Groundwater recharge estimation in Undai watershed area, southern Mongolia

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ABSTRACT

Recharge estimation in arid and semi-arid areas is complicated. As for the country where the potable water for both the people and livestock is supplied from shallow unconfined aquifer due to the lack of existing ground water, the recharge estimation is crucial to water source management. However, since the deficiency of available data, such estimation has not been completed in the Gobi desert of Mongolia. Water-bearing rock units of the Undai river basin consist of Upper Quaternary alluvial-proluvial sands, gravels and pebbles. In this paper, direct recharge was estimated using chloride mass balance (CMB) and rainfall infiltration breakthrough (RIB) model in shallow unconfined aquifer, Undai watershed area Southern Mongolia. As a result of groundwater recharge estimation survey conducted in 2018, the annual mean recharge of the groundwater along the Undai dry riverbed is calculated to be 13.7mm/year according to RIB model based on the water level fluctuation, which makes up 6.3% of total precipitation and 21.7mm/year according to CMB (chloride mass balance), which comprises 10% of the total annual precipitation. The largest recharge estimates were determined using the daily basis RIB method and the smallest estimates were determined using the chloride-mass-balance method.

INTRODUCTION

Study area

Groundwater plays a significant role in socio-economic development in many countries and it is considered one of the scarcest natural resources in many semi-arid areas. Undai watershed area is located in low plain area surrounded with short hills within the region of Gobi desert with the elevation of 1000-1500m above sea level (Fig1). Shallow groundwater serves 100% of water supply for drinking, domestic and livestock watering in study area.

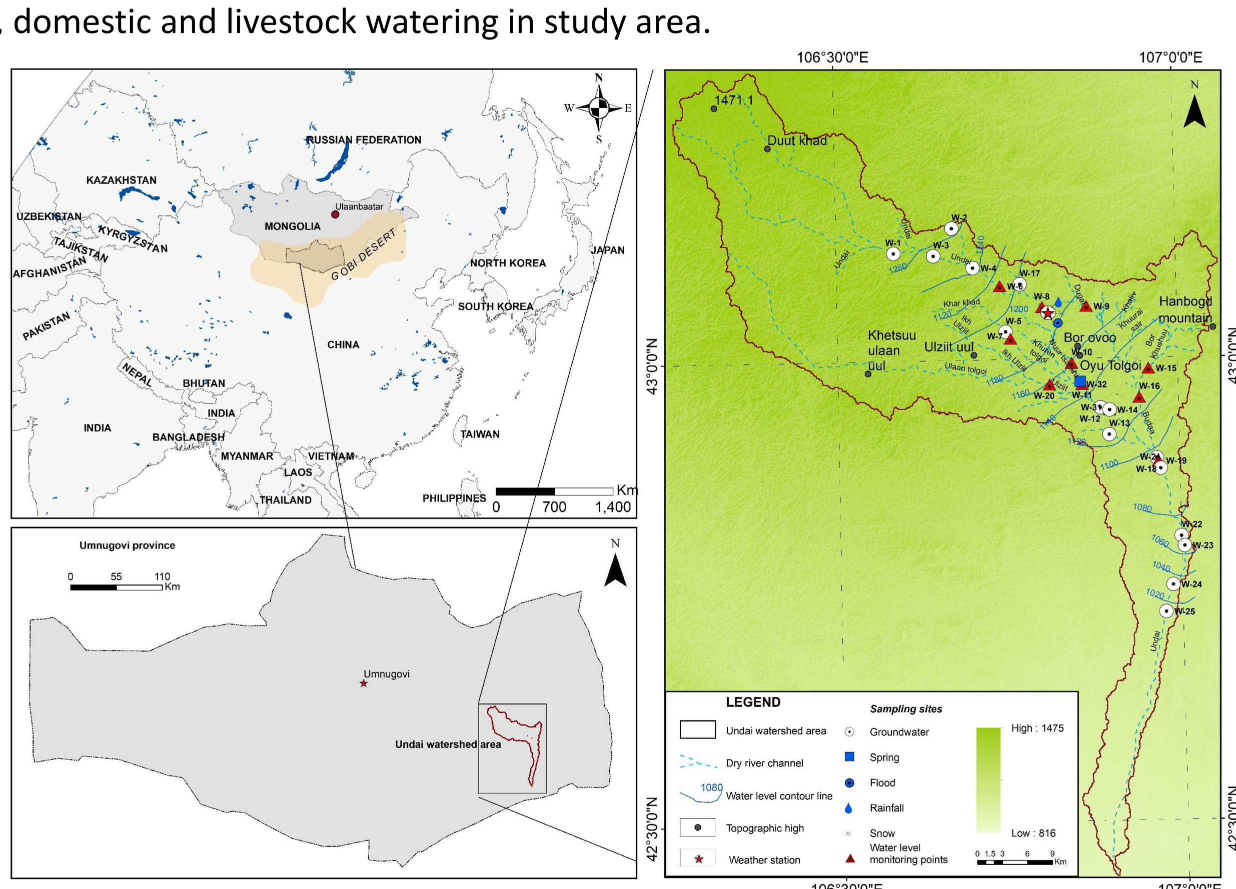
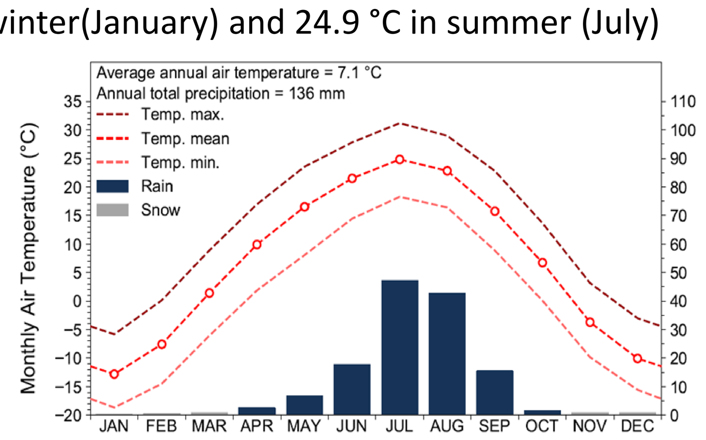


