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A Study on Ground Water Scenario in Dhaka, the Capital City of Bangladesh

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ABSTRACT: The ever increasing population of Dhaka is making the management of water supplies very difficult. In order to properly manage the situation, it is important to assess the existing condition of groundwater level in Dhaka and make future predictions which will enable to prepare accordingly. In this regard few data and information for several deep tube-wells of ten zones of Dhaka water and sewerage authority for the year 1998 to 2018 were collected. This study showed that due to construction of buildings, roads and concrete pavements natural water recharge to aquifer cannot keep pace with the water withdrawal, since more than three decades. This study shows that the average declination of static water level in Dhaka City is 3.06 m per year, where maximum declination occurs at zone six and zone four whereas minimum declination occurs at zone two. As a result, it is observed that specific capacity is decreasing rapidly. This study also shows that in Dhaka city, overall loss of specific capacity per year is 0.1 l/s/m, where maximum loss rate found at zone five and minimum loss rate found at zone one and zone ten. If this loss rate continues, in 2050 most of the Deep Tube Wells will become inactive.

KEYWORDS: Ground Water, Declination, Specific Capacity, Static Water Level

I. INTRODUCTION

Water constitutes two-thirds of the surface of the earth and is a crosscutting resource. Moreover, water is considered as a driving force for sustainable development and a strategic tool to fight against poverty. Water resources have unlimited importance in human survival, socio-economic stability and environmental sustainability. Water covers 71 percent of the earth's surface but only three percent is fresh water out of which a few percentage is "trapped" as ice, mainly in the two polar regions and the remaining fresh water occurs in rivers, lakes and aquifers is used by human being, plants and other animal species.

The alarming news is that in South Asia, the withdrawal rate against available resources is 48 percent [1]. Bangladesh being a riverine country, has been facing dual challenges from water: firstly, unlimited flood water during wet season and secondly, increasing scarcity of fresh water during dry season. Bangladesh is one of the most densely populated countries in the world with a population of over 150 million and has struggled with water supply issues for many years [2]. But it becomes the biggest problem in the nation's capital at Dhaka.

Dhaka is the economic and cultural center of Bangladesh and has evolved into one of the largest mega cities in the world over the past decade [3]. The rapid growth of the population has caused an immense pressure on the water supply of the city [4]. Dhaka Water Supply and Sewerage Authority (DWASA) abstracts up to 78% of the water supply from underground resources [5]. The domestic abstractions together with all private abstractions result in a total abstraction of approximately 1.5 billion cubic meters from the groundwater each year [6]. This has resulted in a drawdown up to 70 meters with an annual decrease of 2 meters [7]. This drawdown of groundwater can eventually lead to drying out the wells [8] and a significant increase in pumping costs [9]. This study will help to assess the current scenario of ground water level in Dhaka city, create awareness among people and take necessary steps to improve the existing condition as well as increase potential groundwater recharge rate for Dhaka city.

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II. LITERATURE REVIEW

Intensive use of groundwater can play a key role in the growth and development of cities. However, understanding the influence of urbanization on groundwater quality and quantity is essential if future resources are to be adequately confined from potential depletion of water quality. Of the 23 mega cities with a population of over 10 Million by 2000, 12 cities are heavily dependent on groundwater and 11 out of the 12 are in developing countries. As the surface and groundwater resources are under threat of vulnerability in terms of quality and quantity, the usage of treated/processed water for drinking is growing in recent years.

Howard and Gelo enlighten the linkages between the dependence of peri-urban aquifers in the water supply provision and urbanization effects. It has been accepted that urban areas evolve through a series of distinct stages as they gradually mature.

During early stages of development, water is normally supplied by shallow open wells in a generally central location. On-site sanitation is the prime method of disposal for human waste. As growth accelerates, the settlement commonly experiences degradation of shallow groundwater and the slow decline of water levels, which observed in many emerging cities nowadays. Deeper wells initially provide a temporary solution but inevitably there is a shift towards new pumping wells in the adjacent peri-urban areas. Finally, increasing demand is met by transporting water from distant sources and the city becomes a major net importer of water.

Dhaka Water Supply and Sewerage Authority (DWASA) abstracts up to 78% of the water supply from underground resources. Overall in Bangladesh, the groundwater level in the capital has dropped by six meters in the last seven years. The water table was 51 meters below MSL in 2010 against 46 meters in 2004. MSL is a measure of the average height of the ocean's surface -- the halfway point between the mean high tide and the mean low tide.

