

# Study of Ground Water Recharge from Rainfall in Dhaka City

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**Abstract-** Ground water is the first choice for the Dhaka city dwellers. Compare to the over exploitation of ground water, the renewable recharge to aquifer is negligible as the surface area is decreasing due to construction of infrastructure and concrete pavement. The average rate of water table declination is 2.5m/yr. Change in rainfall pattern due to climate change affects soil water meteorological balance. This paper presents the quantitative assessment results of rainwater supply to groundwater for the study area (Kaderabad Housing Area, Mohammadpur). Water balance meteorological chart (2014) for this study area shows total 432mm per year stored in the ground which results in moist soil surface between June to September (considered as rainy season in Bangladesh).

**Keywords-** Ground water Recharge, Climate change, Soil water Balance Meteorology.

## I. INTRODUCTION

Bangladesh, one of the most vulnerable countries of climate change induced disasters, facing changes in climatic behavior and weather patterns. The rainfall pattern of Dhaka city is irregular. This change is affecting freshwater supplies for the rising population and per capita consumption. This paper aims at quantification of the rate of natural ground water recharge which is pre-requisite for efficient and sustainable water resource management. Here, soil water balance approach technique has been used to estimate ground water recharge.

## II. APPROACH AND METHODS OF THE RESEARCH

### A. Approach

In order to measure ground water recharge, following steps have been carried out:

(1) Analyze the permeability characteristics of soil, hydraulic properties of groundwater level; (2) select the type and location of the experimental area; (3) research and develop experimental area; (4) analyze meteorological parameter's data of the experimental area; (5) Calculate results and evaluate.

### B. Research Methods

(1) Inheritance method: inherit the previous research results to calculate rainwater infiltration to groundwater for the preliminary chosen of research area; (2) Interview method: collecting meteorological and water quality field experiment data; (3) Soil water balance method: to assess the relationship between meteorological data and water storage capacity of

study area; (5) Specialization method: used to get the comments for better report.

## III. CALCULATION METHODS OF THE RESEARCH

The Soil water balance model calculates spatial and temporal variations in groundwater recharge using publicly available meteorological data in a tabular format. Components of the soil-moisture balance are calculated over a rectangular grid area. The Soil water balance method uses a modified Thornthwaite-Mather soil moisture accounting method. Ground water recharge is calculated from the difference between the change in soil moisture and moisture sources (precipitation, snowmelt, and inflow) and sinks (interception, outflow, and evapotranspiration).

$$R = (P+S+IN)-(I+OUT +ET)-SM \quad (1)$$

Where:

R= Recharge, P= precipitation, S =snowmelt, IN = inflow,

I = interception, OUT = outflow, ET = evapotranspiration,

SM= change in soil moisture.

Precipitation data are input on a daily basis, in inches or mm. Snow is allowed to accumulate and/or melt on a daily basis. The daily mean, maximum and minimum air temperatures are used to determine whether precipitation takes the form of rain or snow. For Dhaka city, snowmelt meteorological data is zero as geographically no snowfall occurs in Dhaka city. Outflow or surface runoff from research area is calculated using a Soil Conservation Service curve number rainfall-runoff relationship. This rainfall-runoff relationship relates rainfall to runoff based on soil type, land use, surface condition, and antecedent runoff condition. The curve number method defines surface runoff in relationship to the difference between precipitation and an "initial abstraction" term. This initial abstraction term is the summation of all processes that may act to reduce runoff, interception by plants and fallen leaves, depression storage, and infiltration.

$$R = \frac{(P-Ia)^2}{P+(S_{max}-Ia)} ; P > Ia \quad (2)$$

Where,

R = Runoff, P=Daily precipitation,  $S_{max}$  = Maximum soil moisture holding capacity,  $Ia$ = initial abstraction, the amount of precipitation that must fall before any runoff is generated.

The initial abstraction (I<sub>a</sub>) term is related to a maximum storage term (S<sub>max</sub>).

$$I_a = 0.2S_{max}; \tag{3}$$

Potential evapotranspiration (PE) is a meteorological term which measures of the ability of the atmosphere to remove water from the surface through the processes of evaporation and transpiration assuming no control on water supply. Whereas, Actual evapotranspiration (AE) is the term to measure the quantity of water that is actually removed from a surface due to the processes of evaporation and transpiration.

$$PET = 1.6(10^{\frac{T}{T}})^2 \tag{4}$$

PET = monthly potential evapotranspiration (cm/month)

T = average air temperature per month (degree Celsius)

I = annual heat index; a = coefficient depends on the place which can be calculated as follow:

$$a = (675 \times 10^{-9} \times I^3) - (771 \times 10^{-7} \times I^2) + (178 \times 10^{-5} \times I) + 0.49239 \tag{5}$$

Since the number of days in a month is not the same, whereas hours of solar radiation received is different according to the season and the distance from the equator, the PET should be adjusted to:

$$PE = \frac{PET \times S \times Tz}{30 \times 12} \tag{6}$$

s = number of days in month; Tz = average number of hours of exposure per day.

#### IV. RESULTS AND DISCUSSION

Water Balance Meteorological chart for this corresponding site area shows ground water recharge depends mainly on precipitation, evapotranspiration and surface run-off. If the amount of precipitation is larger than evapotranspiration and surface run off, then certain amount water is stored in the ground. Precipitation is subjected to soil characteristics. There is no concrete pavement in the study area.

