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Pumping and sustainability of groundwater resources: A case study on Mohadevpur Upazila of northwest Bangladesh

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Abstract

Excessive pumping of groundwater is a warning for sustainability of an aquifer. In this research, abstraction of groundwater and its impact on shallow aquifer in Mohadevpur Upazila are evaluated from analysis of exploratory bore logs, historical record of groundwater level, rainfall, river water level and pumping data. A coarse sand aquifer with occasional gravel and a fine sand aquifer, with thickness 15 m to > 55 m and 3 m to 38 m respectively, are revealed from bore log analysis within 100 m depth. The aquifers, prevailing in most of the area, are confined to semi-confined in nature. Annual fluctuation of hydraulic heads of groundwater were almost stable up to 1991. After 1991, these variations has decreased in most of the area. Seasonal variation in hydraulic heads is strongly associated with monsoon rainfall and river water level. Analysis of data reveal that the annual artificial discharge of groundwater from shallow aquifer has gradually increased with the expansion of irrigation since 1980. In 2015, artificial discharge was about 51 times higher than that of 1980. However, the rate of extraction was reduced at the later period. Decadal changes in hydraulic heads from 1990 to 2020 show that groundwater spatially flows from central part towards peripheral area in all seasons except in south central part of the area in dry season of 2010. Declination of hydraulic heads of groundwater is observed in most of the area for both dry and wet seasons within 30 years from 1990 to 2020. The declination rate varies from 0.1 to 0.35 m/yr. Declining trends in average pressure heads of groundwater are alarming in north east and south east parts of the area. Though the decrease in regular vertical recharge of groundwater is deduced in this area, increased rate of declination in hydraulic head is primarily be an impact of long term pumping of groundwater at higher rates, which might be a cause of enduring environmental issues on that area.

Keywords: Aquifer, Exploitation of groundwater, Hydraulic head, Sustainability.

Introduction

Groundwater has been used as an important source of fresh water for the fulfilment of domestic, irrigation and industrial water demand throughout the world. From 1980 to 2022 the population of Bangladesh increased from 83.93 million to 169.82 million. Over 87% of this population is somewhat related to agriculture-

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based economy. As the largest employment sector in Bangladesh, agriculture has been a key driver to exterminate rural poverty in Bangladesh. However, proper development of agricultural sector is depended on the proper planning of available water resources and systematic use of modern technology. In this research work, a hydrogeological study is carried out in the Mohadevpur Upazila of Naogaon district in north west part of Bangladesh, where the groundwater is used as a main source of water to fulfil the domestic, agricultural and industrial needs especially in dry season.

The study area (Fig. 1) is located in between latitudes 24°48′ N to 25°01′N and longitudes 88°38′ E to 88°53′ E with an area of about 397.67 sq. km. Two distinct landforms characterize the area – a portion of the Barind Tract covering about 70.30% of the total area and the floodplain of the River Atrai covering about 29.70% (UNDP/FAO 1988). Other than, the River Atrai and the River Shib flowing from north to south direction, Sikari Beel and Belakuthi Beel are prominent surface water bodies in the study area.

Tectonically, Mohadevpur Upazila is situated in the Stable Platform of the Bangal Basin. The Stable Platform is a part of the continental crust overlain by the sediments of Cretaceous to Recent times. Distribution of the physiographic units shows the variation in surface geology of the area. The oldest surface deposits outcropped in the Barind area is the Modhupur Clay of the Pleistocene age. This formation is consisting of unconsolidated yellowish brown to brown clay in upper part and changes progressively into coarser sediments with increasing depth. In the areas of recent floodplain alluvium, silts and clay predominate in the upper 8 m to 10 m and with depth these deposits also become coarser (BRAMMER 1971; MORGAN & MCINTYRE 1959; MONSUR 2020).The surface temperature and air temperature are relatively higher in the Barind Tract (BEGUM *et al.* 2003). The study area is characterized by a tropical-humid climate with extreme hot and cold of the country. The cold weather prevails from November to February with temperature ranges from 5°C to 15°C. This period is cool and almost lack of precipitation. The period, from March to May, is hot and has periodic thunders shower. Temperature generally reaches maximum about 42°C in April and May. From June the monsoon starts and prevails up to October.

The population density is 740 person/sq. km (BBS 2011). Economy of this area is mainly based on agriculture. Total cultivated land is 30350 hectares. For the extension of irrigation a huge number of tube wells has been being installed and operated within this area from the early seventies. Due to excess abstraction, maximum depth to groundwater level in and around the well field is declining significantly (SHAMSUDDUHA *et al*. 2009; BEGUM 2003). Over pumping of groundwater may cause the irreversible environmental impacts. Deterioration of groundwater quality is already inferred in some part of the Barind area (KNAPPETT *et al.* 2016; WOOBAIDULLAH *et al.* 1998). Proximity to a confining clay layer expels organic carbon as an indirect response to groundwater pumping which caused arsenic contamination of the pre-Holocene aquifer in Bangladesh (MIHAJLOV *et al.* 2020). Some researchers devised a mechanism to infer the pumping triggered direct evidence of As contamination in aquifers of different localities in Bangladesh, Vietnam and California (MIHAJLOV *et al.* 2020; ERBAN *et al.* 2013; SMITH *et al.* 2018). The main objective of this study is to evaluate the effect of long term pumping of groundwater and its impact on sustainability of the shallow aquifer.

