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Monitoring of drinking water distribution system by SCADA in Antalya City, Turkey

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Antalya water and wastewater administration has recently completed SCADA (Supervisory Control And Data Acquisition) system. The system enabled the on-line continuous monitoring of many water quantity and quality parameters such as flow rate, pressure, temperature, pH, turbidity, electrical conductivity, and free residual chlorine. Additionally, water levels in the distribution reservoirs, water pumps, energy consumption and the closing valves are monitored and controlled by the SCADA system. Beside the on-line continuous monitoring, field sampling and lab analyses of other water quality parameters such as total organic carbon, THM, bromide, iron, nitrogen and phosphorous groups, and coliform bacteria were conducted. The results of field sampling agreed with the on-line monitoring values. The SCADA system proved to be very useful for reducing water losses, improving water quality, reducing energy consumption and improving the reliability of the system.

Introduction

Antalya is one of the most important cities in Turkey that lies along the Mediterranean coast with an approximate population of one million capita. Groundwater wells and one spring are the drinking water resources in the city. The groundwater has good water quality in general except being hard. Consequently, the water receives no treatment but chlorine is added to raw water in the form of sodium hypochloride solution to protect the water quality against any possible pollution during distribution. The practice is to keep free residual chlorine levels between 0.2 to 0.5 mg/l along the water distribution network which complies with the related drinking water standards (RCWIHC, 2005). Average yearly total water losses are estimated at 43% in Antalya City which is close to the overall average in Turkey. The karstic soil formation allows the water to leak down and not to appear on the surface. Consequently, it is difficult to detect water leakage and pipe bursts in the city without using sophisticated systems and techniques.

The SCADA System

Antalya drinking water supply system has been recently equipped with more than 90 stations for the continuous on-line monitoring of water quality and quantity. The stations are located on the groundwater wells, spring water, water reservoirs, pumping stations and at many locations along the water distribution main pipes. The stations are equipped with sensors for the on-line measurements of water temperature, pH, conductivity, turbidity, free residual chlorine, water flow rate, water pressure and water levels in the distribution reservoirs beside energy consumption. The total cost of the SCADA system is around five million Euros. One of the SCADA stations and the on-line measurement sensors are illustrated in Photograph 1. and Photograph 2. The monitored parameters are wirelessly sent to the SCADA (Supervisory Control And Data Acquisition) center located at the main building of Antalya Water and Wastewater Administration (ASAT). These parameters are displayed on large screens located in the SCADA center and also stored for further analyses in the future.

SCADA system illustrates the operation of water pumps, the water level in the distribution reservoirs, the instantaneous flow rate and the total flow rate pumped within a selected period of time. Special alarms alert the operators if the monitored parameters deviate from a certain pre-defined range such as an increase in turbidity level or water flow rate. The same SCADA system is capable of closing and opening the valves and controlling the operation of water pumps just by pressing a button in the SCADA center. As a result, the SCADA system reduced the number of ASAT personnel needed to observe the water levels in the distribution reservoirs and the number of personnel required for controlling the water valves.

Photograph 1. A typical view of a SCADA station located along a water main in Antalya City

Photograph 2. On-line measurement sensors for temperature, pH, turbidity, electrical conductivity and free residual chlorine

Field sampling

Beside the on-line monitoring, water samples before and after chlorination are collected manually from many locations bimonthly and analyzed for additional water quality parameters such as coliform bacteria, iron, manganese, bromide, total organic carbon (TOC), THM, nitrogen and phosphorous groups to investigate the water quality in a comprehensive way. The results of field sampling agreed well with the on-line monitoring. For example, concentrations of substances that demand chlorine such as TOC, bromide, iron, manganese were very low which supports the marginal spatial variations of residual free chlorine levels measured by the on-line sensors.

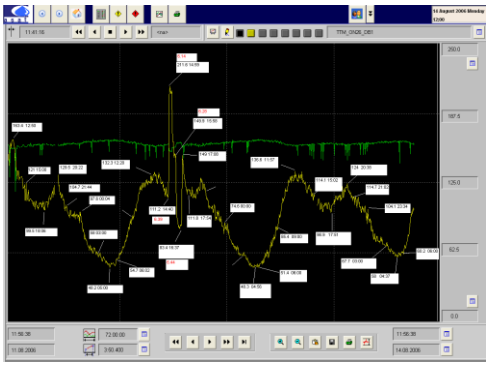
Use of the SCADA system to detect water losses

Water losses in Antalya are divided into i) Physical water losses mainly from the leaks of pipe cracks, pipe joints, and customer connections, and ii) Apparent water losses mainly from the inaccuracy of customer water meters and illegal water connections. Around 60% of water losses is classified as physical while the rest (40%) is classified as apparent water losses. A part of the water distribution system in Antalya city was divided into a number of District Metered Areas (DMAs) for the efficient management of water losses (Tooms, S., and Pilcher, R., 2006). The flow rate to each DMA beside water pressure and water quality are monitored and controlled by SCADA system.

