Physical Modeling Approach for Assessing the Effect of Climate Change on Groundwater at Coastal Area

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Abstract

Seawater intrusion has brought a great deal of attention globally with the worsening effect of rising sea level and changing of climates. Global climate change which has caused the unevenness increased in extreme events such as droughts and floods has anticipated water resources to become impaired. In this study, under the influence of climate change, a shallow unconfined groundwater was laid out orderly to investigate the saltwater intrusion phenomena in coastal aquifers. Experiments were conducted using laboratory rectangular model tank filled with fresh water, well-sorted sand and salt water into three separate chambers. In spite of the fact that numerous experimental procedures have been acquired to investigate the transient development of the saltwater interface in unconfined aquifers, none of them has tackled the possibilities of applying the climate change effect. The main focus of this particular investigation is to compare the relation of recharge and rising of sea level on the behavior of the saltwater interface in the unconfined aquifer from laboratory experiment with the normal cases of flood and the sea level rise as well as the drought and sea level rise. Simulation on the projected rising of sea level due to the climate change leads to significant intrusion outcomes of 52.4% with a toe of the saltwater wedge (TOE) distance of 0.54 m; however, an increase in the magnitude of precipitation rates and freshwater head can ultimately recharge the groundwater. This mitigates the changes of 49% in the saltwater-freshwater interface (SFI) with a receding distance of 0.22 m.

Keywords: climate change, saltwater-freshwater interface, sea level rise, seawater intrusion, unconfined aquifer

1. Introduction

Presently, groundwater has been a primary source to provide consumable freshwater for a prominent percentage of the global population. However, global climate change which has caused the unevenness increased in extreme events such as droughts and floods has anticipated water resources to damage. It is important to understand the outcomes of climate change as it can contribute to bettering the knowledge of predicting possible future impact on groundwater resources, especially when its quality and quantity are being underlined globally. Groundwater makes up 98% of the freshwater resources accessible for human use [1].

Nearly two thirds of the global population live within 400 km of the nearshore borderline, just over half live within 200 km, an area only taking up 10% of the earth's surface [2]. According to [3], if a seaward hydraulic gradient present, the fresh groundwater in coastal aquifers will commonly discharges into the ocean. For an unconfined aquifer, a water table occurs. The aquifer above the water table is unsaturated and moisture movement occurs, including rainfall infiltration to the groundwater. The dominant groundwater flow occurs in the saturated zone below the water table. In the final part of the aquifer seawater is introduced at the seaward. Since seawater is more dense than fresh water, it has a tendency to obtrude into the aquifer and beat below the less dense freshwater to forge a saltwater wedge. A freshwater-saltwater interface is established once the seawater comes into contact with the fresh water. The interface is a diffusion zone, where hydrodynamic dispersion occurs [3]. The physical parameter of the aquifer and flow rate condition is contingent upon the thickness of the interface [4]. Normally, the mixing of the saltwater-freshwater in coastal aquifers is likewise due to the determined factors such as tidal variations, extending over a relatively long time climate change and tidal level varieties, cracking in coastal stone shaping and dependent on a particular season change in recharge rates and evaporation [5]. Recharge rates can as well be brought down in countries with rapid urbanization and thus impervious surfaces [5]. Building drainage channels can induce the water level to decrease and encourage intrusion occurrence [6]. A greater extent detailed investigation on coastal groundwater and seawater intrusion has been mentioned in [7]-[9] studies.

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