In the past, the underground vacuum in the city used to be recharged by the water flowing from the north- from the aquifer of Gazipur district and its adjoining areas. But, at present, these areas too are suffering from severe depletion of groundwater level. Over the past seven years, the water table of Gazipur district has dropped from four meters below MSL to 16 meters.

III. METHODOLOGY

Groundwater situation on static water level is an important parameter for ground water budgeting, protection of quality degradation and future expansion plan. Hydraulic distribution also provides valuable information for evaluation of groundwater availability, flow trends and designing of upper well casing.

In order to study the long term trend of groundwater level depletion in Dhaka city of Bangladesh, groundwater level data is required. Mainly ground water level monitoring is carried out routinely by BWDB, BADC and DPHE. DPHE maintain observation wells at different location in Bangladesh. All the available data of observation well is collected from DAWASA, BWDB. Number of tube wells and their installation year, data of previous tube wells are collected from BADC, DWASA. The data of groundwater withdrawal of Dhaka city is collected from DWASA[10]. Data regarding groundwater level of observation wells were collected from BWDB [11]. The expansion of Dhaka city was mainly in and around the river Burigunga. The canals within the mega city Dhaka & the rivers surround the city are acting as natural drainage system, water reservoir and the river route. These canals are Begunbari khal, Segunbagicha khal, kallayanpur khal, Dholai khal etc. The surrounding rivers are Buriganga, Shitolakhya, Balu, Turag & Dhaleshwari. DWASA provides information of Fixture depth, static water level, pumping water level and specific capacity etc. They provided data of installation and reinstallation of wells for last 37 years (1980-2017). To evaluate average declination rate and average specific capacity, several tube wells from different zones have been chosen according to the consideration of latest installation, fixture depth, Static water level and Specific capacity so that data represents the current scenario and a long term trend of groundwater depletion can be established in Dhaka city of Bangladesh. After rearranging the collected data the missing data is filled by adopting several statistical measures. Then a zoning map is drawn which showed ground water level depletion rate in Dhaka city. And also the loss of specific capacity and few future projections regarding ground water condition of Dhaka city are shown through graphical representation.

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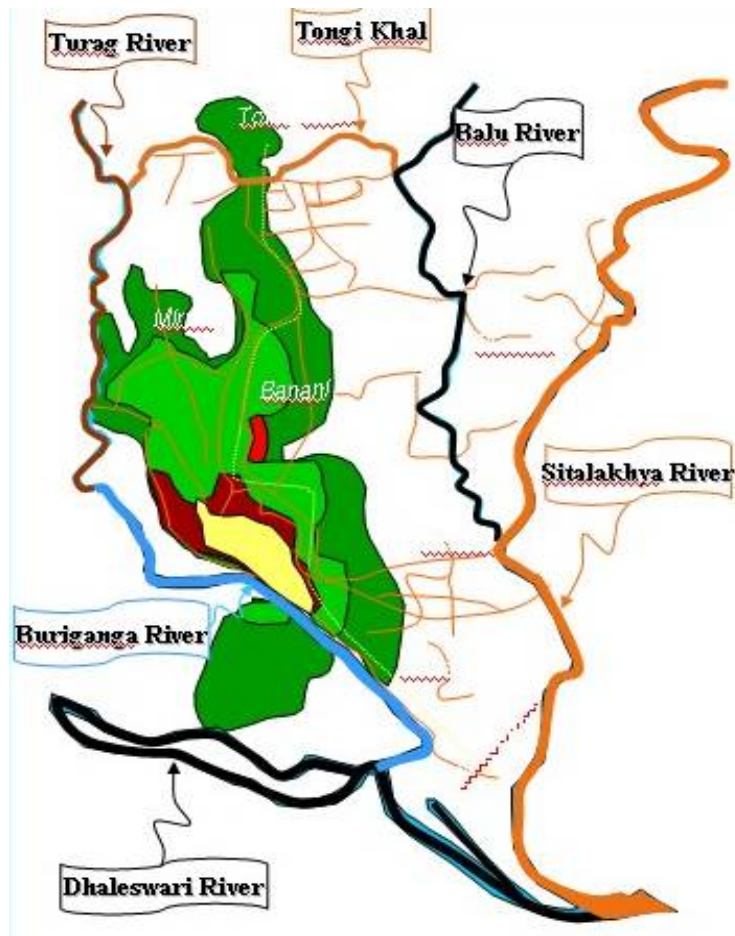


Figure 1: Map of service area of DWASA

IV. EXPERIMENTAL RESULTS

For this study, five tube wells have been selected from each ten zones of DWASA and compared the static water level of two different years, based on data availability of recent years for each well and three tube-wells were selected for collection of data of specific capacity. By using simple statistical means, interpolation and average yearly declination rate for each zone and is determined.

