JDS International Seminar II

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Hydrological Understanding of Groundwater Resources in Dhaka City, Bangladesh

Content

- Introduction
- Objectives
- Methodology
- Findings
- Summary
- Future Works

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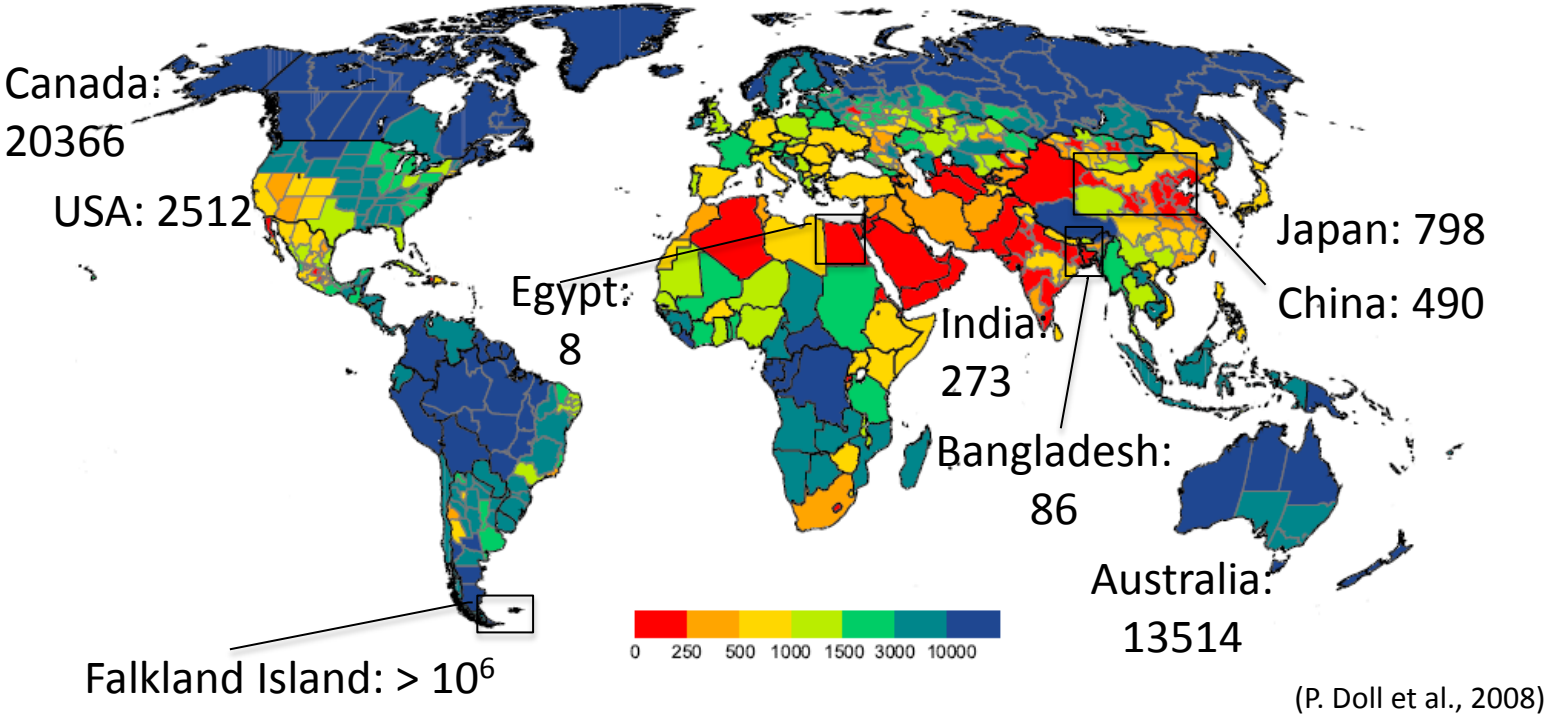
INTRODUCTION

- **Groundwater (GW) is an almost ubiquitous source of generally high-quality fresh water. (Taylor et al., 2013)**

Fig: Per-capita groundwater resources in administrative units, in m^3/(capita yr).



(P. Doll et al., 2008)

- **GW in Highly Populated Area:** Have lower per-capita groundwater resources **< 1000 m3/(capita yr)** (P. Doll et al., 2008)

Groundwater on Different Aspects

- **GW in Developing World:**
  - Preferred as a source of potable water:
    - ➔ ready availability and
    - ➔ natural protection from contamination. (Hoque et al., 2007)
  - **Developing countries** in the **tropics** ➔ **Rapid Urbanization**. (A. Gupta et. Al., 1997)
- **GW in Tropical Area:**
  - In tropical landscapes where land-cover and land-use change have been rapid and complex; (J. Krishnaswamy et al., 2013)
- **GW in Flood Plain Area:**
  - Groundwater resources are significantly influenced and extensively recharged by flood plain areas.
  - Extensive floodplains along large rivers play an important role in the hydrological cycle and water resources.
  - Reduction of inundation area reduce the GW recharge. (So Kazama et al., 2007)

PREVIOUS STUDY

- **GW in Delta Area:**
  - Shallow aquifers underlying Asian mega-deltas are characterized by strong seasonal variations associated with monsoon rainfall. (M. Shamsudduha et.al. 2009)
  - In Ganga Delta aquifers,
    Rainfall and Floodwater ➔ Groundwater
    (Ratan K et al., 2011)

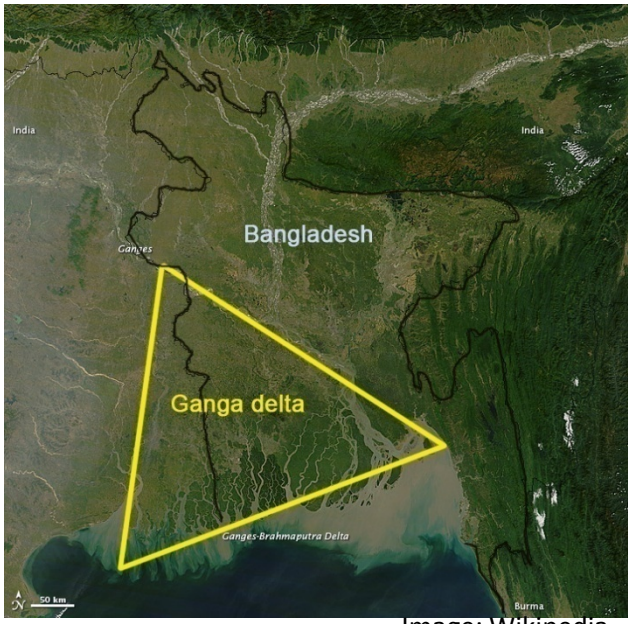


Image: Wikipedia

- **In Humid region:**

Solved Issues

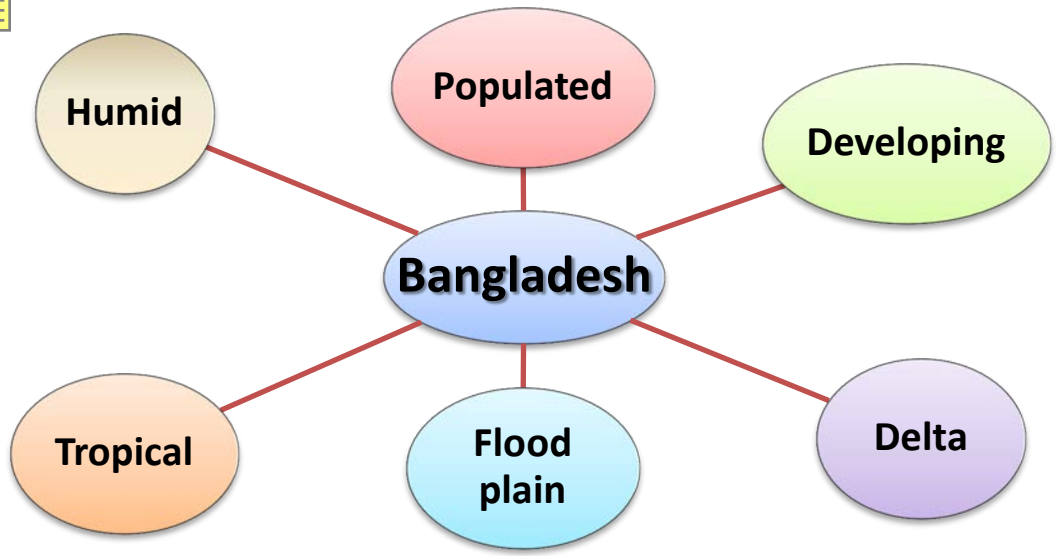
✓Evolution of Groundwater chemistry with rapid urbanization.
✓Groundwater and Surface water interaction

