UNIVERSITI TEKNOLOGI MARA
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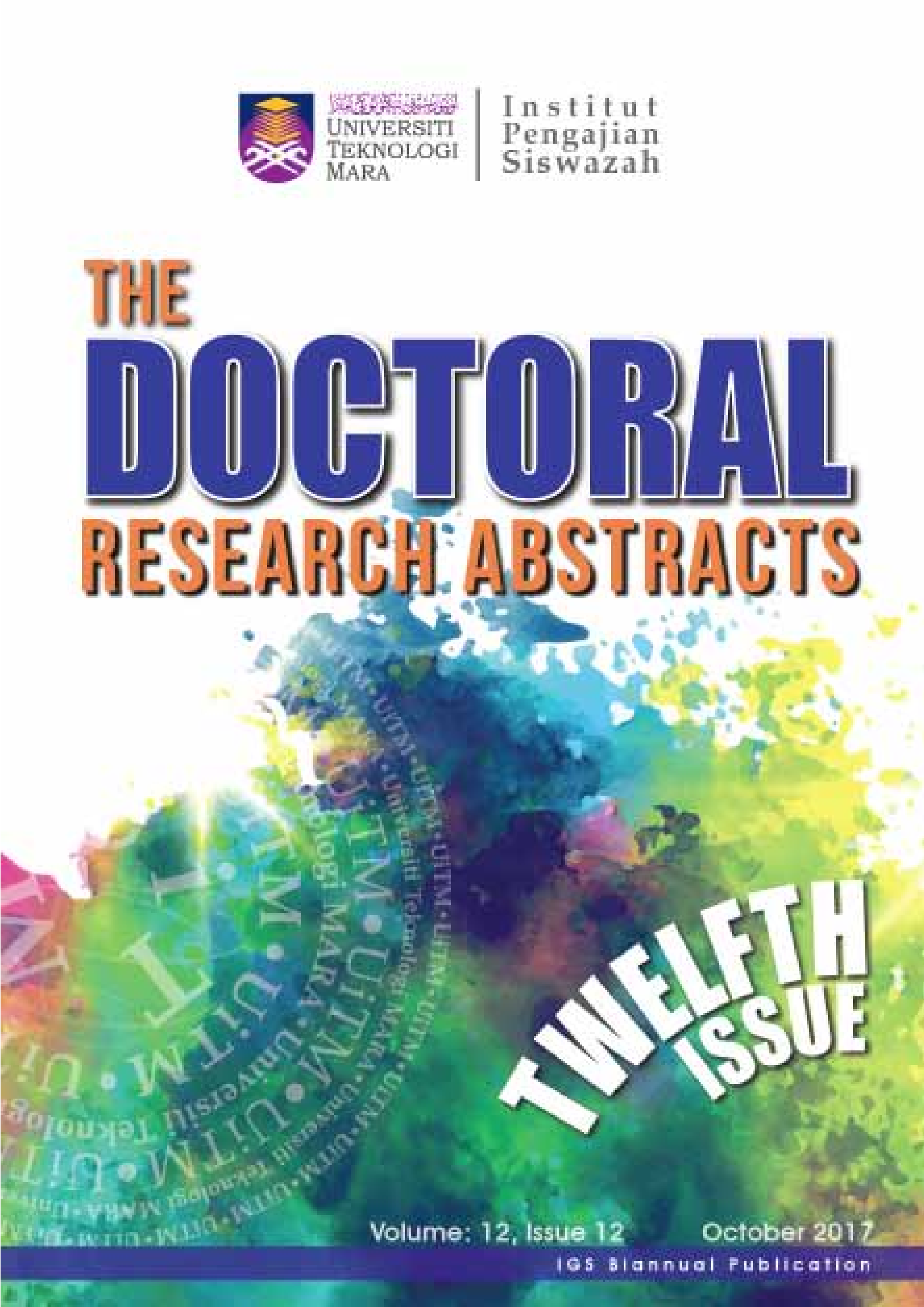
THE DOCTORAL RESEARCH ABSTRACTS



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Name : IZZADIN ALI AHMED AL-SHAEZ

Title : MODELLING GROUNDWATER AQUIFER TO ESTIMATE WATER SUSTAINABILITY IN SANA'A BASIN

Supervisor : PROF. DR. DASIMAH OMAR (MS)
DR. SITI MAZWIN KAMARUDDIN (CS)

Escalating water scarcity threatens global sustainable development. Water scarce regions will increase worldwide during the current century, as the water demand rate is more than twice the population growth rate. Yemen has one of the fast growing population rates in the world and is facing high water stress. Sana'a city, in particular, is experiencing a critical water shortage due to industrialisation, urbanisation and fast population growth rate. The water table at Sana'a aquifer, which is a groundwater-dependent city, has dropped significantly since 1972, as new technology was introduced to extract groundwater. Some studies estimated that Sana'a city would be the first metropolitan area to run dry during the coming few decades due to unsustainable groundwater pumping, as many wells will be depleted. This dissertation's main aim is to evaluate the impact of climate change on groundwater resource in the Sana'a basin aquifer. To achieve the objectives of the study, firstly, the total groundwater recharge amount and spatial distribution were estimated using chloride mass balance. Selected wells and locations were chosen to collect groundwater and rainfall samples. In total, 22 sites spread all over the basin were chosen and the samples were collected during the two rain seasons from March-May and July-August in the year 2014. Likewise, 22 wells covering all the basin area were chosen to take groundwater samples for the chloride concentration test. The samples were taken during the rain season from March-May and July-August in 2014. After that, a chloride content analysis was carried out in the laboratory. The samples were collected and transported according to the standard procedure under the chemistry laboratory specified conditions. The results indicate that the overall recharge rate is almost 6.3% of the annual rainfall. Secondly, the Decile method was used to forecast rainfall variability, and thirdly, a groundwater flow model, using Visual MODFLOW, was developed. A close agreement was achieved between the simulated and observed heads for the calibration stress periods. Then the developed model is used to simulate the hydrogeological dynamics response under the following future scenarios: 1) Business as Usual conditions; 2) Dry weather conditions (decile method); 3) Wet weather conditions (decile method); 4) Median weather conditions (decile method); 5) Alternate wet and dry weather conditions; Business as Usual conditions with groundwater augmentation of 20%; 7) Business as Usual conditions with groundwater augmentation of 40%. The output of all simulated scenarios indicates that the Sana'a basin aquifer storage will decrease under various weather conditions with the passing of time. In all simulated scenarios, the largest change in groundwater storage was during the period 2046-2050, with a significant groundwater extraction for the Dry Weather Condition scenario. It is estimated that this period is the peak on groundwater extraction. The aquifer yield will decline under all weather conditions as exhaustion of reserves occur. However, Scenario 6 shows the minimal over-exploited areas while over-exploited areas disappeared in scenario 7 which shows that it is the sustainable scenario that could sustain the groundwater for the coming generations. This study demonstrates that climate change will render fresh groundwater resources unuseful for mankind, but integrating future climate change and population growth impacts into the water management planning is a necessity in order to proceed towards a resilient groundwater management system.