description of Physicochemical Parameters

Physicochemical parameters of Groundwater sample collected for the five times: comparisons of parameters with the guidelines are described in the following section.

Table 4.1: Comparison Standard of Water Quality Guidelines

Parameters	WHO Guidelines	IS-10500:2012 Guidelines	Unit
pH	6.5-8.5	6.5 to 8.5	-
TDS	1000	500-2000	(mg/l)
EC	1500	700-3000	(µS/cm)
Turbidity	5	1-5	(NTU)
Iron	0.3	0.3	(mg/l)
Chloride	250	250-1000	(mg/l)
Total Hardness	500	200-600	(mg/l)
Total Alkalinity	250	200-600	(mg/l)

pH

The pH indicates the acidic or alkaline material present in the water. In the study area, range of pH for both pre monsoon and monsoon period shows that the area is generally acidic in nature and therefore values of total alkalinity for all the times are within the permissible limit. The comparison of pH with IS; Standard is shown in Fig.6.

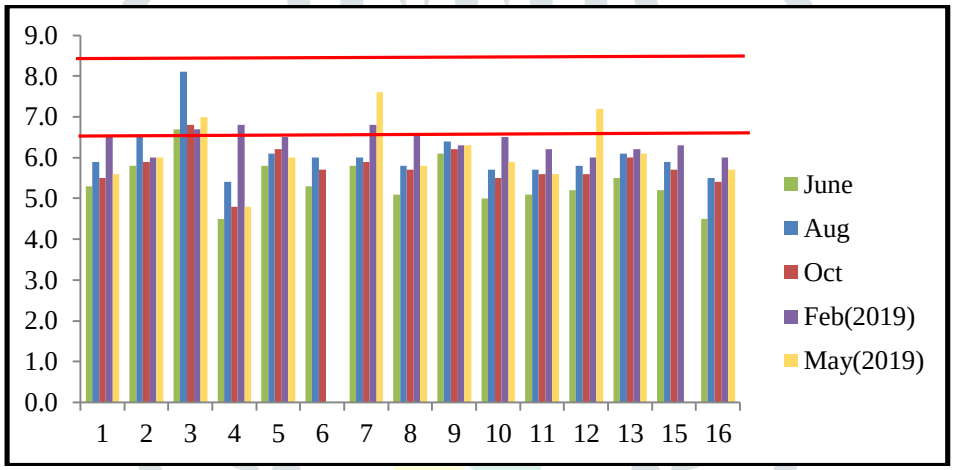


Fig.6. Comparison with IS-10500:2012 Standard for pH

Electric Conductivity (EC)

Electric conductivity can determine the concentration of salt in ground water. Some of the tube wells reach the upper limit in pre-monsoon season and some tube wells are higher than the limit during monsoon. It may be due to high constituents present in the water body. The comparison for Electric Conductivity is shown in Fig.7.

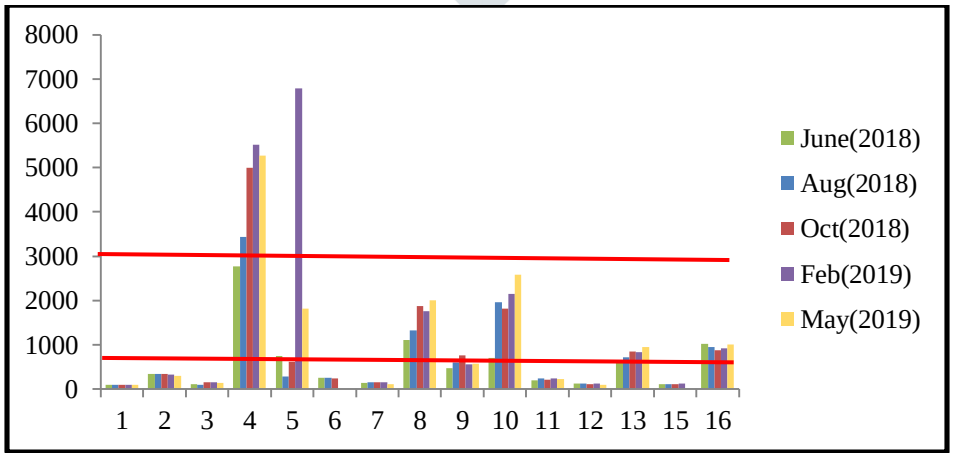


Fig.7. Comparison with IS-10500:2012 Standard for EC

Total Dissolved Solids (TDS)

The prolonged intake of water with higher Total Dissolved Solids can cause kidney stones and heart diseases [4]. In the study area, high presences of TDS may be due to some of the influences of anthropogenic sources such as domestic sewage, solid waste dumping and influence of rock-water interaction. The comparison of TDS for all tube wells is shown in Fig 8.