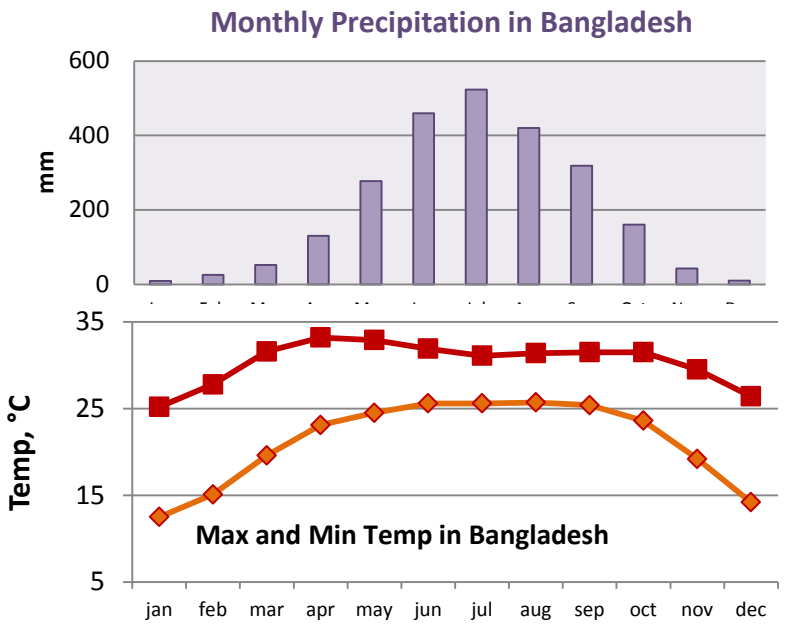
Unsolved Issues:

✓ Contribution of Climate Change towards Groundwater.
✓Groundwater Recharge process in two different aquifer system of floodplain alluvium and Pleistocene clay zone.

- **During the 20th century, precipitation :**
  - **increased ➔In high northern latitudes**
  - **decreased ➔ in some sub-tropical and lower mid-latitude regions.**

(Bovolo et al. 2009)





Despite In Bangladesh, it has

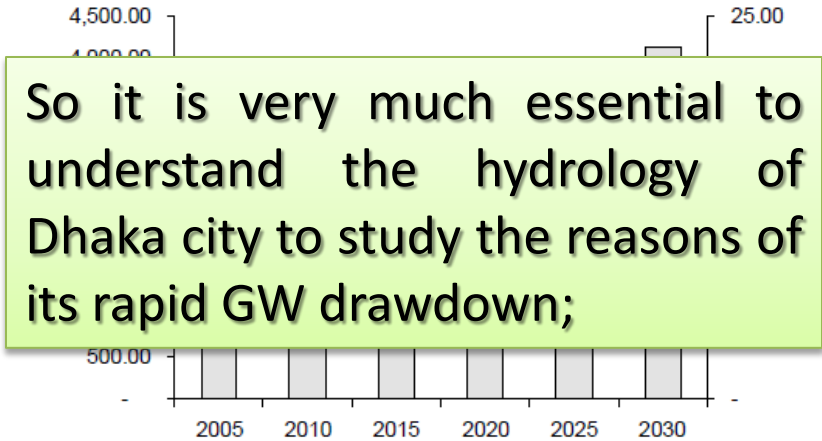
- Sufficient rainfall (2400 mm)
- Tropical humid climate (10 ~ 35 °C)
- Alluvial flood plain
- Abundant surface water (800 River; 24,140 km) (BMD, 2013)

Suffering from GW issue for quantity and quality specially in the central region!

- **Dhaka is a vital central region of BD for its political and economical importance**

In Dhaka it is projected that

- Water demand will double in next 15 years;
- Land subsidence from 2000 to 2020 would be 6.4 cm; (IWM, 2008)



So it is very much essential to understand the hydrology of Dhaka city to study the reasons of its rapid GW drawdown;

PREVIOUS STUDY IN BANGLADESH

- In Bangladesh **decreasing** tendency of annual **rainfall** was indicated in Madhupur Tract (central region of Bangladesh). (Kazi, 2001)
- Systematic groundwater development began in the city of Dhaka in **1949**. (Ahmed et al. 1999)
- More than **79%** population of Dhaka relies on groundwater. (Dhaka WASA, 2013)
- Due to the over extraction of groundwater, last 15 years the groundwater table declined **@ 3.5 meter/year**. (Sultana, 2009)

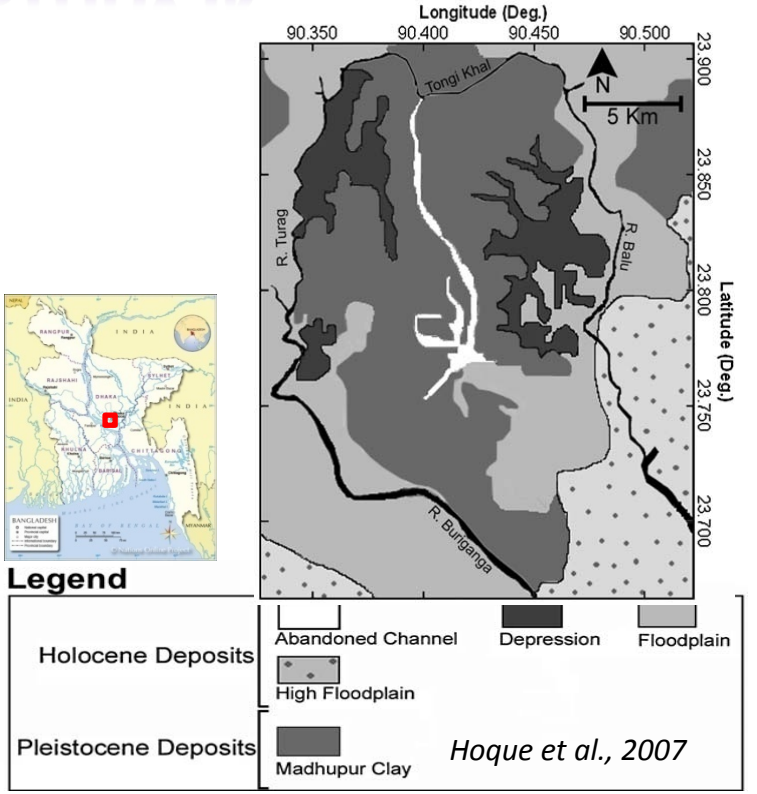


Fig: Surface Geology of Dhaka

- ✓ **Upper parts of the aquifer are already dewatered throughout the Dhaka city;** Mohammad A. Hoque et al., 2007)
- ✓ **Due the intensive pumping, vertical leakage of relatively poor quality water may occur.** (Sultana, 2009)

For better understanding the hydrology of Groundwater of Dhaka it is inevitable to know its recharge process!