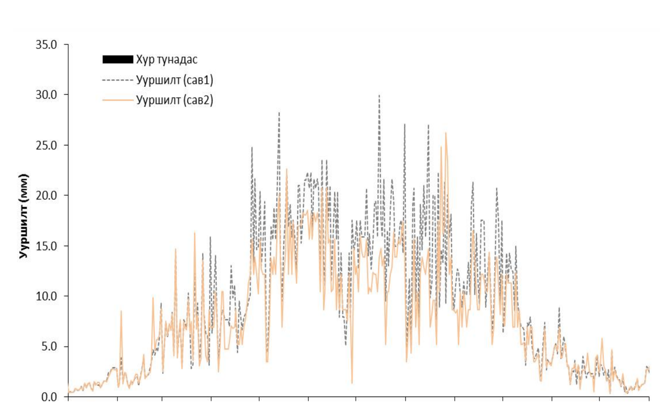
Fig.1 Location of the Undai watershed area

Climate

The mean annual temperature: 7.1 °C, mean annual precipitation: 98.8 mm and 80% of precipitation from June to September. Annual evaporation: 2200 mm, Average monthly temperatures = –11.6 °C in winter(January) and 24.9 °C in summer (July)



Graph 1. Air temperature and precipitation



Graph 2. Evaporation

Hydrogeology

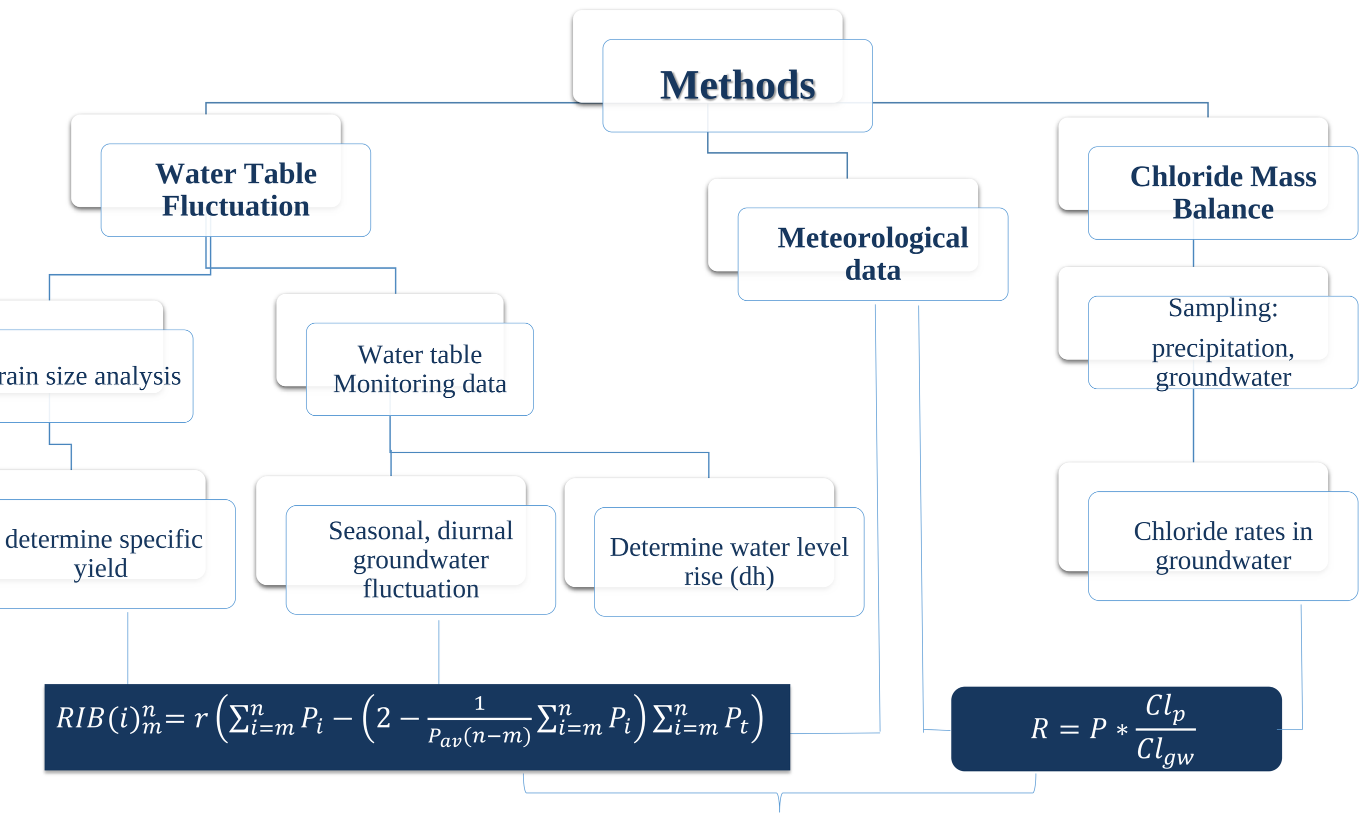
Aquifer found in Upper Quaternary sediments is commonly found in temporary flow channels. The water-bearing units consist of sand, cobble, pebble, gravelstone, and occasionally sandstone. The water availability is various depending on percentage of clay particles. The