Materials and Methodology

In this research, 14 exploratory bore logs data were analyzed to find out the location, depth, extent, thickness and constituents of aquifers and aquitards prevailing in the study area. The data were collected from Bangladesh Water Development

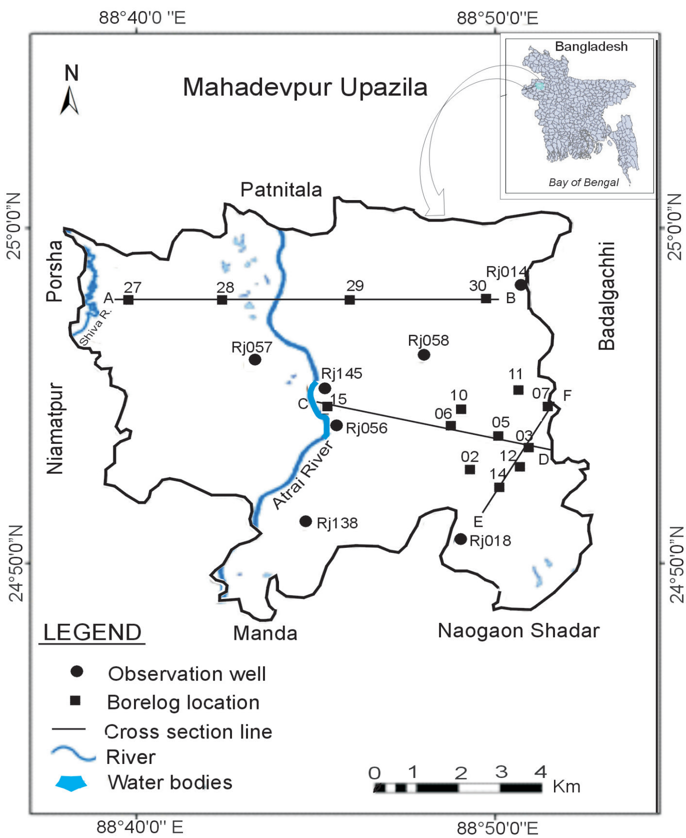

Fig. 1. Location map of the study area.

Board (BWDB). In the bore log data collection program, drilling of shallow (about 53.35 ~ 107 m depth) holes were accomplished by core drilling rigs which collected split-spoon and washed samples at selected intervals and at changes in lithology. The lithological log is prepared at the test site by the field geologist. Groundwater level data from 7 (seven) piezometric wells for 40 years (1980-2020), collected from BWDB and BIADP (Barind Integrated Area Development Project), were analyzed to observe the occurrence, movement and fluctuation of hydraulic head of groundwater. The piezometric wells are small diameter wells equipped with screens installed at depths of 22.36 m to 34.67 m. Data locations are presented in the map (Fig. 1).

For each observation well these water level data has been recorded periodically (every Monday at approximately 6 am) over the years. Daily and annual rainfall (from 1980 to 2020), river water level and discharge data of the River Atrai for the same period collected from Bangladesh Meteorological Department (BMD), Bangladesh Water Development Board (BWDB) and Water Resources Planning Organization (WARPO) were used to verify the changes in the sources of annual recharge to the aquifer in the study area. A record on historical growth of various irrigation equipments in the study area was also collected from the reports of Bangladesh Agricultural Development Corporation (Badc 2007 & 2020) and Barind Multipurpose Development Authority (Bmda 2004) to assess artificial discharge from the aquifer.

Results and Discussion

Geometry and Type of Aquifer

Analysis of individual exploratory bore log, hydro-stratigraphic cross sections (Fig. 2) and a three-dimensional fence diagram (Begum *et al*. 1997) portray the variation in lithology, thickness and extension, particularly a three-dimensional view of the subsurface sequential position of the aquifer and aquitards in the study area. The aquifer is sandwiched between upper and lower clay and silty clay aquitards over most of the area. The aquifer consists of fine to coarse grey to yellowish brown sands and occasional gravels of the Dupi Tila Formation of the Pliocene age. Thickness of the coarse sand and fine sand aquifers range from 15 m to > 55 m and 3 m to 38 m respectively.

The upper brown to reddish brown clay and silty clay layer varies up to 15 m in thickness. The lower silt and clay layer with very fine sand lenses is encountered in 6 bore logs at depth from 35 m to 48.78 m with thickness ranged from 1.5 m to > 60 m. From lithological characteristics and sequential position of the strata, it is assumed that the aquifer existed in this area is confined to semiconfined in nature. Hydraulic

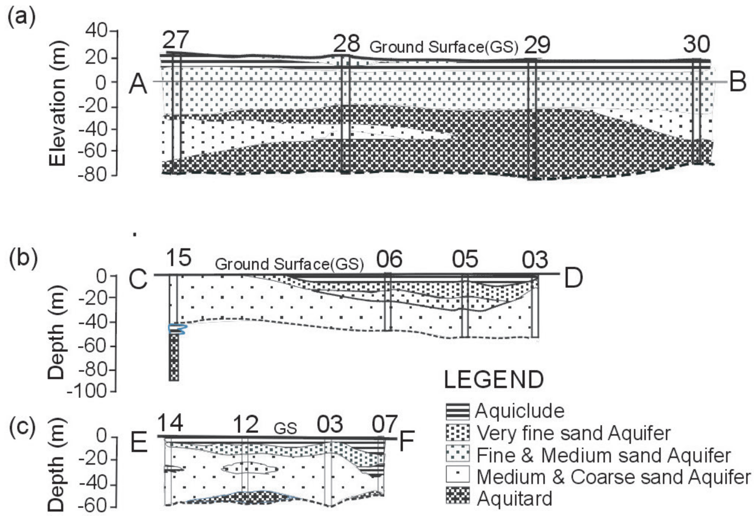

Fig. 2. Subsurface hydro-stratigraphic cross sections along the lines AB(a), CD(b) and EF(c). The lines are shown in the location map of (Fig. 1).

properties of the aquifers calculated by previous works (BEGUM 2003; BEGUM *et al.* 1997) also comply the observation about the nature of aquifers in this area.