Objectives

- To Identify the recharge sources of groundwater in Dhaka;

STUDY AREA: Dhaka city

Densest Megacities of the world

density ➔ 45,000 pop/sq-km. (Joel Kotkin, 2011)

Population: 14.6 million (World Bank, 2013)

Area: 360 km^2;

Water body: 48.56 km^2

Avg Altitude from Sea Level: 4 m

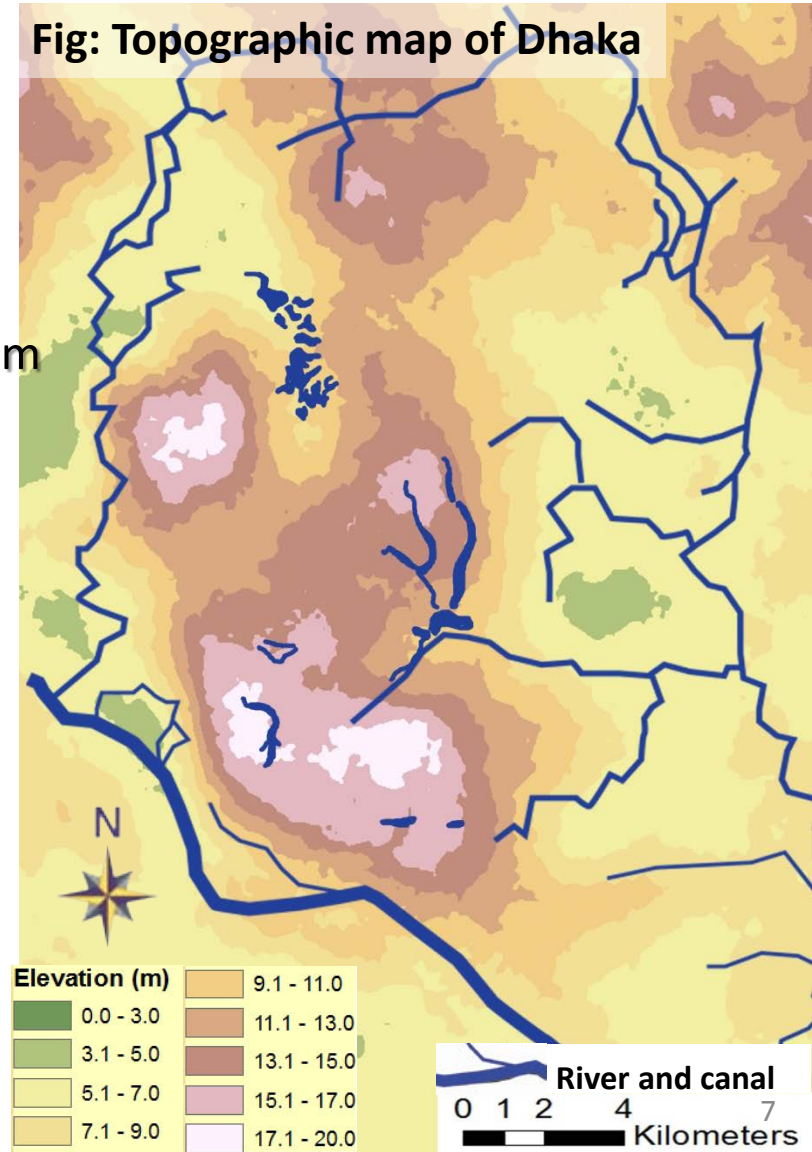
Climate: Tropical Monsoon (Hoque et al. 2007)

Temperature: 12~34 °C

Annual Rainfall: 2150 mm

Dhaka city is situated in the Pleistocene uplifted block (Madhupur Tract) within the passive margin surrounded by subsiding floodplains. (Miah & Bazlee, 1968)

Fig: Topographic map of Dhaka



Source: Bangladesh Bureau of Statistics(2011),

Study Area

✓Aquifer and aquitard layers do not have similar gradient as surface topography.

✓ Overlying and underlying aquitard / aquiclude units separate all three aquifer units.

✓ Abrupt change of hydrostratigraphic unit thickness in places without following usual gradient.

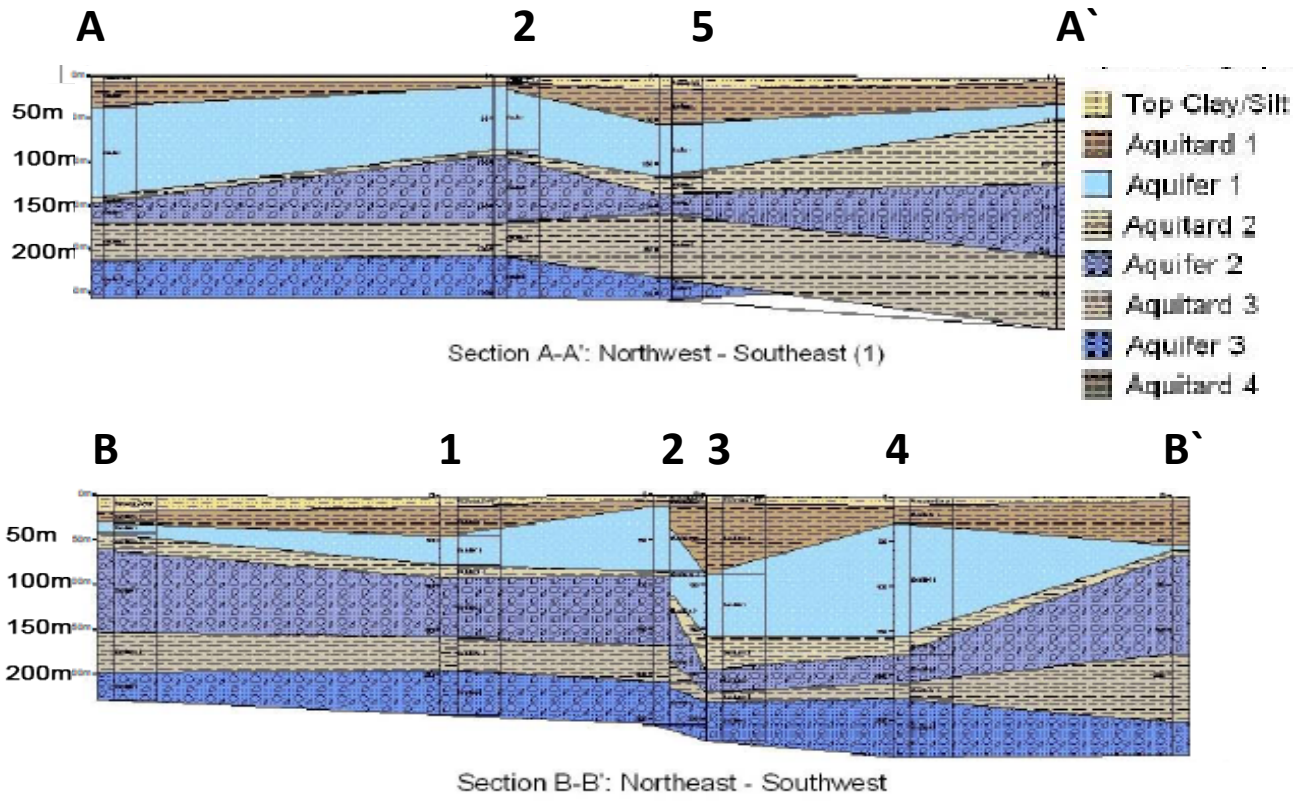
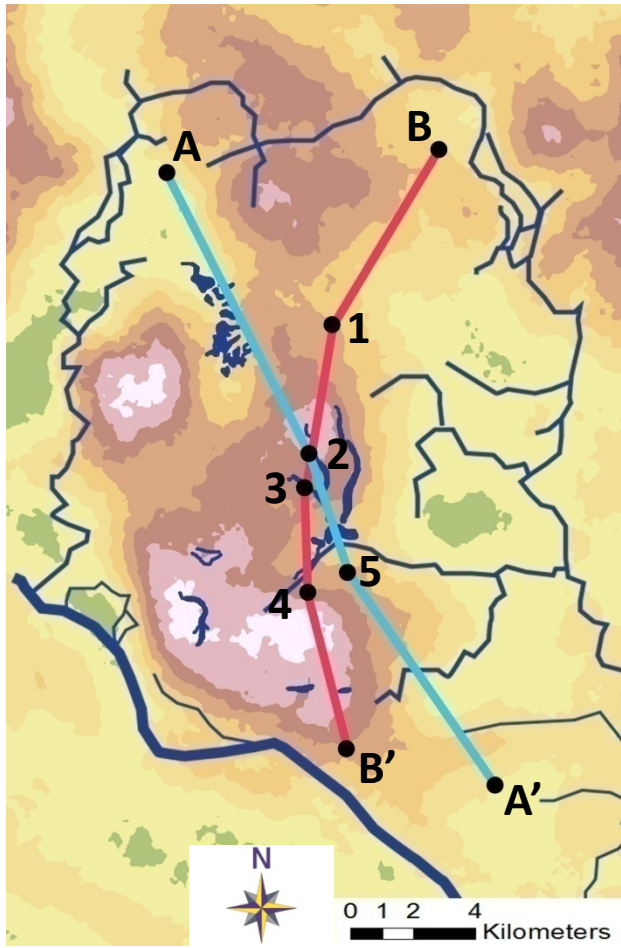


Fig: Hydrostratigraphic cross section under Dhaka aquifer.