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Table 1: Static water level of several tube-wells in zone -1 of DWASA

Zone	Well No.	Location	Date of Completion	SWL (m)	Declination Rate (m/y)	Avg. Declination Rate (m/y)
1	101	Bashaboo-1 (North)	2004	59.45	2.3	2.2
			2016	86.89		
	104	Bashaboo-4 (South-Kadamtala)	2007	22.91	3.6	
			2013	43.03		
	105	Ahmedbag	1999	42.00	2.2	
			2011	68.77		
	109	Mugdapara-2 (Opposite of ICD)	2004	55.95	1.0	
			2016	56.43		
	112	Gandaria-1 (Dist. Rd)	1998	29.00	2.0	
			2014	61.29		

In Table-1, data of static water level of five different tube-wells situated in zone-1 of DWASA during two different years is provided. Yearly declination in ground water level is calculated there from and finally average declination is estimated as 2.2 m/y.

Table 2: SWL declination rate in ten zones of DWASA

Zone	1	2	3	4	5	6	7	8	9	10
Declination Rate of SWL (m/y)	2.2	2	2.76	4.14	3.92	4.1	2.6	2.9	2.28	3.74
Avg Declination Rate of SWL (m/y)	3.06									

Similar calculations are repeated for the other nine zones and finally the average yearly declination of SWL of ground water is found to be 3.06 m as shown in Table-2. From the above table it is observed that highest declination of ground water level occurs in zone 4 and lowest in zone 2. Using the above data, zoning map of ground water declination rate is plotted (figure-2) which gives a quick review of the overall situation of ground water situation in Dhaka city.

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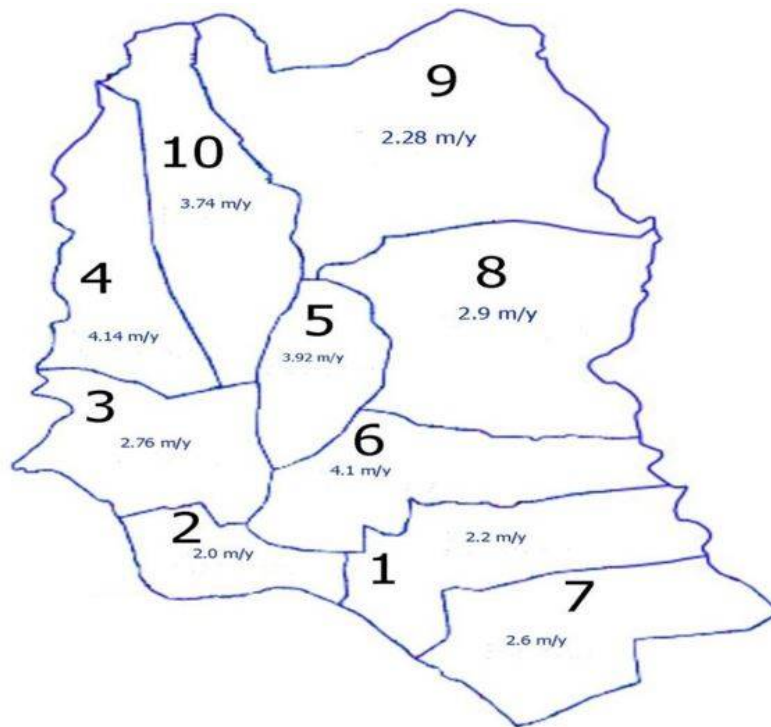


Figure 2: Zoning map based on declination of static water level

In order to understand the future scenario of ground water level a future projection of SWL and its graphical representation is shown below in table-3 and figure-3. If excessive withdrawal of Ground water continues and condition of insufficient recharge of Ground water sustains, by the year 2050 on an average static water level in Dhaka city will decline by 161 m.

Table 3: Present condition and future prediction of Declination of SWL (m) in Dhaka City

Zone/Year	1	2	3	4	5	6	7	8	9	10
2000	50.25	22.16	31.4	24	45.4	40	18.4	30	12.11	28.36
2017	87.05	50.96	74.6	76.2	85	100.8	70.6	82.2	60.71	71.56
2030	119.25	70.16	103.4	111	111.4	154	105.4	117	93.11	100.26
2050	165.25	102.16	151.4	169	155.4	230	163.4	175	147.11	148.36

In the following figure-3, it is revealed that by 2050, SWL of almost all the tube-wells of Dhaka city will be lowered by more than 150 m below ground level. In such cases, few tube-wells will not be able to extract water any more.

