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چکیده

رویکردهای فعلی برای تعیین کمیت آب‌های زیرزمینی شامل بیلان آب و ماهواره ثقل‌سنج است. با این حال، روش بیلان آب شامل برآورد نامشخص پارامترهایی از جمله تبخیر-تعرق و رواناب است. روش ماهواره‌ای زمان و تلاش بسیار زیادی را می‌طلبد. روش گزارش شده در این مقاله پیشنهاد استفاده از تئوری شکست به روشی جدید برای پیش‌بینی کاهش ضخامت اشباع در آب‌های زیرزمینی است. یک مسئله مهم در تئوری شکست، تعیین نقطه شکست است. روش پیشنهادی از عمق آب به عنوان نتیجه نهاییِ فرایندهای شارژ/تخلیه در آبخوان استفاده می‌کند تا ضخامت اشباع باقیمانده حاصل از نرخ پمپاژ اعمال شده در یک منطقه را برای ارزیابی کاهش و یا تخلیه آب زیرزمینی محاسبه کند. برای شبیه‌سازی و تجزیه و تحلیل داده‌های جمع آوری شده از سال ۱۹۶۲ تا ۲۰۰۹، از دو پارامتر تابع ویبل و تحلیل بیز استفاده شد. روش پیشنهادی در یک آبخوانِ غیر قابل تجدید بدون هیچ گونه شارژ مجدد آزمایش شد. در نتیجه، کاهش مداوم عمق آب معیار اصلی مورد استفاده برای تخمین کاهش سطح آب شده است. ارزش روش پیشنهادی جهت پیش‌بینی تأثیر احتمالی میزان پمپاژ فعلی بر ضخامت اشباع - بر اساس داده‌های ضخامت - باقیمانده است. محدودیت روش پیشنهادی این است که فرض می‌کند شیوه‌های مدیریتی اعمال شده در طول دوره پیش‌بینی ثابت هستند. این مطالعه پیش‌بینی می‌کند که پس از ۳۰۰ سال احتمال ۸۰ درصدی تخلیه آبخوان اشباع شده وجود دارد.

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New Approach For Prediction Groundwater Depletion

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ABSTRACT

Current approaches to quantify groundwater depletion involve water balance and satellite gravity. However, the water balance technique includes uncertain estimation of parameters such as evapotranspiration and runoff. The satellite method consumes time and effort. The work reported in this paper proposes using failure theory in a novel way to predict groundwater saturated thickness depletion. An important issue in the failure theory proposed is to determine the failure point (depletion case). The proposed technique uses depth of water as the net result of recharge/discharge processes in the aquifer to calculate remaining saturated thickness resulting from the applied pumping rates in an area to evaluate the groundwater depletion. Two parameters, the Weibull function and Bayes analysis were used to model and analyze collected data from 1962 to 2009. The proposed methodology was tested in a nonrenewable aquifer, with no recharge. Consequently, the continuous decline in water depth has been the main criterion used to estimate the depletion. The value of the proposed approach is to predict the probable effect of the current applied pumping rates on the saturated thickness based on the remaining saturated thickness data. The limitation of the suggested approach is that it assumes the applied management practices are constant during the prediction period. The study predicted that after 300 years there would be an 80% probability of the saturated aquifer which would be expected to be depleted. Lifetime or failure theory can give a simple alternative way to predict the remaining saturated thickness depletion with no time-consuming processes such as the sophisticated software required.

1. Introduction

1.1. Groundwater depletion

Groundwater depletion is the continuous reduction of groundwater storage volume when groundwater abstraction exceeds aquifer recharge so that in the long term the groundwater cannot sustain development activities. Groundwater depletion represents a great challenge, especially in nonrenewable aquifers such as the Nubian Sandstone aquifer in the Western Desert, Egypt. This aquifer suffers from continuous water level decline as a result of over-pumping during and after the development of El Kharga Oasis (Barber, 1977; Soliman, 2013). Initially, the wells in this region were flowing. However, after nearly 50 years of continuous pumping the head drop in some areas is estimated to be 60 m (Soliman, 2013). The average thickness of the aquifer in the Oasis is around 400 m (Ezzat, 1976,; Himida, 1968).

1.2. Quantifying groundwater depletion

Current approaches for quantification of groundwater depletion are based on the water balance method and volumetric approach such as the temporal gravity method to estimate dynamic storage. McGuire et al. (2003) used integrated measurements of changes in groundwater levels and storativity to estimate groundwater depletion. Kjelstrom (1995) used water balance and pumping tests. Faunt et al. (2009) used deterministic calibrated groundwater flow models to quantify groundwater depletion. David and Allen (2015) used a logistic equation to study changes in groundwater storage. Many researchers such as Rodell and Velicogna (2009) and Famiglietti et al. (2011) quantified groundwater depletion using gravity changes over time by a satellite technique. This work is concerned with exploring lifetime approaches in predicting saturated thickness depletion of the non-renewable aquifer.

1.3. Study site location

The El Kharga Oasis is located in the Western Desert of Egypt along the Nile Valley at longitude 30° 20′ and 30° 40′ east and

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