METHODOLOGY

Secondary Data

A. Statistical Analysis

Organization:

- Bangladesh Meteorology Dept: Meteorological data
- Dhaka WASA: GW depth (production well), Water production, Usage;
- BD Water Dev. Board: GW depth (Monitoring well)
- Inst. of Water Modeling: Geological data, Assessment report
- BD Bureau of Statistics: Demography

B Chemical Analysis

Field Survey:

Sample Collection:
SW, GW, Rain water
Time:
Wet season
Dry Season

pH, EC, Temp

- Isotope Analysis
$d^{18}O$, dD
- Inorganic ion analysis

Primary Data

A. Existed Data

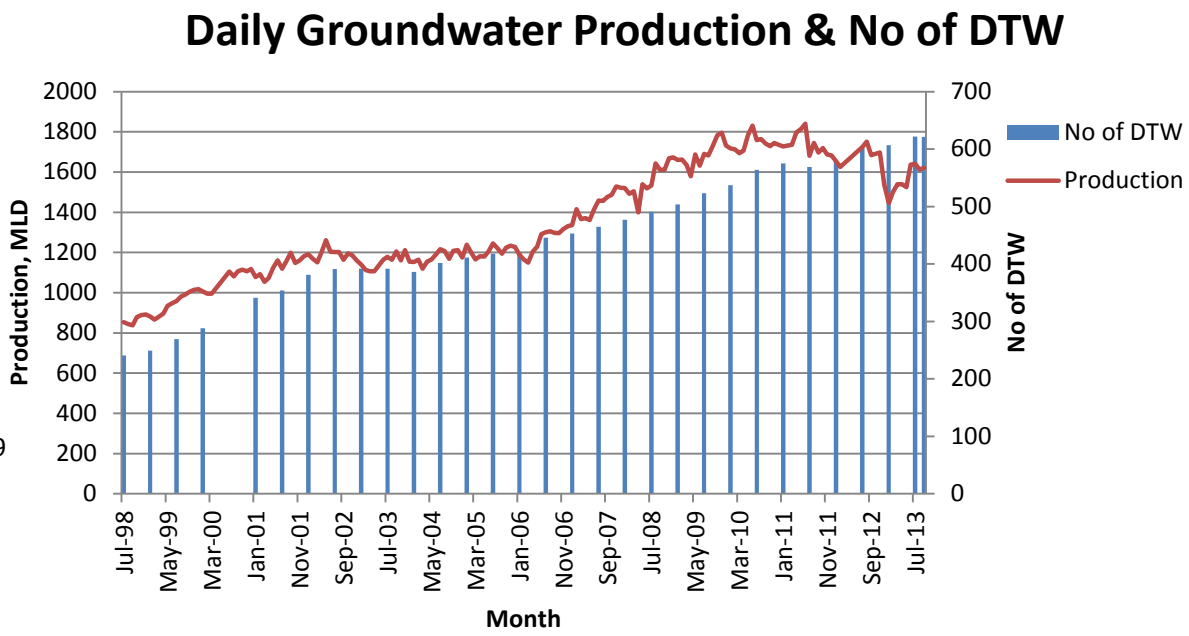
B. Experimental date

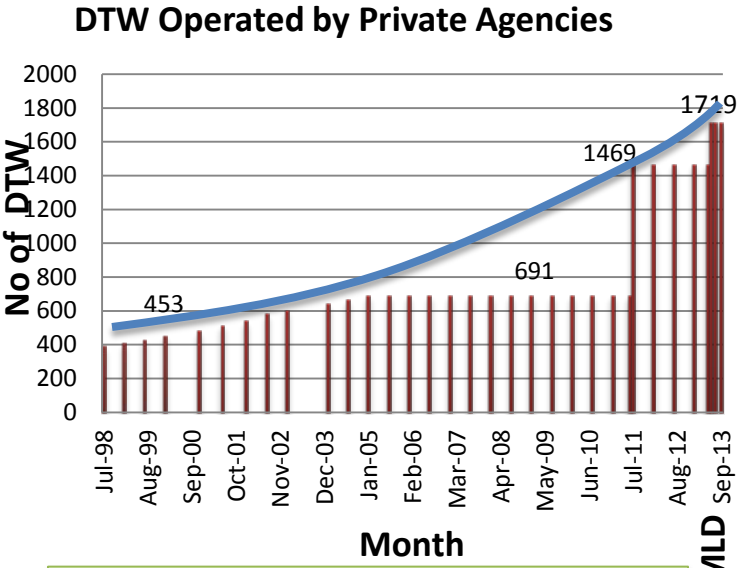
Anthropogenic & CC Issues

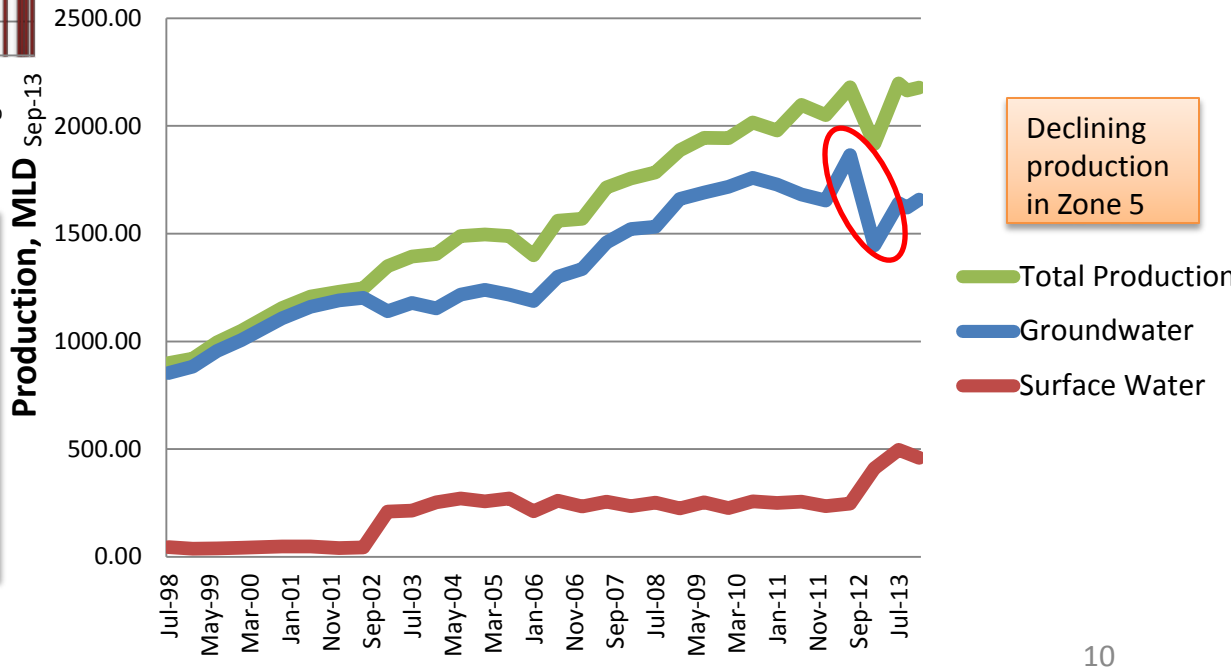
Recharge Source

A. EXISTED DATA

Daily GW Production



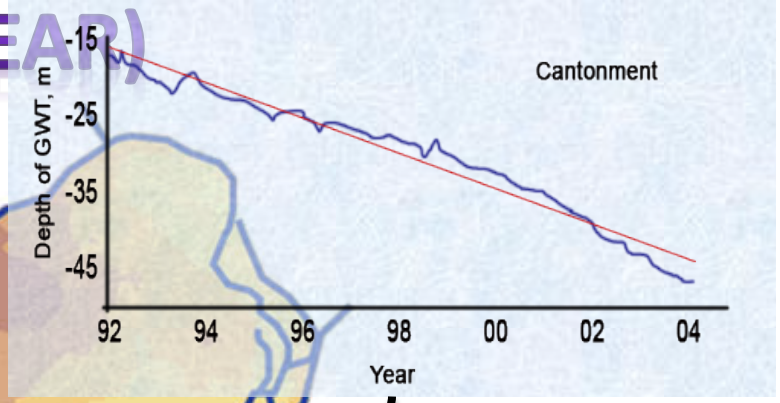


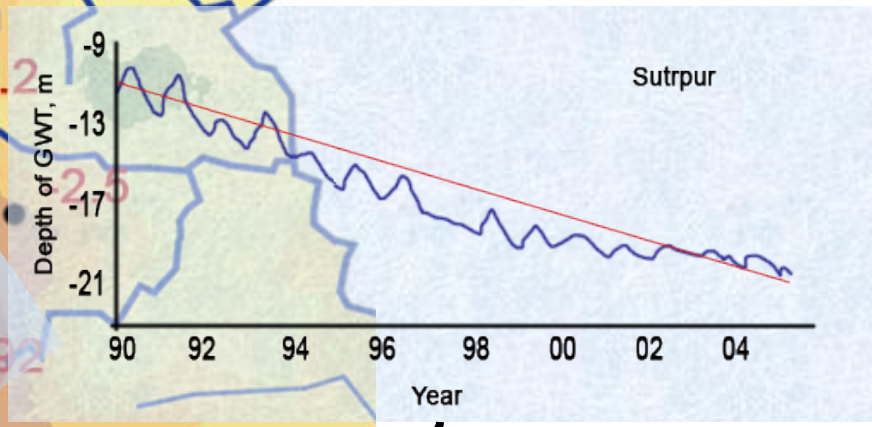