Fluctuation of Groundwater and Surface Water

In this research work, weekly groundwater level data from January 1980 to December 2020 are analyzed and used to calculate the total hydraulic head based on Bernoulli Principle (BERNOULLI 1968). Results are presented in the Fig. 3. The figure (Fig. 3) demonstrates the elevation of groundwater levels are highly seasonal and influenced by the strong seasonal variations of monsoonal rainfall (Fig. 4a). Seasonal changes in initial pressure heads were almost stable up to 1991 and ranging from 3.99 to 7.62 m for dry and wet seasons respectively. After 1991, these variations have gradually been decreased in most of the area fluctuating from 0.48 to 4.3 m. Overall trend of average pressure heads of groundwater has also been declining in all observation wells since 1991 except well no. RJ145 (Fig. 3). In well no. RJ145, the pressure head shows an increasing trend from 2015 (Fig. 3g-2). The increasing trend in pressure head could be attributed to the pumping of groundwater at lower rate from 2015 (Fig. 5 & 6). From the observation of seasonal fluctuation and long term changes in hydraulic head in between 1980 to 2020, alarming condition are found in and around the area of observation well nos. RJ014, RJ057, RJ058 and RJ138 (Fig. 3a,b,c & d). Declination of groundwater level in other parts of the Barind Tract area are also detected by different research works (BEGUM & MARRIOTT 2011; HASAN *et al*. 2018; SHAMSUDDUHA *et al*. 2009).

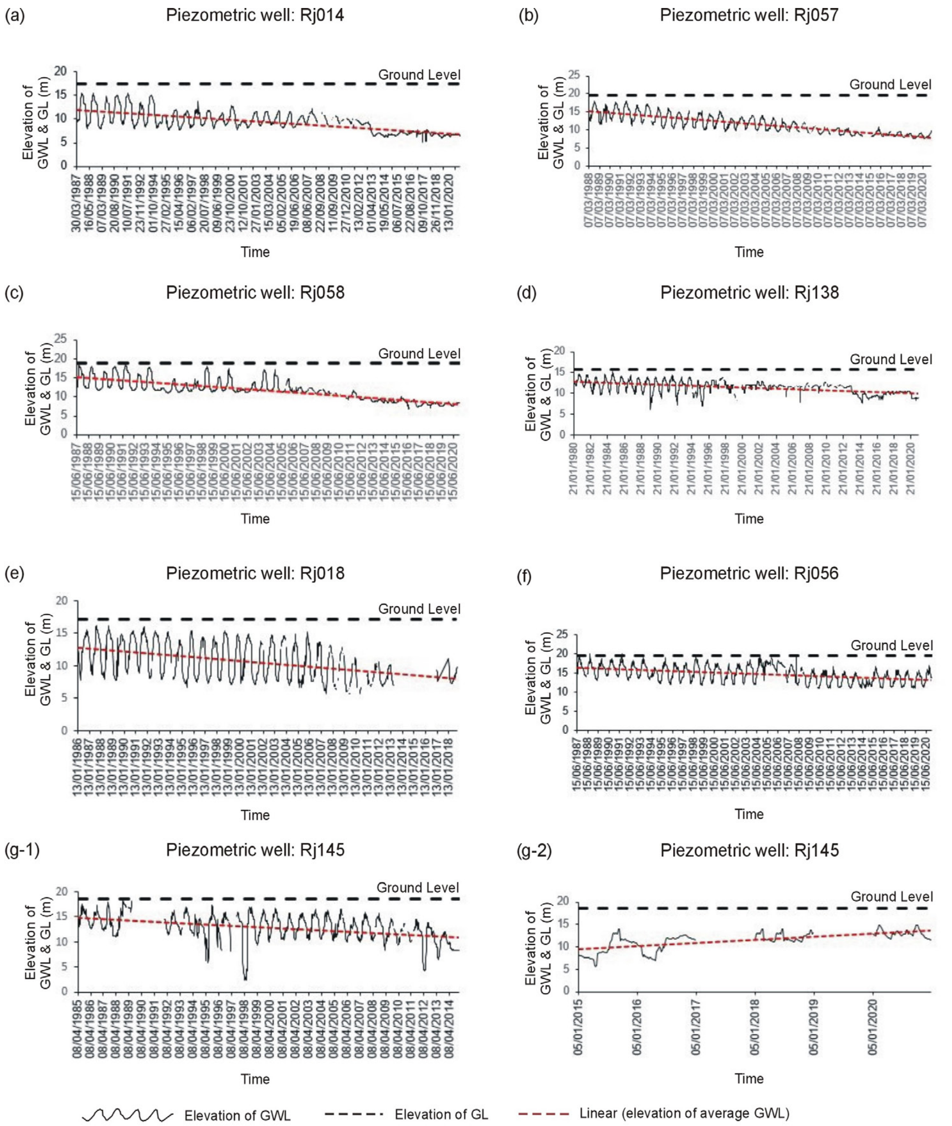

Fig. 3. Hydrographs represent the seasonal variation in hydraulic head of groundwater. Linear trend lines also signify the gradual declination (**a** to **g**-1) and increase (**g**-2) in hydraulic head.

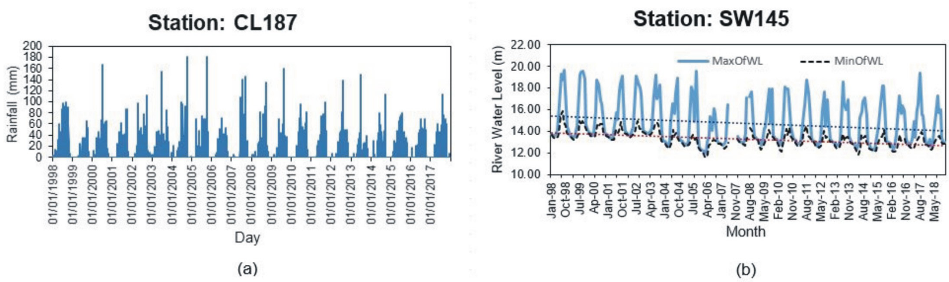

Fig. 4. Hydrographs of (a) daily rainfall and (b) monthly river water level data represent the seasonal variation in the monsoon rainfall and river water level for the River Atrai in the study area respectively. Solid and dash curves (b) symbolize maximum and minimum water level. Linear trend lines (b) also represent the gradual declination of river water level for dry and wet season.