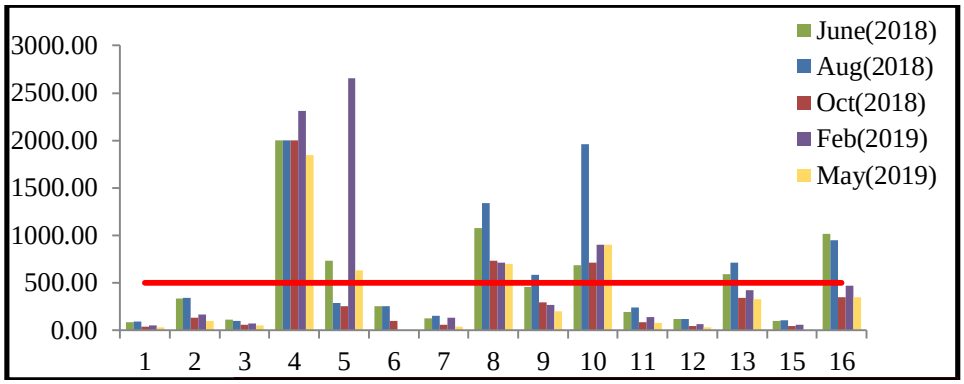


Fig.8. Comparison with IS-10500:2012 Standard for TDS

Hardness (TH)

Hardness of water has no known adverse effect however it causes unpleasant taste, reduce ability of soap to produce lather and hard water is unsuitable for domestic use. In the study area, some of the wells is higher than the limit. Groundwater in the area exceeding limit of 300mg/l CaCO3 is considered to be hard and this may be due to solid waste leakage and geology of the area. Comparison for Total Hardness for all the months is shown in Fig.9.

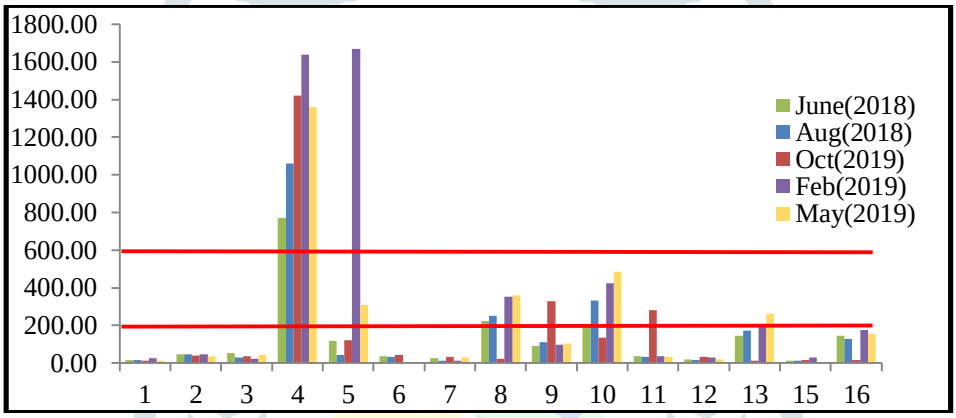


Fig.9. Comparison with IS-10500:2012 Standard for TH

Chlorides

Mostly, chlorides are found in the form of sodium chloride in groundwater. The concentration of chloride depends upon the porosity and permeability of the soil. In the study area, the concentration ranged 11-930 for pre-monsoon and 6-1100 for monsoon season. Some area exceeded the maximum permissible limit and it would be due to the intrusion of salt water as the location of the sample point is located in the nearest distance from the river: buffer 400. The minimum value 6mg/l of Chloride is located in the far distance of buffer 1200 from the river. The comparison of chloride for all monitoring months is shown in Fig.10.

