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Multi-channel electrical conductivity monitoring of borehole fluid in the coastal aquifer

J. Shin (1), **S. Hwang** (1), K. Park (1), Y. Park (1), H. Oh (1), S. Choi (1), S. Lee (1)
(1) Korea Institute of Geoscience and Mineral Resources, hwangse@kigam.re.kr

Introduction: Particularly in seawater intrusion related research, fluid electrical conductivity change is one of major concerns, and effective monitoring can help to optimize a water pumping performance in coastal areas. It is essential mounting sensors at proper depth since the fluid electrical conductivity is sensitive to tidal effect (Lee et al, 2000). This tells us the multi-channel electrical conductivity monitoring is of paramount consequence. It, however, is a rare event when this approach becomes routinely available in that commonly used commercial stand alone type sensors are very expensive and inadequate for a long term monitoring of electrical conductivity or water level due to their restricted storage and difficulty of real-time control. For this reason, we have developed a real-time monitoring system that could meet these requirements. This system has many advantages over the techniques through the existing commercial sensors, it is user friendly, cost-effective, easy to control measurement parameters - sampling interval, acquisition range, and others. Furthermore, the devised system might be broadly employed in other phenomena due to its channel-expandability and sensor-type compatibility. With our sustainable array-type monitoring system, electrical conductivity is continuously monitored and logged for boreholes drilled in seawater intrusion zone. The Development and Application of Multi-channel Monitoring System: The system consists of network module, I/O module, and electrical conductivity sensors. Network interface (FieldPoint-1601, National Instruments Co.) can support a variety of communication options ranging from serial to Ethernet, and connect up to nine I/O modules. FP-AI-110 (National Instruments Co.) device used as I/O module is versatile analog input module that can be used to measure a variety of voltage and current level. This module measures and linearizes signals onboard to return scaled values to control or monitoring software. The mounted electrical conductivity sensors (Global Water Inc.) produce a 4-20 mA output signal - an industrial standard signal for process control monitoring, and cover range from 0 to 5,000 / 20,000 uS/cm. The software system embodied by LabVIEW allows us to flexibly control all parameters and check on the status of all the stations. It configures each channel of the modules to return data scaled to calibrated electrical conductivity, graphically displays real-time data to review the results history over a user-specified time interval and simultaneously saves for further analysis. In addition, because we can connect virtually any sensor directly to a variety of high-accuracy analog or digital I/O modules, and also filter, digitize, calibrate and scale raw sensor signals to desired engineering units, the generated system might be expected to fulfill the monitoring, data logging and subsequent more quantitative analysis in various fields of study. The built monitoring system has been utilized in boreholes drilled in seawater intrusion zone. We have re-calibrated sensors considering the electrical conductivity of target area, which is less than 600 uS/cm. Electrical conductivity values for designated depths have been monitored and logged at an interval of 1,000 ms in one borehole during uniformly pumping water in the other borehole 30 meter distant. Monitoring has been consecutively executed for 24 hours, and the responses of electrical conductivity at some channels have been regularly increased or decreased while pumping up water. It, with well logging data implemented before/after pumping water, verifies that electrical conductivity changes in the specified depths originate from fluid movements through sand layer or permeable fractured rock. Conclusion: The multi-channel monitoring system facilitates the acquisition of data from a wide range of sensors, manipulation, retrieval, graphical presentation of the results and the remote control of parameter in real time. It delivers not only comprehensive information about electrical conductivity fluctuation, but also supplies clues to saltwater mobility caused by water pumping in saltwater/freshwater transition zones. Although studied area currently belongs to freshwater zone, it is influenced by adjacent brackish aquifer in that the change of electrical conductivity is high when pumping up water about 20 ton a day. Eventually, the multi-channel electrical conductivity monitoring system, with succeeding monitoring by various water pumping pattern and time, secures the maximum efficiency of aiding us to optimize a water pumping design for preventing seawater intrusion in coastal areas.

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