Water levels of the River Atrai (Fig. 4b), for dry and wet seasons, shows a gentle declination of river water levels over the years from 1998 to 2018, which indicate the decreasing trend of regular river water discharge as well in the study area.

Groundwater Abstraction and Decadal Changes in Hydraulic Head

For the development of irrigation, the number of shallow tube wells (STW) and deep tube wells (DTW) installed in the study area has gradually been increasing over the years since 1980 (BWDB 1990) (Fig. 5). This number has noticeably been increased from 1993. In 1980, number of STW and DTW installed was 279 and 17 respectively. Within 2017, the numbers attained at 15578 and 575 respectively, though the number of STW was reduced after 2015. Expansion of tube wells taped in an aquifer has augmented the use of groundwater of that area.

Considering data reported by the field survey conducted by BIADP (Barind Integrated Area Development Project) in 1989, groundwater discharge from the aquifer has been estimated in this research. The survey depicted that the DTWs are generally run for nearly 120 days per year in dry season at an average rate of 13 hours daily (BWDB 1990). The average discharge capacity of a DTW and a STW are 2 cusec and 0.5 cusec (sometimes less) respectively. The report also specified that some wells were dry and some were become dry during pumping. Considering discharge capacity, five STWs are assumed to be equivalent to one DTW and total yearly discharges for forty years (1980-2020) are estimated in this research and presented in Fig. 6. Same approach was practiced by BWDB (1990) to calculate the equivalent number of DTWs.

Infiltrated rainfall, flooded water and channel discharge are the main sources of groundwater recharge (WOOBAIDULLAH *et al*. 1998; UNDP 1982). The historical record of annual rainfall (Fig. 7) shows that the pattern of annual rainfall from 1980 to 1998 is analogous and the annual rainfall for this period ranging from 1200 to 2140 mm with an average of 1668 mm. This pattern, however, has been changed for the period 1999 to 2020. The average amount of annual rainfall for this period is 1426 mm with a range from 709 to 1785 mm. Though the average annual rainfall of this area is always below the average annual rainfall of Bangladesh, the noticeable change is found in the amount which is decreased in last 22 years from 1999 to 2020. This change may be an indication of global climate change and have an impact of lowering in hydraulic head of groundwater.

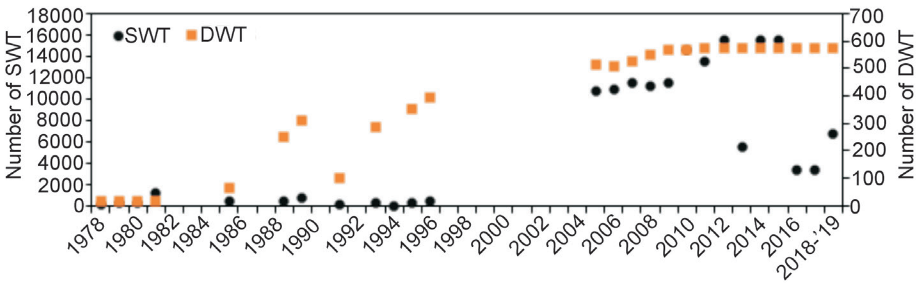

Fig. 5. Historical growth of various irrigation equipments - Shallow Tube Well (STW) and Deep Tube Well (DTW) installed in the study area.

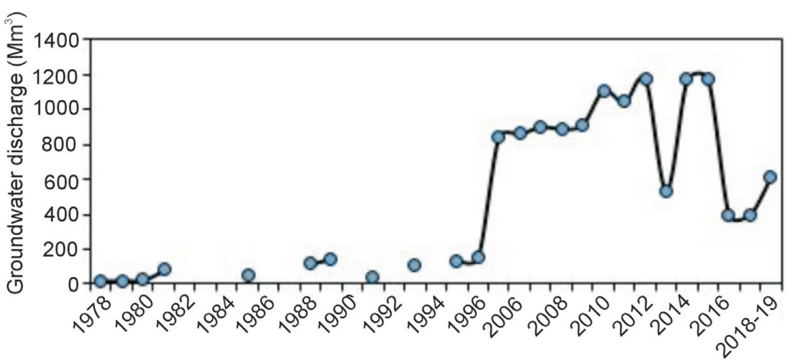

Fig. 6. Historical record of artificial discharge of groundwater from the shallow aquifer.

Contour maps of hydraulic heads for dry and wet seasons (Figs. 8a,b) are prepared by using ArcGIS 10.8. The maps represent decadal changes in hydraulic heads and groundwater movement in the shallow aquifer for the years 1990, 2000, 2010 and 2020. The spatial movement of groundwater show groundwater flows from central part towards peripheral area except in south central part of the area in dry season of 2010.

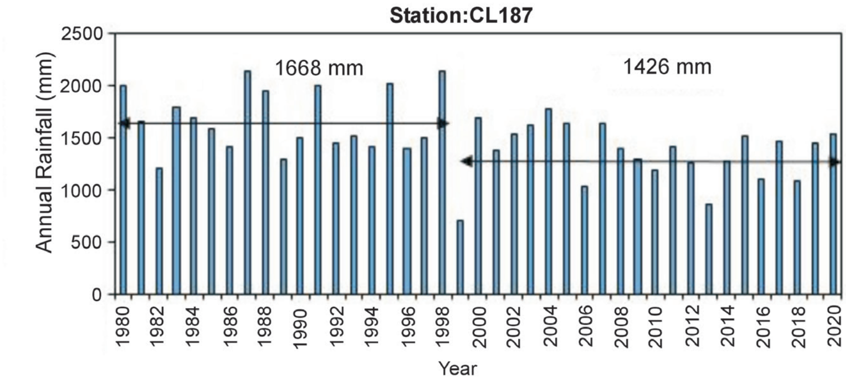

Fig. 7. Annual rainfall pattern indicates the average annual rainfall has been decreased significantly from 1999. Dotted lines indicate the average annual rainfall.