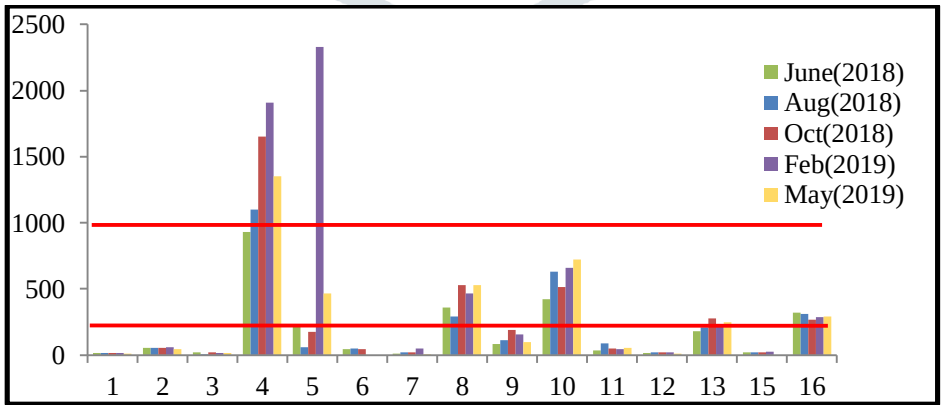


Fig.10. Comparison with IS-10500:2012 Standard for CL

Comparison of Electric Conductivity (EC) along the Buffer Lines

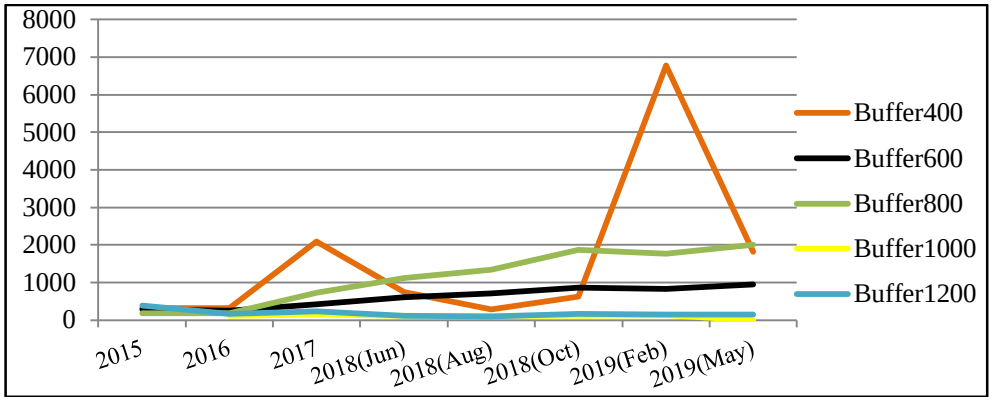
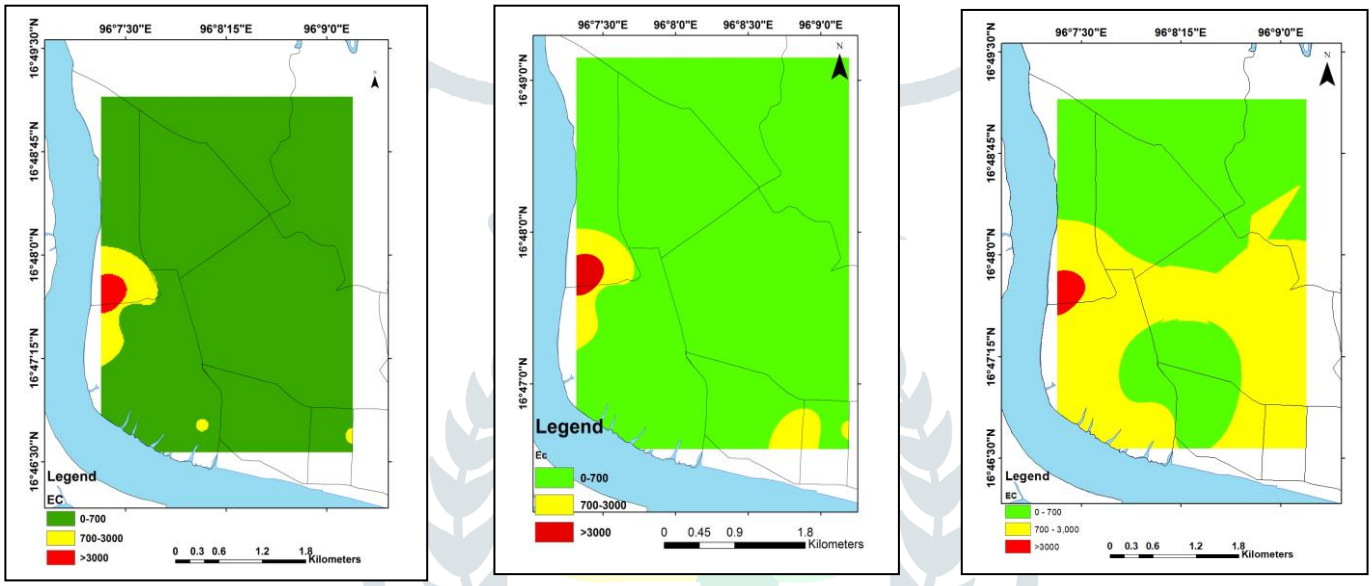
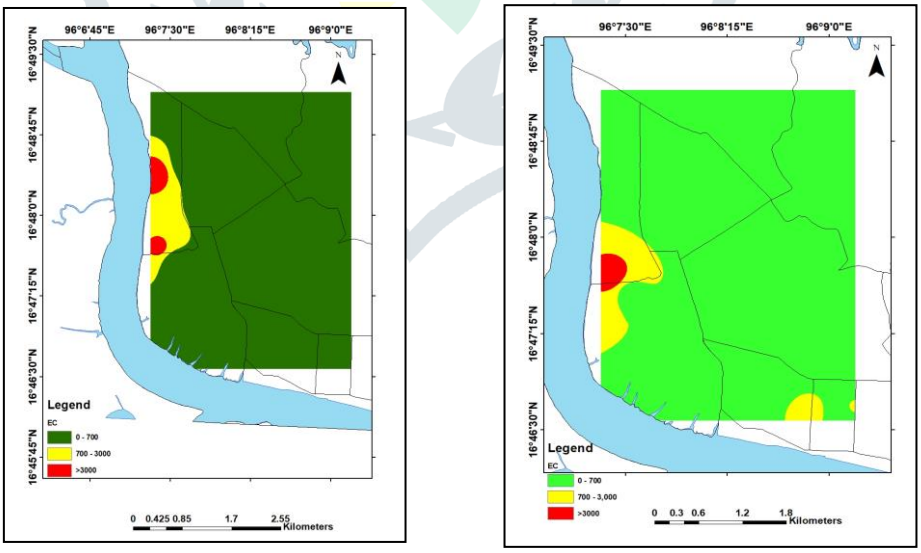