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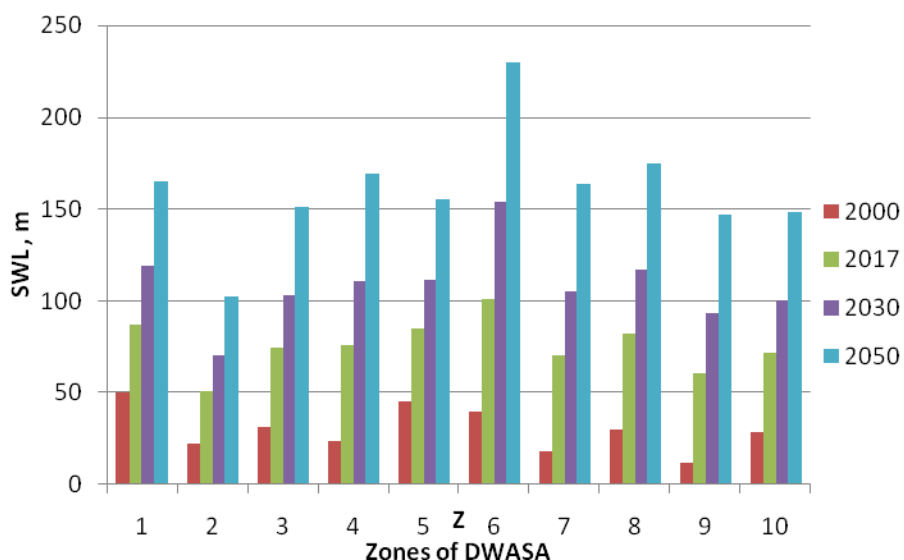


Fig. 3: Present condition and Future Prediction of Declination of ground water level

In table-4, specific capacity of three tube-wells in zone-5 of DWASA for two different years is given. From the following table it is revealed that specific capacity of a particular tube-well is reducing. Loss of specific capacity is estimated there-form and finally average loss of specific capacity of zone -5 is found to be 0.22 l/s/m

Table 4: Specific capacity of zone 5 of DWASA

Zone	Well No.	Location	Date of Completion	Specific Capacity (l/s/m)	Sp. Capacity loss Rate (l/s/m)	Avg. loss Rate of Sp. Capacity (l/s/m)
5	502	Banani-4 (Rd.no.8)	1998	5.02	0.054	0.22
			2005	4.64		
	503	Banani-5	1998	5.65	0.505	
			2000	4.64		
	511	Mohakhali Laboratory	2003	4.66	0.101	
2010			3.95			

Due to continuous lowering of GWL specific capacity of ground water is also decreasing day by day. Similar calculations are repeated for the other nine zones and finally the average loss in specific capacity of ground water is found to be 0.10 l/s/m (table -5). If such condition continues, by the end of 2050, average specific capacity will be reduced to 1.80 l/s/m, which is 51% less than average specific capacity of Ground water (3.7 l/s/m) of 2018.

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Table 5: Yearly loss in specific capacity in ten zones of Dhaka city

Zone	1	2	3	4	5	6	7	8	9	10
Loss of Specific Capacity per year (l/s/m)	0.05	0.15	0.08	0.03	0.22	0.17	0.1	0.06	0.11	0.03
Avg Loss of Specific Capacity per year (l/s/m)	0.1									

By using the average loss in specific capacity, a future projection of specific capacity in ten zones of DWASA up to 2050 is shown in table-6. The following table shows that specific capacity is reducing drastically

Table 6: Present condition and prediction of Specific capacity(l/s/m) of Ground Water

year/zone	1	2	3	4	5	6	7	8	9	10
2000	3.97	7	4.39	4.14	4.96	4.15	6.07	4.5	4.9	5.07
2009	3.52	6.46	3.76	3.96	4.06	2.8	5.53	4.14	4.09	4.53
2018	3.07	5.92	3.13	3.78	3.16	1.45	4.99	3.78	3.28	3.99
2030	2.47	5.2	2.29	3.69	1.96	0	4.27	3.3	2.2	3.27
2050	1.47	4	0.89	3.39	0	0	3.07	2.5	0.4	2.07

Finally, a graphical representation of specific capacity showing the present scenario as well as future projections is done in figure-4. The graph shows a continuous reduction in specific capacity and by the end of 2050 specific capacity of tube-wells of zone 5 and zone 6 will reduced to zero.