The maps clearly represent the declination of hydraulic heads in most of the area for both dry and wet seasons during the period of 30 years from 1990 to 2020. From statistical analysis of these results, declination rate for each observation well has been calculated (Table 1). In wet season, the rate varies from 0.35 to 0.11 m/yr and maximum declination rate is observed in the areas near well no. RJ058. In dry season, maximum declination rate is detected in well no. RJ138. From 2010, the rate was increasing with 0.32m/yr. However, it was 0.14 m/yr from 1990 to 2010 in the same area. Minimun rate (0.1m/yr) of hydraulic head declination is found in areas near the well no. RJ056. Increased rate of declination in hydraulic head of groundwater may primarily be an impact of withdrawal of groundwater at higher rates which is already inferred from Fig. 5 and Fig. 6.

Table 1. Declination Rate in hydraulic head of groundwater detected in different observation wells.

Observation	**Declination Rate (m/year)**	
Well ID	*Dry Season*	*Wet Season*
RJ014	0.08	0.27
RJ018	0.15	0.24
RJ056	0.1	*0.15
RJ057	0.16	0.27
RJ058	0.16	0.35
RJ138	** 0.32	0.11
RJ145	*0.11	0.11

Note: * Hydraulic head was declining from 1990 to 2010, but increasing from 2010.
** Hydraulic head was increasing from 1990 to 2010, but declining from 2010.

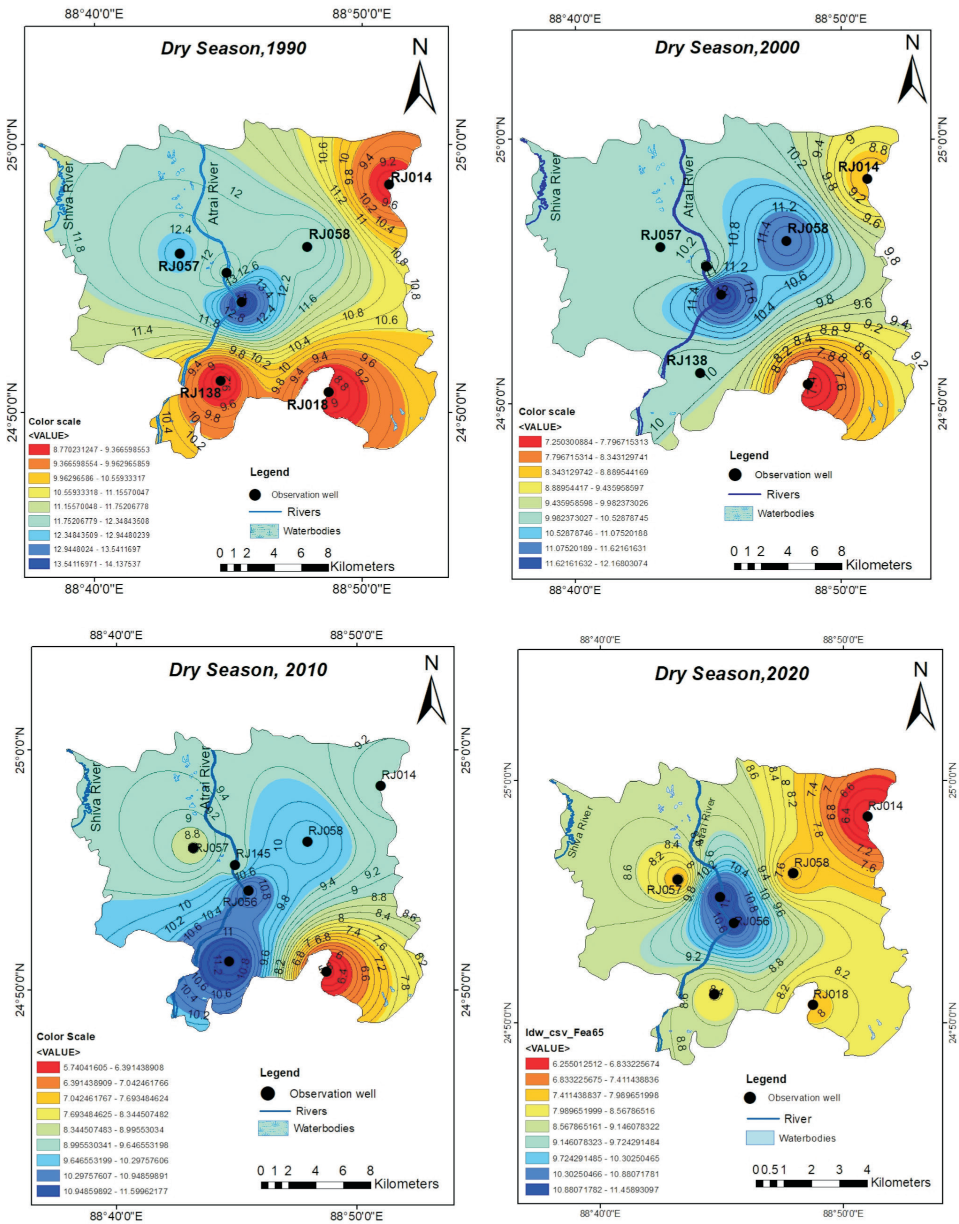

Fig. 8a. Decadal Changes in hydraulic head and spatial movement of groundwater in shallow aquifer of Mohadevpur Upazila for dry season.

Some researchers have already mentioned that the groundwater exploitation in many locations has become unsustainable and suggested artificial recharge to the aquifer to prevent the permanent groundwater mining (MOJID *et al*. 2019). To avoid the permanent degradation of groundwater quality and to save the aquifer for next generation, time to time monitoring and proper management are, therefore, essential in this area.

