Quick Sand in Large Diameter Wells: Analytical and Numerical Analyses

M. Kompani-Zare[1], N. Samani[2], S. Behrooz-Kohenjani[3]
1- School of Agriculture, Shiraz University, Shiraz, Iran
2, 3- Science Faculty, Shiraz University, Shiraz 71454, Iran
samani@susc.ac.ir

Abstract

Large diameter wells gaining water from the bottom are dug in the sandy and collapsible aquifers. When the vertical hydraulic gradient on their bottom reaches a critical value, quicksand occurs. Another difficulty encountered is drawdown in the wellbore and the drying up of the well. To overcome these problems, the flow around and beneath these wells is numerically simulated and the dimensionless drawdown-time and dimensionless vertical gradient-time curves are developed. It was found that the ratio of filling material thickness to well radius affect the shape of these type curves. The type curves may be used to design pumping rate and duration as well as well radius.
Keywords: Quicksand, Large diameter well, Vertical gradient.

1. INTRODUCTION

In many arid regions around the world the ground surface is covered by dune sand deposited by wind. These sediments are always thick and are the main source of ground water. The wells dug in these sandy aquifers are collapsible. Therefore, wells are lined and sealed with brick, concrete or cemented stony walls. These wells usually uptake water from their bottom. If pumping rate exceeds a specific limit quicksand occurs at the bottom. As quicksand occurs, a large amount of sand will gradually be extracted from the body of the aquifer around the well. The extraction of sand creates large holes and destroys the well structure. Another problem in this kind of wells is drying up of the well. Because of low hydraulic conductivity of fine sand the drawdown in the wellbore is large, and the well is dried up after a short period of pumping. The question here is that how much the safe pumping rate and time are for which quicksand and drying up of the well do not occur.

Quicksand and its controlling parameters were studied before by [6, 7]. These studies are mainly concentrated on quicksand related to dam construction and foundation of large structures. Patchick [7] investigated the quicksand in water wells. His study is basically qualitative and he did not focus on the detailed simulation of flow into the wells. Here in this paper it is proposed to investigate the effect of well dimensions and the aquifer parameters in controlling the quicksand phenomenon. Well dimensions parameters include well diameter, well casing thickness and depth. Aquifer parameters include hydraulic conductivity, specific yield and saturated thickness of the aquifer. By finding the effect of each parameter on the quicksand occurrence, one can suggest a set of parameter values for which quicksand does not occur.

Flow to large diameter wells is studied by many investigators [10]. However, the large diameter wells gaining water only from the bottom have not been assessed yet. The unique property of the wells studied in this research is that, the wellbore is partially filled with aquifer materials and the flow in the filled portion of the wellbore is vertical upward. The analytical solution for flow to these large diameter wells have not been found yet. Therefore, to determine the vertical hydraulic gradient, the main cause of quicksand, the flow to the well is simulated numerically. To simulate the radial flow around a well, MODFLOW 2000 [5] may be embedded with some methods such as those presented by Reilly and Harbaugh [8] or Samani et al. [9]. Here the so-called LSM (Log Scaling Method) presented by Samani et al. [9] is utilized along with MODFLOW 2000. By simulation of the unsteady flow around and beneath the well, the spatial and temporal variation of the vertical hydraulic gradient at the bottom of the well and the drawdown in wellbore can be determined. The emphasis is on delineating how aquifer and well characteristics affect pumping-induced drawdown, so that field practitioners will be able to plan the safe pumping rate and duration and to design a well free of quicksand.

2. STUDY SITE:

The study site is Chah Kutah region, in Bushire province, south west of Iran. There are many large diameter water wells in Chah Kutah region which supply irrigation water (Fars Water Affair Organization 1998) and gain water from the bottom. This region is covered by dune sand in its north eastern parts. Further to north