water-bearing bed ranges from 1m to 3m, rarely reaches to 7m in thickness. Mostly the groundwater is shallow aquifer and is located at the depth of 1.0-5.0m below the surface.

Objective

The main purpose of the study is to estimate an average rate of recharge in shallow groundwater at Undai watershed area.

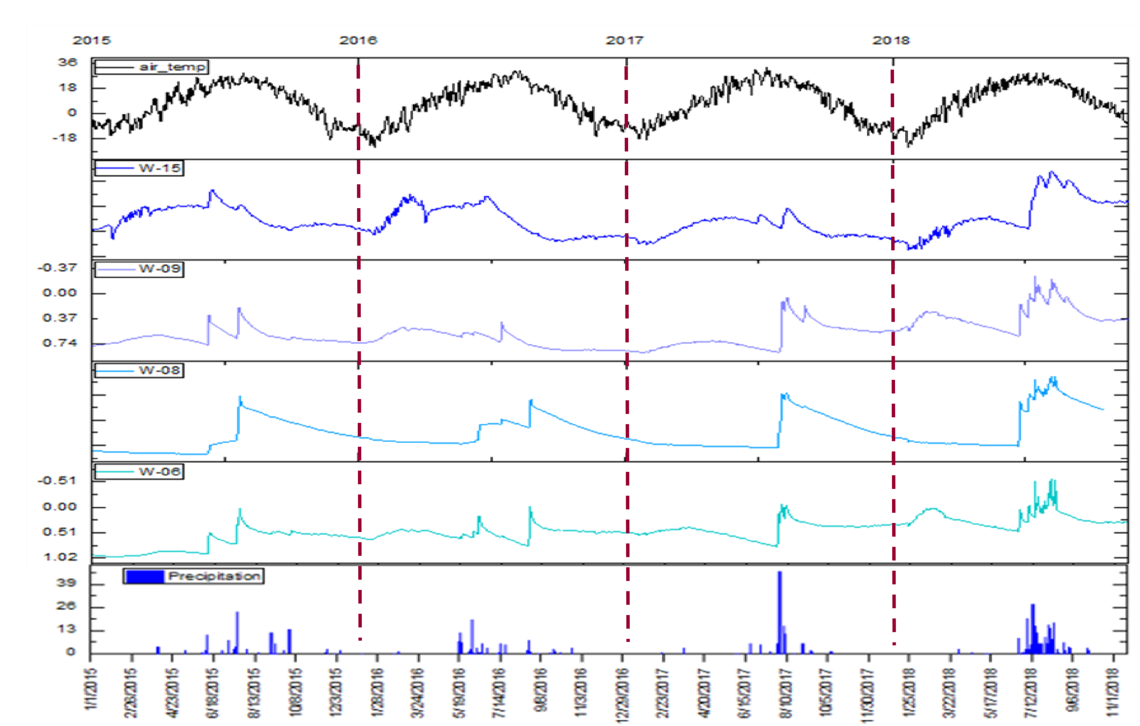
METHODS

During the fieldwork of 2018, we collected 60 groundwater from the 14 boreholes and rainwater samples along the Undai dry riverbed. Moreover, The data used in coherency analysis between precipitation and groundwater level consist of 3 years of daily and monthly data from 2015 to 2018. All water level data originated from Oyu tolgoi groundwater monitoring program.