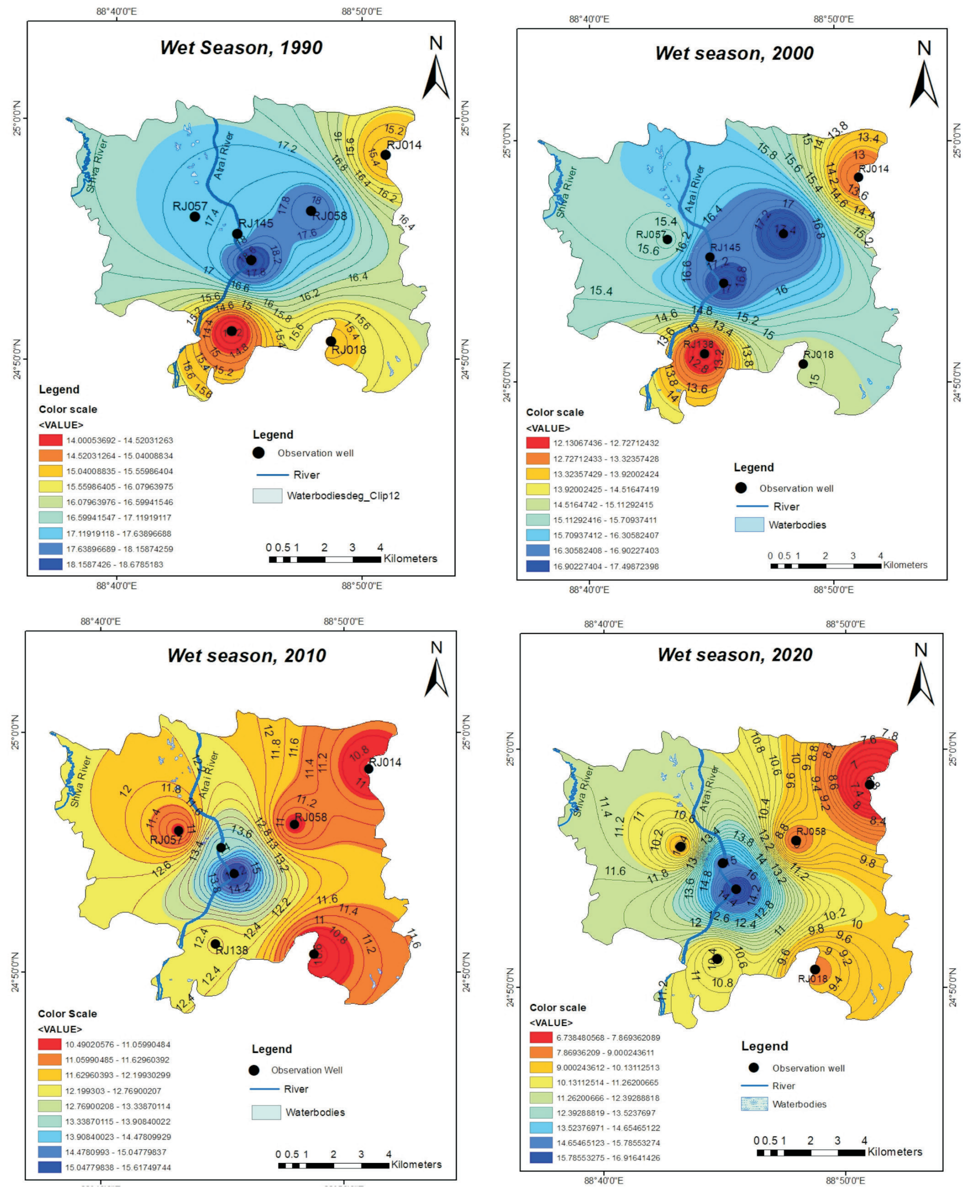

Fig. 8b. Decadal Changes in hydraulic head and spatial movement of groundwater in shallow aquifer of Mohadevpur Upazila for wet season.

Conclusion

Groundwater Extraction and its impact on sustainability of the shallow aquifer of Mohadevpur Upazila has been evaluated in this study. A coarse sand aquifer with occasional gravel (15 m to > 55 m thick) and a fine sand aquifer (3 m to 38 m thick) are revealed within about 100 m depth. The aquifers prevailing in most of the area are confined to semi-confined in nature.

The groundwater spatially flows from central part towards peripheral area in all seasons. Seasonal fluctuation in hydraulic head of groundwater, varied from 4 m to 7.6 m for dry and wet seasons, respectively, were almost stable up to 1991. After 1991, the fluctuation has been decreased in most of the area ranging from 0.48 m to 4.3 m. Seasonal fluctuation and long term changes in hydraulic head reveal that the declination of pressure heads are in alarming condition in and around the areas of observation well nos. RJ014, RJ057, RJ058 and RJ138. From 1990 to 2020, the declination rate varies from 0.35 to 0.11 m/yr and 0.32 to 0.1 m/yr during wet and dry seasons, respectively.

The average annual rainfall decreased significantly from 1999 to 2020. Water level of the River Atrai has also been gently declining since 1998. Decreasing in average amount of annual rainfall and lowering of river water level indicate that the regular vertical recharge of groundwater has decreased in the study area. On the other hand, abstraction of groundwater has been increased since 1980. Estimated amount of extracted groundwater was 51 times higher in 2015 than that of 1980. After 2015 the extraction was reduced significantly. However, in 2020 the amount was 26 times higher than that of 1980.

Though the decrease in regular vertical recharge of groundwater is deduced in this area, increased rate of declination in hydraulic head of groundwater is primarily be an impact of long term pumping of groundwater at higher rates. To avoid the irreversible environmental impacts due to permanent depletion of pressure head of groundwater, proper management of this invaluable resource and its reservoir are subjected to concern.

References

Bangladesh Agricultural Development Corporation (BADC), 2007, Minor Irrigation Survey Report 2006-07; *Survey and Monitoring Project for Development of Minor Irrigation*, Bangladesh Agricultural Development Corporation (BADC), Dhaka, 184p.