The number of private boreholes has also increased substantially and abstraction through these wells remains unquantified but is likely to be significant. (Hoque et al. 2007)

Source: Dhaka WASA, 2013

GW DEPLETION RATE (M/YEAR)





-2.2
-4.6
-2.2
-3.0
-1.92
-0.64

Reasons might be:

- **Higher demand/pumpage comparatively to other;**
- **Higher discharge;**
- **Lower replenishment;**

"Abstraction is the main discharge from underlying aquifer system." *(IWM, 2008)*

N

River and canal

0 ½ 1 2 3 4 Kilometers

Elevation (m)

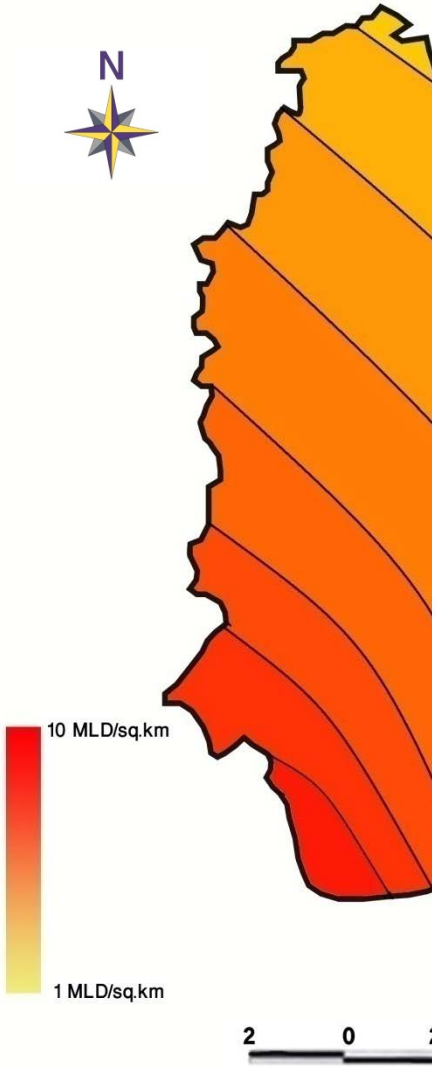
0.0 - 3.0	9.1 - 11.0
3.1 - 5.0	11.1 - 13.0
5.1 - 7.0	13.1 - 15.0
7.1 - 9.0	15.1 - 17.0
	17.1 - 20.0

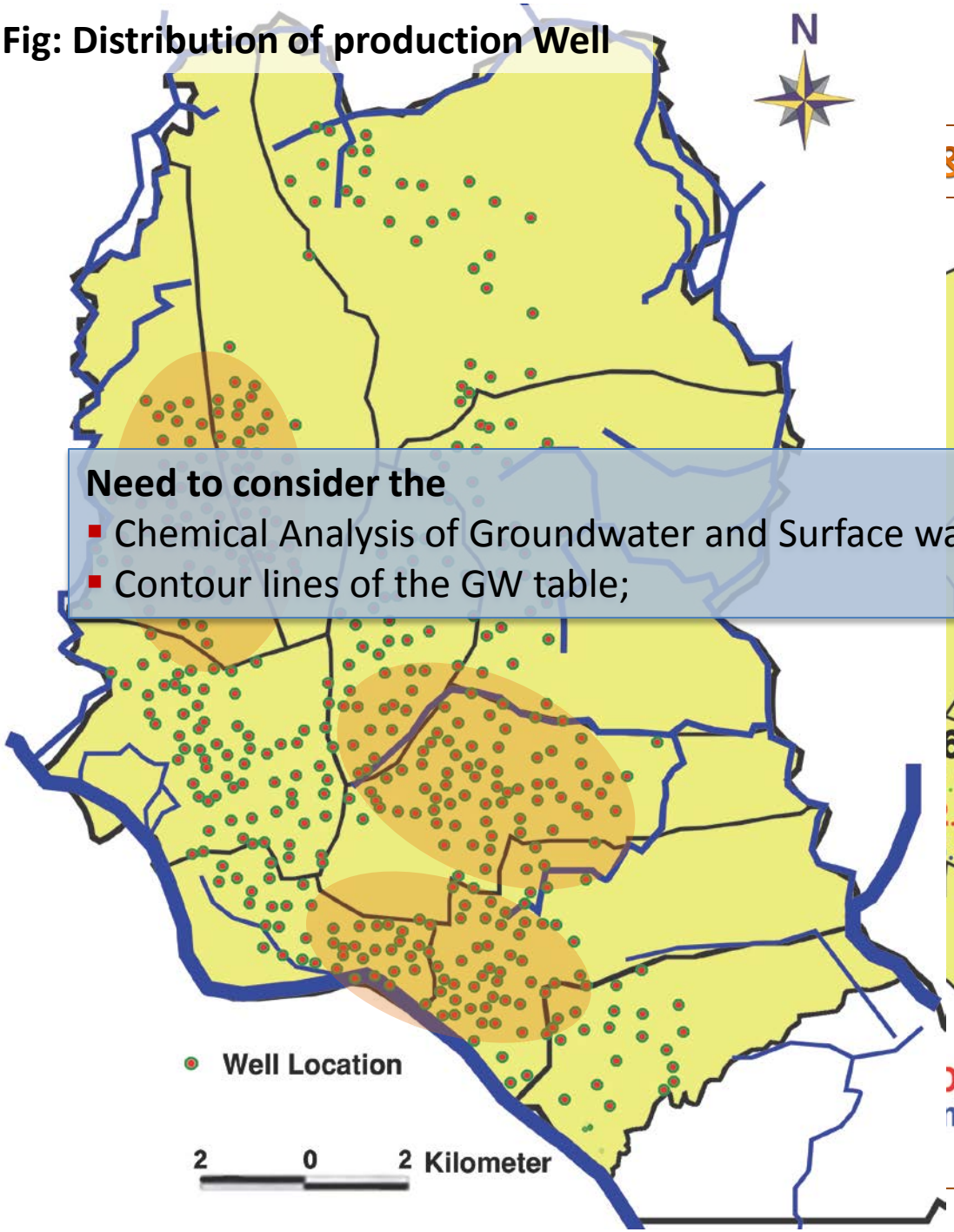
PUMPING

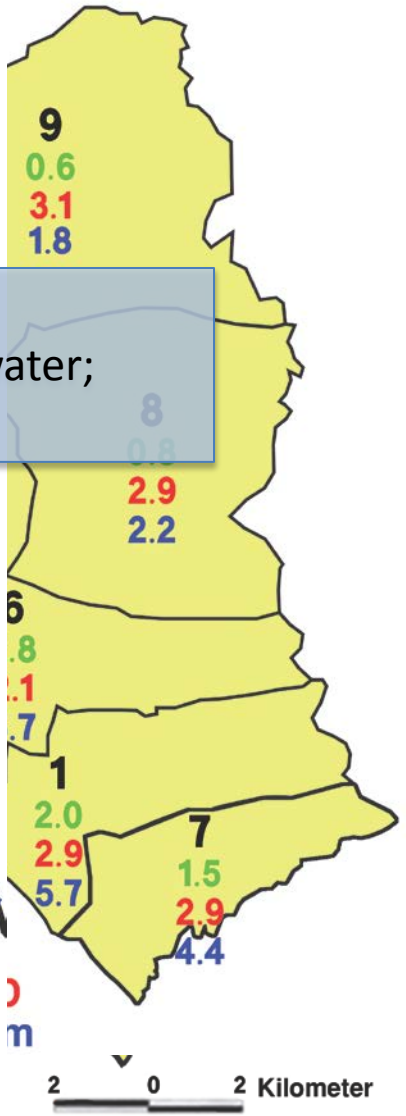
Spatial distributio

& Avg Production

Fig: Distribution of production Well







Need to consider the

- Chemical Analysis of Groundwater and Surface water;
- Contour lines of the GW table;