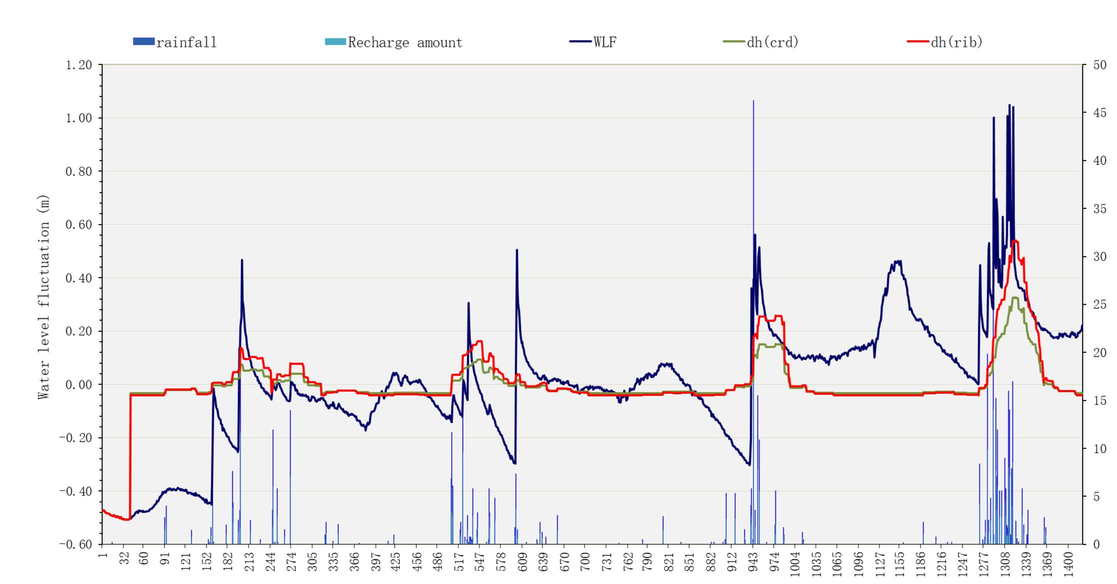
RESULT

Graph 3 shows the daily water-table depths of the four observation wells and daily precipitation from January 2015 to November 2018. The characteristics of the well hydrographs are very similar with the depth of less than 1m.



Graph 3. Comparison of water level and precipitation

RIB model



Graph 4. Days of simulation by RIB model

According to the RIB model, it refers mechanism a: water level fluctuations result from preceding rainfall events. This was often observed at places with relatively quick infiltration rates (range from hours to 1 day) (Xu, 2013).

Chloride mass balance

Weighted average chloride concentration of rain water was calculated as:

$$Cl_x = \frac{\sum_{i=1}^n Cl_i P_i}{\sum P_i}$$

(Nativ and Riggio, 1989)

Range of recharge using CMB has 2.5-21.67 mm/year in 2018.

The maximum amount of the recharge is 21.67 in W-13 located in the part of tributary.

Bore number	Annual precipitation, mm	Recharge, mm/year	Recharge, %
W-1	216	2.35	5.07
W-2	216	6.32	13.65
W-3	216	-	-
W-4	216	6.19	13.37
W-5	216	5.72	12.36
W-12	216	4.74	10.23
W-13	216	21.67	46.81
W-17	216	8.67	18.72
W-18	216	7.59	16.38
W-21	216	-	-
W-22	216	5.42	11.70
W-23	216	6.74	14.56
W-24	216	3.94	8.51
W-25	216	20.23	43.70

CONCLUSION

The result of this research has revealed that the groundwater in the arid and semi-arid regions is mainly recharged during the precipitation period between June and August.

As a result of groundwater recharge estimation survey conducted in 2018, the annual mean recharge of the groundwater along the Undai dry riverbed is calculated to be 13.7mm/year according to RIB model based on the water level fluctuation, which makes up 6.3% of total precipitation and 21.7mm/year according to CMB (chloride mass balance), which comprises 10% of the total annual precipitation. The largest recharge estimates were determined using the daily basis RIB method and the smallest estimates were determined using the chloride-mass-balance method.

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