Bangladesh Agricultural Development Corporation (BADC), 2020, Minor Irrigation Survey Report 2018-19; *Survey and Monitoring Project for Development of Minor Irrigation,* Bangladesh Agricultural Development Corporation (BADC), Dhaka, 54p.

BANGLADESH BUREAU OF STATISTICS (BBS), 2011, Population and Housing Census; *Ministry of Planning*, Government of Peoples Republic of Bangladesh, Dhaka, 23p.

BANGLADESH WATER DEVELOPMENT BOARD (BWDB), 1990, Water Survey for Barind Integrated Area Development Project (BIADP); *Final Report*, **1**, Dhaka, 95p.

BARIND MULTIPURPOSE DEVELOPMENT AUTHORITY (BMDA), 2004, DATA BANK; *Groundwater and Surface water Resources Bangladesh*, Rajshahi, 125p.

BEGUM, S.F., 2003, Hydrogeological study in western Barind area of Bangladesh by numerical simulation and remote sensing; Unpublished *PhD Dissertation*, Nagoya University, Japan, 141p.

BEGUM, S.F., BASHAR, K. & HOSSAIN, S., 1997, An Evaluation of Hydraulic Parameters of the aquifer and wells of the Western Part of the Barind Area, Bangladesh; *Bangladesh Geoscience Journal*, **3,** 49-64.

BEGUM, S.F., ISLAM, M.R., YAMAGUCHI, Y. & OGAWA, K., 2003, Studies on Surface Temperature Using Remote Sensing Technique in the NW Part of Bangladesh; *Geocarto International*, **18**(2), 41-49.

BEGUM, S.F. & MARRIOTT, M. J., 2011, Sustainability of groundwater resources: a case study on Nachole upozila in high barind of north west Bangladesh; *Advances in computing and technology 6th annual conference*, London, UK (ISBN: 978-93-80689-06-7), 150-156.

BERNOULLI, D., 1968, *Hydrodynamics*; Dover Publication, Inc. New York, 456p.

ERBAN, L. E., GORELICK, S. M., ZEBKER, H. A. & FENDORF, S., 2013, Release of arsenic to deep groundwater in the Mekong Delta, Vietnam, linked to pumping-induced land subsidence; *Proc. Natl. Acad. Sci. USA,* **110**, 13751–13756.

HASAN, M. R., MOSTAFA, M.G., RAHMAN, N., ISLAM, M.S. & ISLAM, M.M., 2018, Groundwater Depletion and its Sustainable Management in Barind Tract of Bangladesh; *Research Journal of Environmental Sciences*, **12**(5), 247-255. DOI:10.3923/rjes.2018.247.255

KNAPPETT, P. S. K., MAILLOUX B.J., CHOUDHURY, I., KHAN, M. R., MICHAEL, H. A., BARUA, S., MONDAL, D. R., STECKLER, M.S., AKHTER, S.H., AHMED, K.M., BOSTICK, B., HARVEY, C.F., SHAMSUDDUHA, M., SHUAI, P., MIHAJLOV, I., MOZUMDER, R., and VAN GEEN, A., 2016, Vulnerability of low-arsenic aquifers to municipal pumping in Bangladesh; *J. Hydrol.*, **539**, 674–686.

MIHAJLOV, I., MOZUMDER, M. R. H., BENJAMÍN, C., BOSTICK, STUTE, M., MAILLOUX, B.J., KNAPPETT, P.S.K., CHOUDHURY, I., AHMED, K.M., SCHLOSSER, P. & GEEN, A.V., 2020, Arsenic contamination of Bangladesh aquifers exacerbated by clay layers; Nature Communications, **11**(1):2244 doi: 10.1038/s41467-020-16104-z.

MOJID, M. A., PARVEZ, M. F., MAINUDDIN, M. & HODGSON, G., 2019, Water Table Trend-A Sustainability Status of Groundwater Development in North-West Bangladesh; *Water*, **11**, 1182; doi:10.3390/w11061182

MONSUR, M. H., 2020, *Qaternary Geology of Bangladesh*; Event plus, Dhaka, 384p.

MORGAN, J.P. & MCINTYRE, W.G., 1959, Quaternary Geology of the Bengal Basin, East Pakistan and India; *Bull. Geol. Soc. Amer;* **70**, 319-342.

SHAMSUDDUHA, M., CHANDLER, R.E., TAYLOR, R.G. & AHMED, K.M., 2009, Recent trends in groundwater levels in a highly seasonal hydrological system: the Ganges-Brahmaputra-Meghna Delta; *Hydrology and Earth System Sciences*, **13**, 2373–2385.

SMITH, R., KNIGHT, R. & FENDORF, S., 2018, Overpumping leads to California groundwater arsenic threat; *Nat. Commun.* https://doi.org/10.1038/s41467- 018-04475-3.

UNDP, 1982, Groundwater Survey: The Hydrogeological Conditions of Bangladesh; Technical Report DP/UN/BGD-74-009/1, New York,113p.

WOOBAIDULLAH, A.S.M., AHMED, K.M, HASAN, M.A. & HASAN, M.K., 1998, Saline groundwater management in Manda thana of Naogaon District, NW Bangladesh; *Journal Geological Society of India*, **51**, 49-56.