Source: Dhaka WASA, 2013

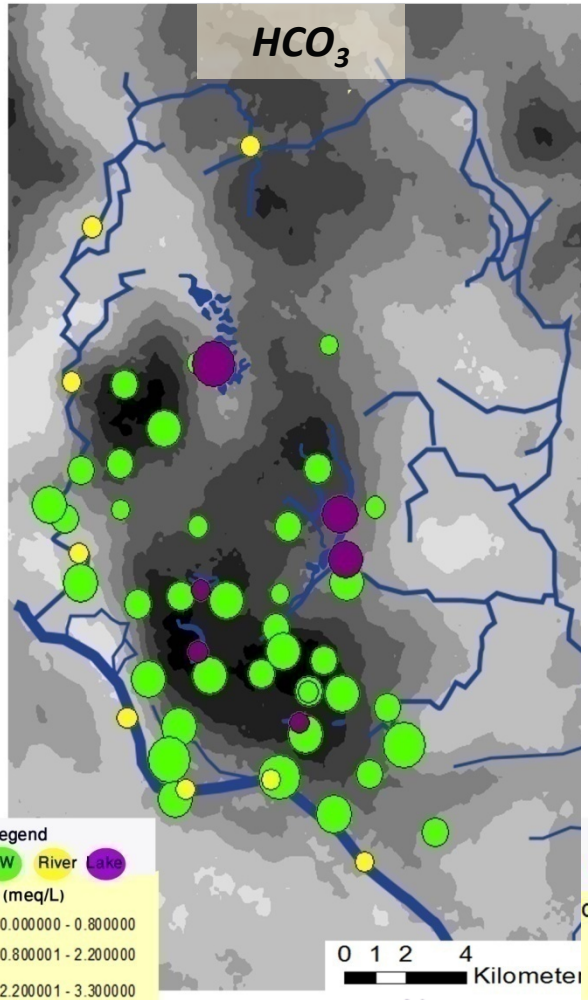
B. EXPERIMENTAL DATA

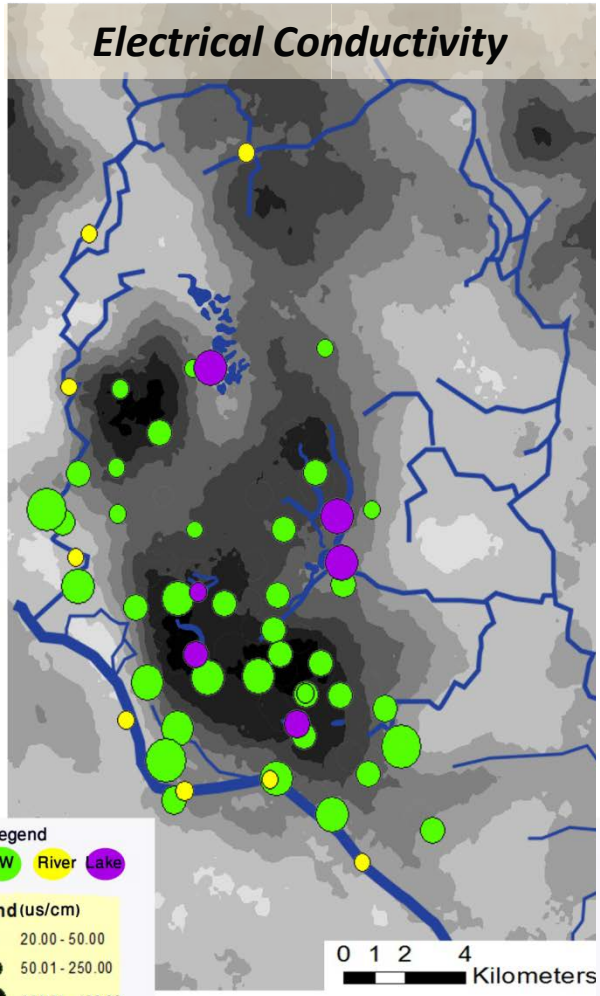
Field survey

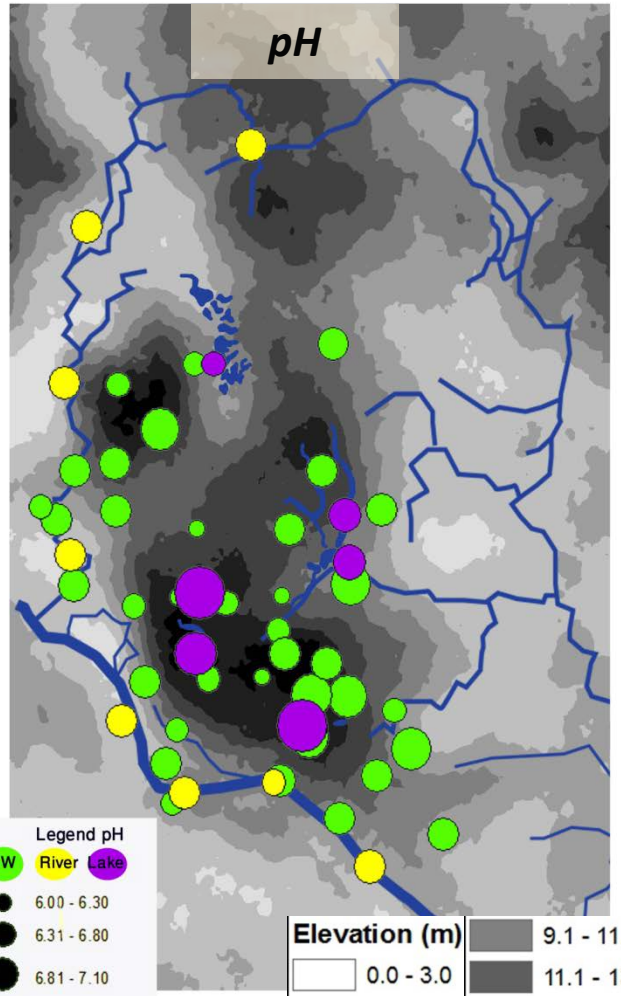
August 2014 (Rainy Season)