Fig.11. Comparison graph of electric conductivity along buffer lines



(a) (b) (c)



(d) (e)

Fig.12. Spatial distribution maps of EC in (a), June (2018); (b), August (2018); (c), October (2018); (d), February (2019) and (e), May (2019)

The areas of river banks along tidal river where tidal flats and channel deposits occurs can give fair yield but the quality of water is poor due to salt water intrusion and tidal action. Based on the data of 2015 to 2017 from YCDC and the present measurements of pre-monsoon and monsoon in 2018 and 2019, EC values are compared along the buffer lines. As shown in the graph of Fig.11, after the decreasing of EC values from 2015 t0 2016, there is again a steady rise increase in EC values especially near from the Yangon tidal river.

V. Conclusions

There are four zones of groundwater resources in Yangon and groundwater is extracted through the tube wells at random and there is no control with regard to location, size, depth, quality and amount of extracted rate etc. In the study area, fresh water floats on top of the saline water and there is a delicate hydrologic balance between fresh and saline water. In spite of the good yield, the water quality is poor due to salt water intrusion from the tidal river. Therefore, groundwater quality analysis is done to examine salt water intrusion near Yangon River. It can be seen that electric conductivity is higher in the areas of 800m Buffers distance from the river. If the rate of groundwater extraction is still at the present rate, the negative impact of salt water intrusion can occur in these areas. It should therefore be regarded as a groundwater conservation zone in the areas of near Yangon River especially in the distance of 800m from the river.

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