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ভূগর্ভস্থ পানি উত্তোলন এবং পানি সম্পদের স্থিতিশীলতাঃ বাংলাদেশের উত্তরপশ্চিমে অবস্থিত মহাদেবপুর উপজেলার উপর একটি সমীক্ষা

সৈয়দা ফাহলিজা বেগম, ফারিহা ইসলাম ও লিলিমা আক্তার

সারসংক্ষেপ

এই গবেষণা প্রবন্ধে বাংলাদেশের নওগাঁ জেলার মহাদেবপুর উপজেলার ভূগর্ভস্থ পানি উত্তোলন এবং ভূগর্ভস্থ জলাধারে এর প্রভাব মূল্যায়ন করা হয়েছে। বাংলাদেশের এই অঞ্চলটি বরেন্দ্র এলাকায় অবস্থিত। এই অঞ্চলের মানুষের পানীয় জল, গৃহস্থালি, কৃষি এবং শিল্পের জন্য ব্যবহৃত প্রয়োজনীয় পানির একটি বড় অংশ ভূগর্ভস্থ জলাধার থেকে উত্তোলন করা হয়। বিশেষ করে শুষ্ক মৌসুমে ভূ-উপরোস্থিত জলাধারে পানির পর্যাপ্ত সরবরাহ না থাকায় চাষাবাদের সেচকার্যক্রম পরিচালনার জন্য ভূগর্ভস্থ পানি অত্যন্ত গুরুত্বপূর্ণ ভূমিকা রাখে।

এই গবেষণায় ভূতাত্ত্বিক উপাত্ত পর্যালোচনা করে ১০০ মি. গভীরতার মধ্যে দুটি জলবাহী শিলাস্তরের অবস্থান নির্ণীত হয়েছে। একটি ১৫ মি. থেকে > ৫৫ মি.পুরুত্বের মোটা দানাদার বালুর জলাধার, অপরটি সরু দানাদার বালুর জলাধার যার পুরুত্ব ৩ মি. থেকে ৩৮ মি. পর্যন্ত। পানি উত্তোলন যোগ্য জলবাহী শীলাস্তর দুটির জ্যামিতিক গঠন ও বৈশিষ্ট্য বিশ্লেষণে দেখা যায় যে, গবেষণা এলাকার অধিকাংশ অঞ্চলে শীলাস্তর দুটি আবদ্ধ' থেকে আংশিক আবদ্ধ' ভূগর্ভস্থ জলাধার বৈশিষ্ট্য সম্পন্ন। এই গবেষণায় ৪০ বছরের (১৯৮০-২০২০) ভূগর্ভস্থ পানিস্তরের উপাত্ত বিশ্লেষণ করা হয়। ভূগর্ভস্থ পানির চাপ জনিত পানিস্তর (হাইড্রলিক হেড) এর বাৎসরিক হ্রাস-বৃদ্ধি পর্যালোচনা করে শুষ্ক ও আদ্র মৌসুমে যথাক্রমে ৪ মি. এবং ৭.৬২ মি. পরিলক্ষিত হয়, যা ১৯৯১ সাল পর্যন্ত স্থিতিশীল ছিল। তবে ১৯৯১-এর পর থেকে এই হ্রাস-বৃদ্ধি ক্রমেই কমতে শুরু করে, অধিকাংশ অঞ্চলে যার ব্যাপ্তি যথাক্রমে ০.৪৮ মি. এবং ৪.৩০ মি.। ভূগর্ভস্থ পানিস্তরের মৌসুমী হ্রাস-বৃদ্ধির উপর উক্ত অঞ্চলের বৃষ্টিপাতের পরিমাণ এবং নদীর পানিস্তরের প্রবল প্রভাব রয়েছে। এই গবেষণায় দেখা গেছে যে, উক্ত অঞ্চলে প্রবাহিত আত্রাই নদীর পানিস্তর এবং গড় বৃষ্টিপাতের পরিমাণ ১৯৯৯ সাল থেকে ক্রমেই হ্রাস পেয়েছে, যার ফলে ভূগর্ভস্থ জলবাহী শীলাস্তরের নিয়মিত পূণর্ভরণ হ্রাস পেতে পারে।

সেচ সংক্রান্ত উপাত্ত বিশ্লেষণে আরো দেখা যায় যে, ১৯৮০ সাল থেকে সেচ কার্যক্রম সম্প্রসারণের জন্য ভূগর্ভস্থ পানির উত্তোলন ক্রমেই বৃদ্ধি পেয়েছে। ১৯৮০ সালের তুলনায় ২০১৫ সালে পানির উত্তোলনের পরিমাণ ৫১ গুণ বৃদ্ধি পেয়েছিল। গত ৩ দশক (১৯৯০-২০২০) এর চাপ জনিত পানিস্তর বিশ্লেষণে দেখা যায় যে, সাধারণতঃ সকল মৌসুমে ভূগর্ভস্থ পানি গবেষণা এলাকার কেন্দ্রীয় অঞ্চল থেকে প্রান্তীয় অংশে প্রবাহিত হয়। এই ৩০ বছরে অধিকাংশ অঞ্চলে, শুষ্ক ও আদ্র উভয় মৌসুমে, ভূগর্ভস্থ পানিস্তরের পতন পরিলক্ষিত হয়। অঞ্চল বিশেষে এই পতনের হার ০.১ মি/বছর থেকে ০.৩৫ মি/বছর। গবেষণা এলাকার উত্তর-পূর্ব এবং দক্ষিণ-পূর্ব অংশে পানিস্তরের গড় পতনশীল প্রবনতা উদ্বেগজনক।

পরিশেষে বলা যায় যে, যদিও এই এলাকায় ভূ-উপরোস্থিত পানির প্রাপ্যতা হ্রাসের কারণে ভূগর্ভস্থ পানির নিয়মিত পূণর্ভরণ হ্রাস পেতে পারে, ভূগর্ভস্থ পানিস্তরের ক্রমবর্ধমান পতনের কারণ হিসাবে, প্রাথমিকভাবে, পাম্পের সাহায্যে অধিক মাত্রায় দীর্ঘ মেয়াদে ভূগর্ভস্থ পানি উত্তোলনের প্রভাবই দায়ী বলে প্রতীয়মান হয়। ভূগর্ভস্থ পানিস্তরের স্থায়ী পতনের কারণে পরিবেশের যে অপরিবর্তনীয় সমস্যা সৃষ্টির সম্ভাবনা রয়েছে তা বিবেচনায় নিয়ে উক্ত এলাকার ভূগর্ভস্থ পানি এবং ভূগর্ভস্থ জলাধারের টেকসই ব্যবস্থাপনায় সচেতনতা প্রয়োজন।