- **Water Sample collection: GW: 39; SW: 14;**

Fig: Sample Location







River and canal

WATER QUALITY

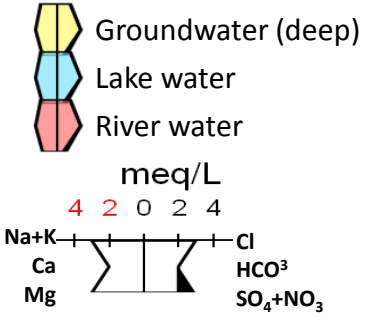


Fig: **Piper diagram of water samples of Dhaka.**

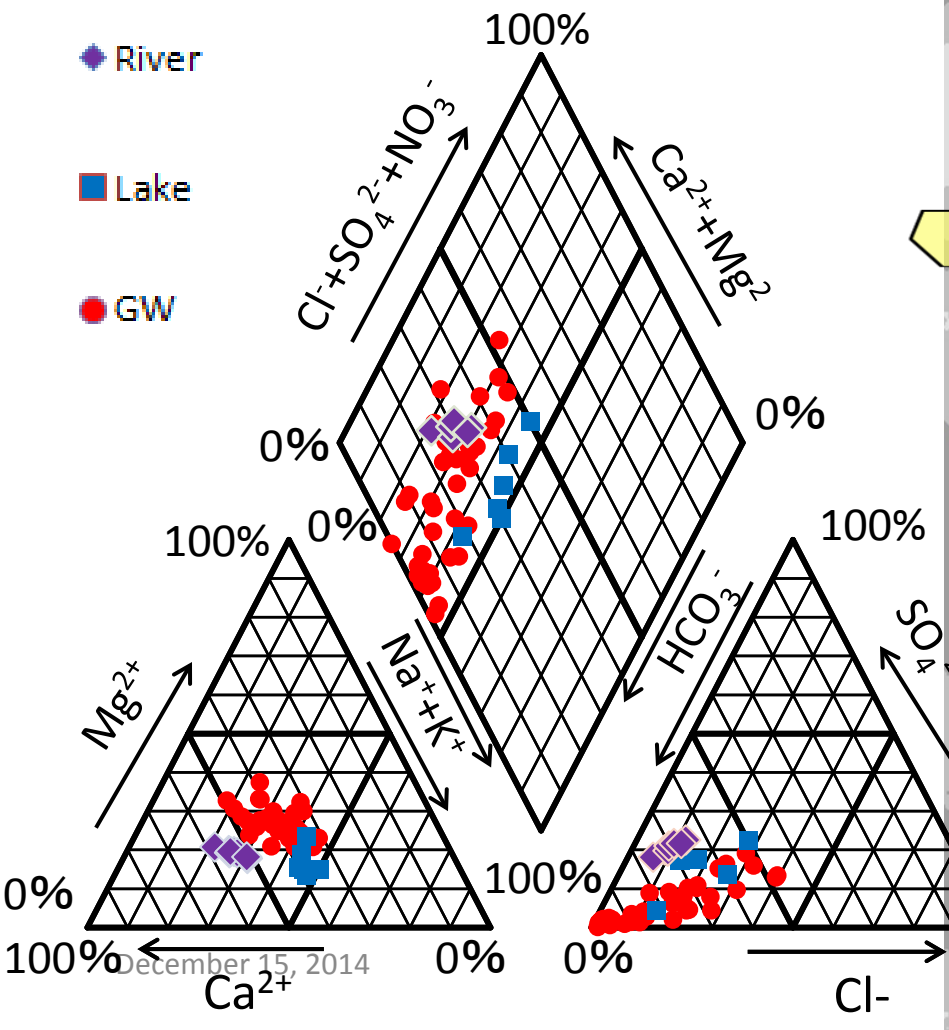
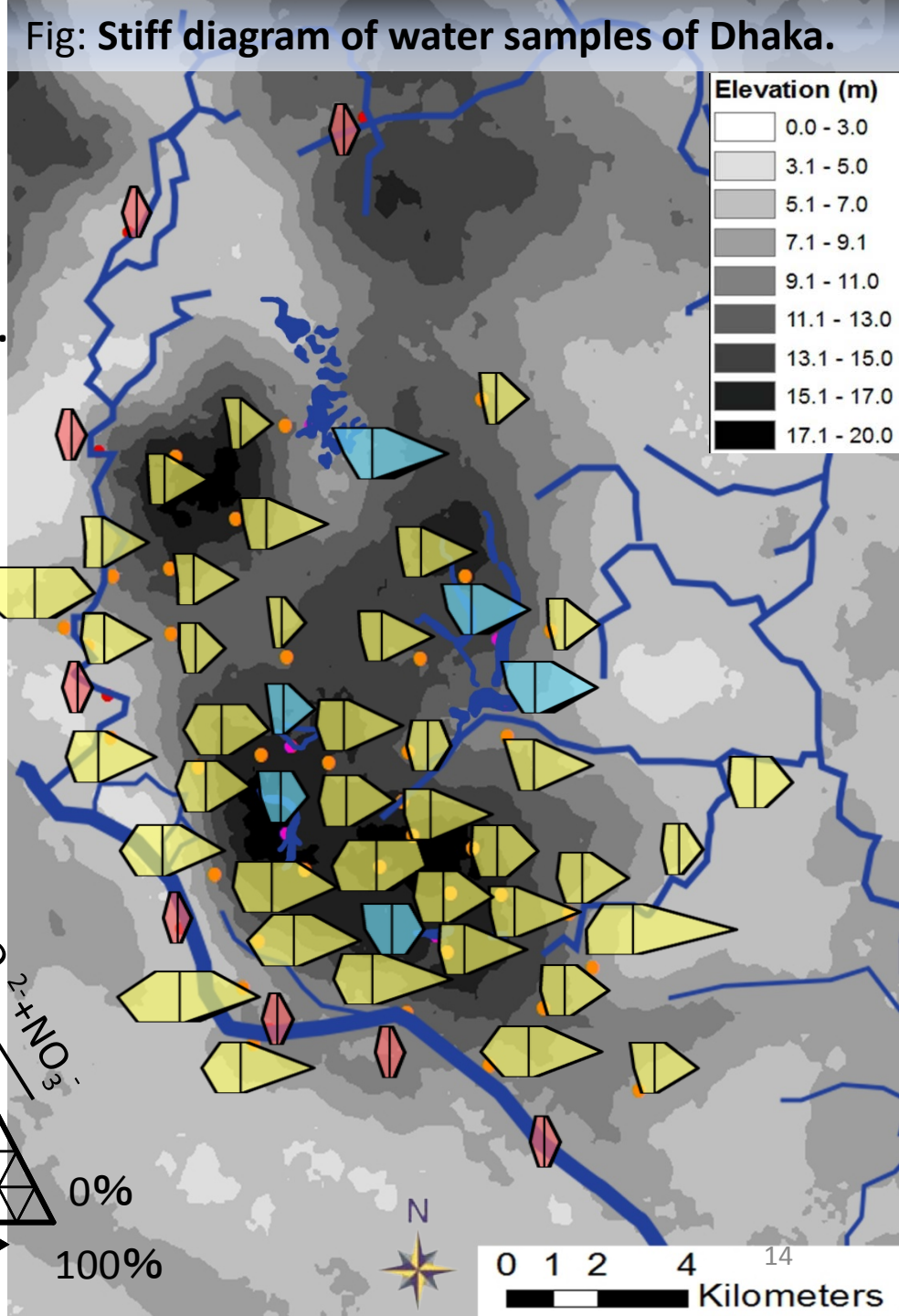
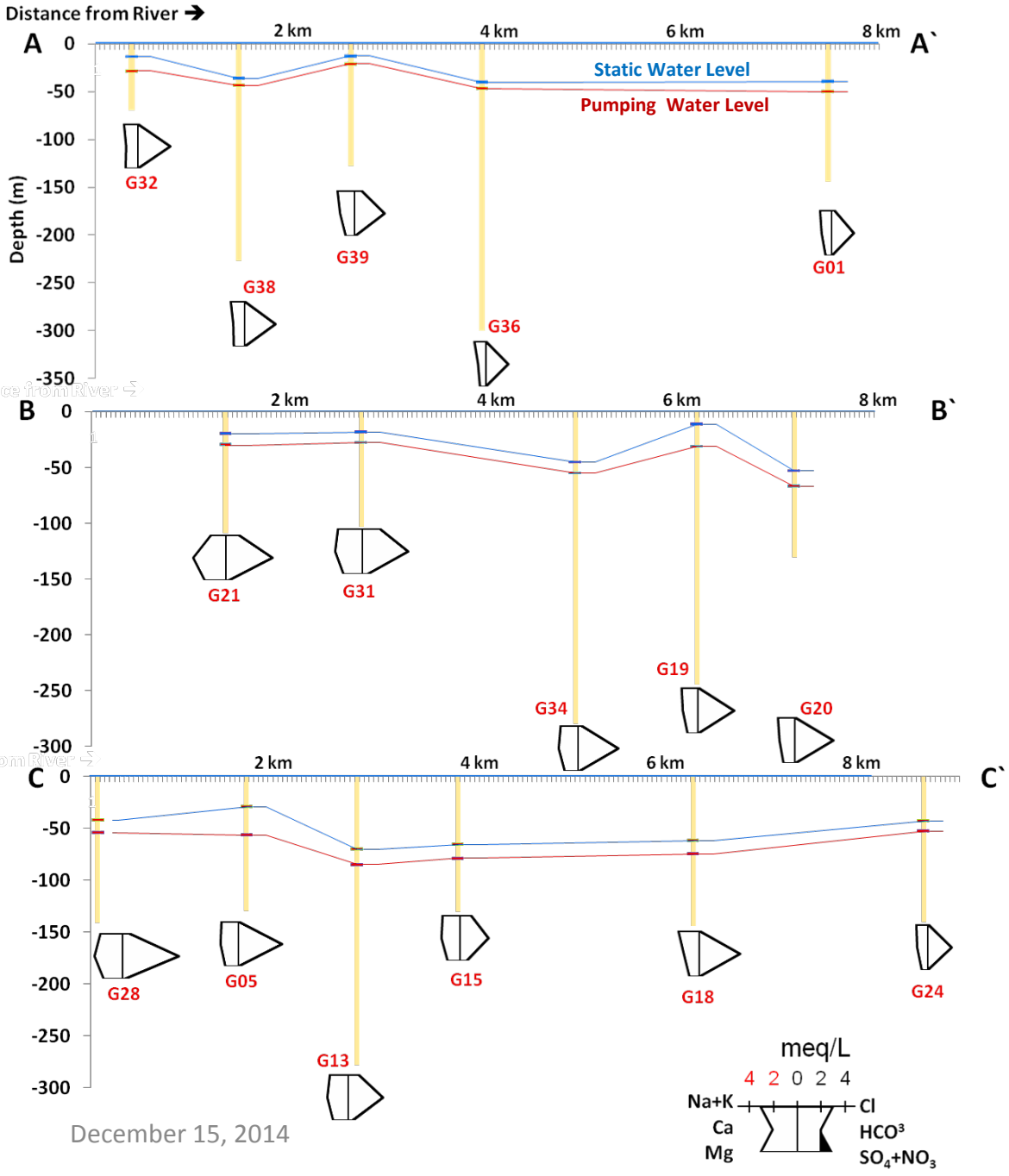
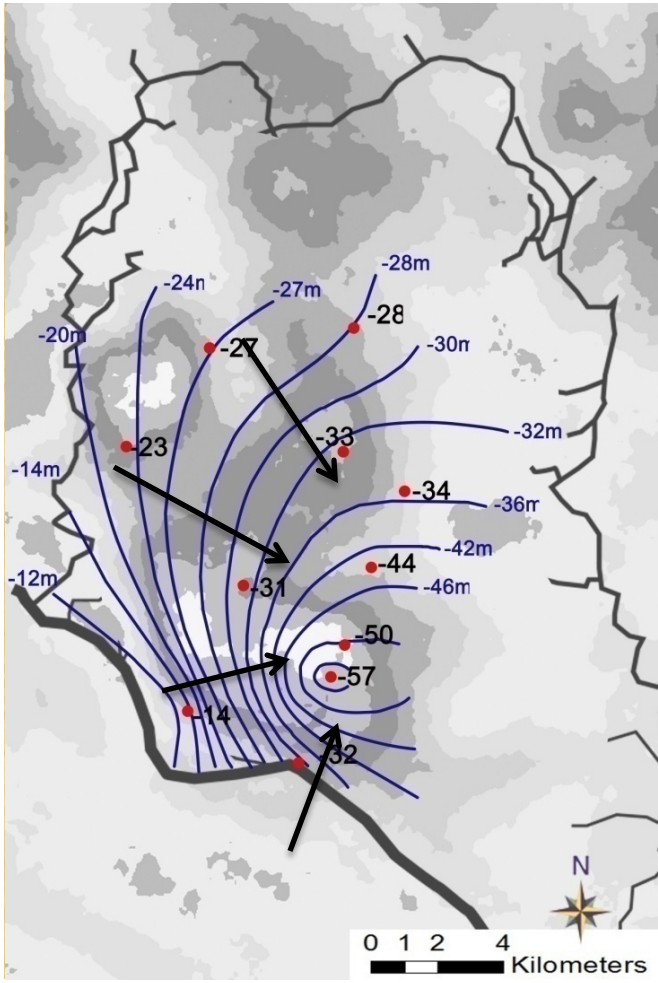