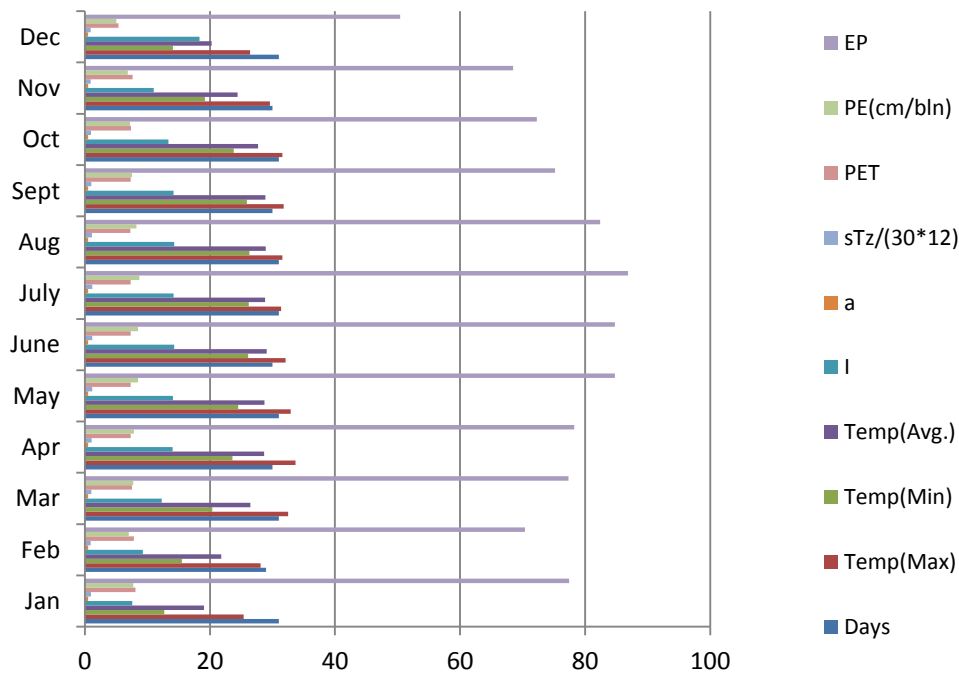


Figure 1. Monthly Evapotranspiration (2014)

Between June to September month, due to heavy rainfall, precipitation rate is heavy. As a result this time event is considered to provide maximum amount of water recharge. In

Bangladesh, this is assumed to be the rainy season. From water balance meteorological data we have seen that total 432 mm per 5 m stored in the ground which results in moist soil surface.

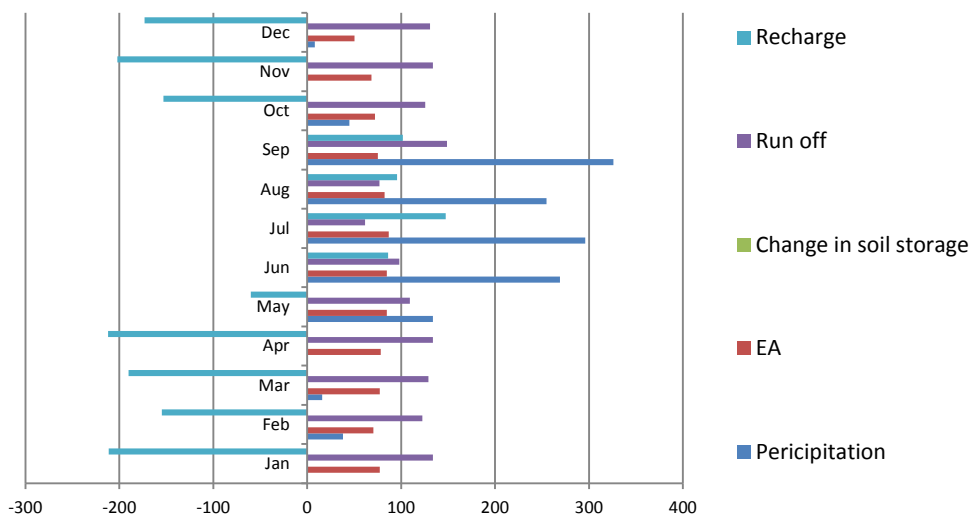


Figure 2. Monthly water balance meteorological (2014)

Between October and May month, winter and summer season, a decreasing pattern of rainfall happens. As a result, the amount of precipitation decreases. Little amount of rain fall that happens, contributes to surface runoff or evapotranspiration. Almost no water is stored in the ground resulting dry soil surface.

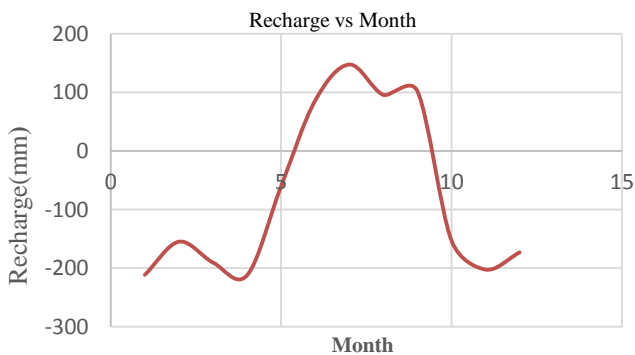


Figure 3. Monthly Water recharge (2014)

Estimation of recharge, by whatever method, is normally subject to large uncertainties and errors. Though the site area was in the Dhaka city, considering no concrete pavement which will affect ground water recharge. To calculate water recharge uniform precipitation over the total study area, uniform soil moisture and water holding capacity are assumed.

As initial soil storage is uncertain, it is assumed as zero that means considering it as base, no storage was done before. Soil characteristics vary from depth at different location in a study area. In this research silty clay type soil has been taken in to account for calculation. Advanced geological survey can eradicate this type of uncertainties.

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