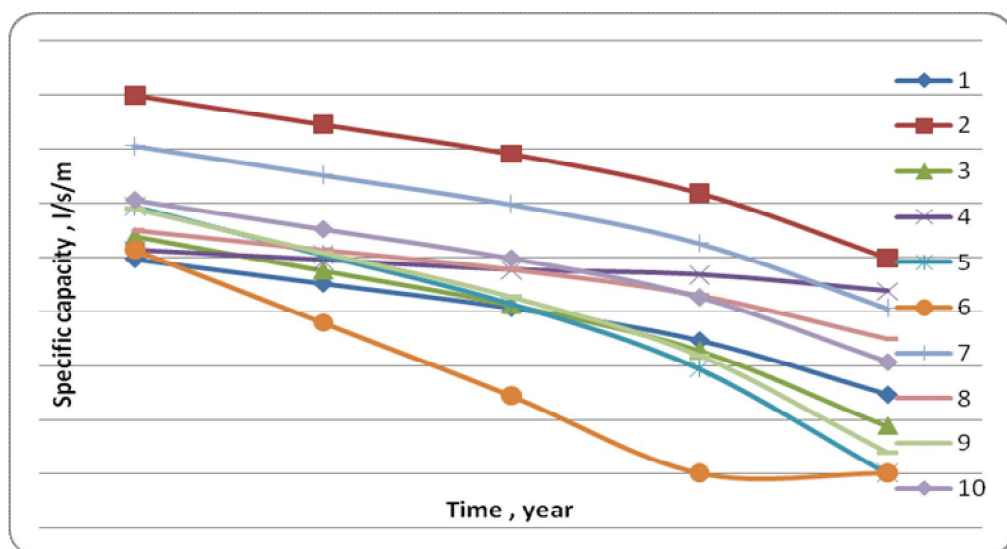


Fig. 4: Graphical representation of present specific capacity and future prediction

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IV. CONCLUSION

Groundwater table in the capital has dropped down to 100.80 meters below the surface, 60 meters in the last eighteen years. In 2000 the groundwater table was only 40.0 meters below the surface, declining at the rate of over three meters on average every year. This study shows that due to construction of buildings, roads and concrete pavements natural water recharge to aquifer cannot keep pace with the water withdrawal since more than three decades, causing declination of water table. This study shows that the average declination of GWL per year in Dhaka City is 3.07 m, where maximum declination occurs at zone four and minimum declination occurs at zone two. A previous study shows that due to excessive withdrawal of ground water an annual decrease in level is about 2 meters [12]. If such declination continues and condition of insufficient recharge of Ground water sustains, by the year 2050 on an average static water level in Dhaka city will decline by 161 m.

During the study it is observed that specific capacity of ground water table also decreasing rapidly. The result shows that in Dhaka city loss of specific capacity per year is 0.1 l/s/m, where maximum loss rate found at zone five and minimum loss rate found at zone ten. By the year 2050 average specific capacity will be reduced to 1.80 l/s/m which is 51% less than average specific capacity of Ground water table (3.7 l/s/m) of 2018. If this situation continues, in 2050 several deep tube-wells will become inactive.

The present water supply in Dhaka city is heavily dependent on groundwater that ensures a future threat with acute water crisis. Though DWASA has already started to shift its present groundwater based production system to surface water production, the shift demands huge investment and time. Moreover, the status of peripheral rivers of Dhaka city is highly degraded and a major portion is under illegal encroachment. That is why it is highly unlikely to fulfill the future demand just by relying on these sources. Considering the present crisis and future demand, it is high time to seek additional sources. If water table continues to fall then a vacuum will be created in the aquifer which could cause a sudden collapse in the surface. Excessive withdrawal of groundwater to meet the needs of about 15 million city residents and inadequate recharging will result in intrusion of southern saline water into the groundwater reservoir, depriving this mega city of pure drinking water.

Some recommendations to improve the water supply system of Dhaka city may be listed as follows:

1. Increase surface water collection rate by adopting new technology should to improve the quality of surface water.
2. Alternative source of water supply for example - rainwater harvesting can be introduced at a massive scale to ensure supply of drinking water to the households who still have no piped connection.
3. Permeable concrete should be introduced by construction industry to increase infiltration.
4. Decentralization of several activity, so that pressure of the excessive population on the exiting population can be minimized. As well as infiltration rate may be increased.
5. Pollutant load of existing river can be minimized by introducing ETP in every industry (small or big).
6. Recycling of waste water and to use it in different work and way.
7. Adoption of Green Building concept and increase tree plantation.
8. Sewerage treatment system should be more efficient so that effluents do not pollute their destination.
9. Devise and implement pro-poor water policies by taking climate change, future urban growth, consumers' water demand and preference into consideration.
10. Proper awareness campaign through print and electronic media should be carried out to inform and to aware people regarding, right to water and the reduction of the misuse of water.

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