Fig: **Stiff diagram of water samples of Dhaka.**



Variation of Water Quality

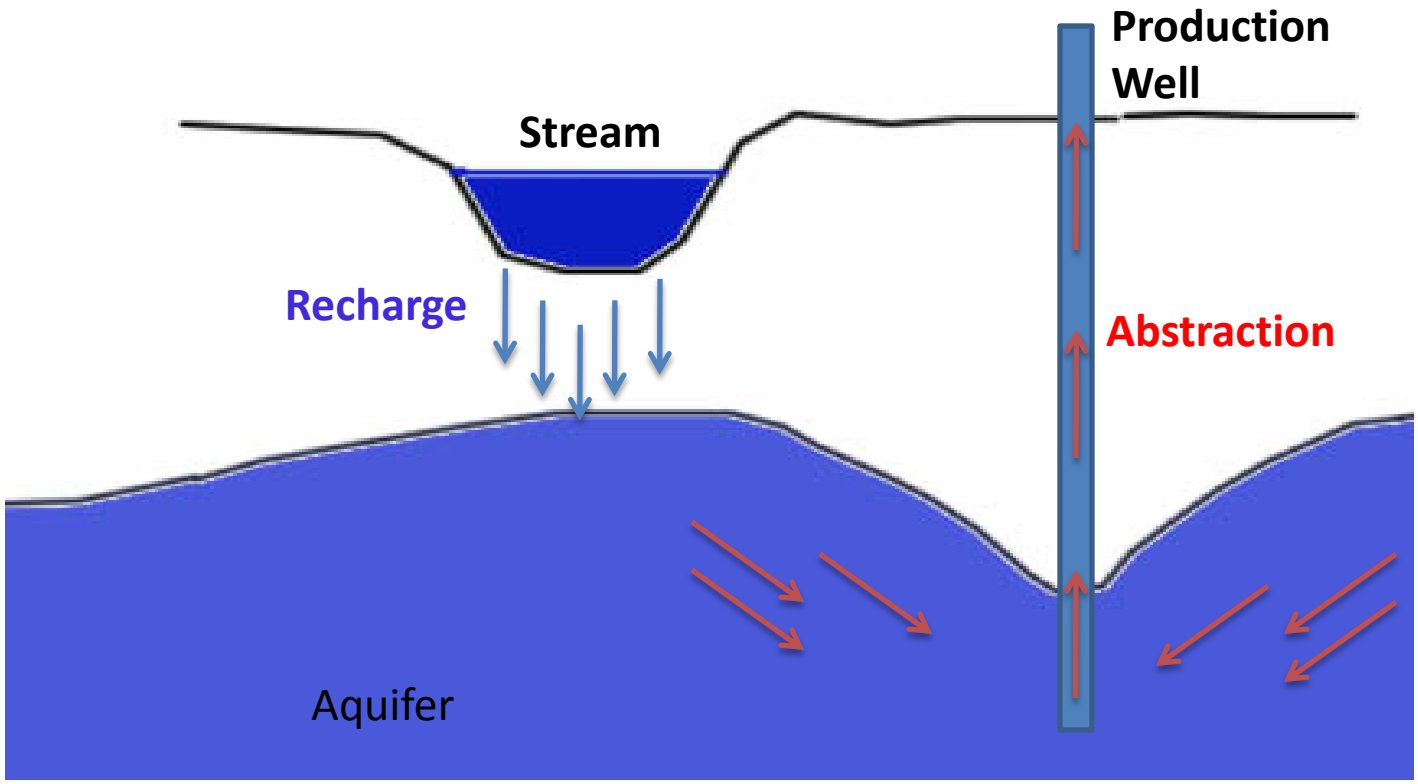




Elevation (m)	
0.0 - 3.0	9.1 - 11.0
3.1 - 5.0	11.1 - 13.0
5.1 - 7.0	13.1 - 15.0
7.1 - 9.0	15.1 - 17.0
	17.1 - 20.0

Preliminary Result

For downstream region:



SUMMARY

- Extensive groundwater abstraction may be the primary reason of rapid GW drawdown;
- Groundwater flow from the peripheral region towards central region leads the possibility of GW recharge from the river bed;
- Water quality varies significantly from the down stream region to central and upstream region;
- GW is mostly Ca-Mg-HCO_3 type;
- Water samples are dominated by HCO_3 with a very low concentration of Cl^-. SO_4 and NO_3 are almost nil.

FUTURE WORKS

- Performing the Isotope ($d^{18}O$, dD) analysis of the water samples ;

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Thank You