SCADA system helped in quick detection of pipe bursts due to the abnormal increase in flow rates which is easily detected on-line as shown in Photograph 3. It is worth to mention here that the leaked water usually does not appear on ground surface due to the karstic characteristics of Antalya City which implies difficulties in detecting pipe bursts.

Monitoring the water flow rates entering to the reservoirs beside the water level in the reservoirs prevented the overflow from reservoirs and helped in detecting leakages in the reservoirs by checking the water budget. For example, the data sets supplied by the SCADA station at *Çaglayan* water distribution reservoir

(15000 m^3 storage capacity) showed that there was a water leakage of 100 m^3/hour originated from a serious crack in the inlet pipe of the reservoir as depicted in Photograph 4.



Photograph 3. SCADA flow rate after a breakdown in one of the water distribution pipes

Photograph 4. Crack in the inlet pipe to *Caglayan* water reservoir in Antalya City detected by carrying out water budget

Water pressures were analyzed during different water consumption rates and the excess pressure values were reduced using pressure release valves (PRV) to reduce physical water losses as recommended by many researchers (Reis and Chaudhry, 1999; Thornton and Lambert 2006). For example, water pressure was reduced from 5.5 bar to 3.0 bar by usin PRV at the DMA called *Vestel* . This resulted in reducing physical water losses to considerable values as determined by the SCADA system and shown in Figure 1 .The level of pressure reduction up to 3.0 bars was chosen by applying the USA-EPA EPANET hydraulic model (TUBITAK, 2009). Consequently, no complains were received from the customers. As a result, ASAT plans to apply pressure management in the other areas of Antalya city which exhibit excessive water pressure.

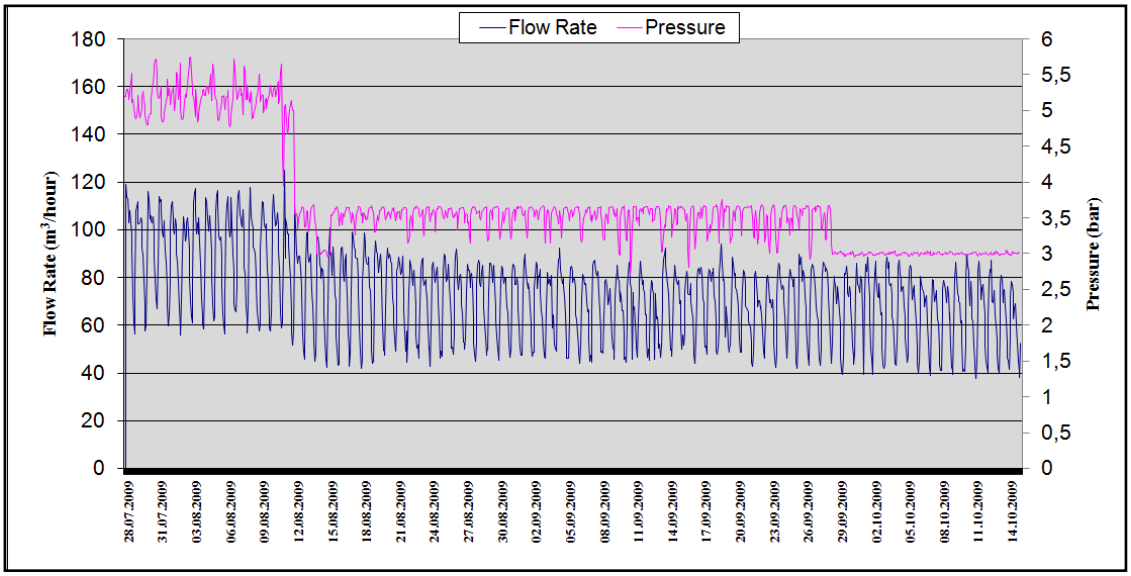


Figure 1. Reduction of water pressure from 5.5 bars to 3.0 bars at *Vestel* DMA

Inaccuracy of customer water meters is in general an important source of apparent water losses (Thornton, Reinhard and Kunkel G, 2008). Many water meters fail to record water consumptions at low flow rates

below 10 litres per hour. This inaccuracy even becomes worse with increasing the age of water meters. In Antalya city, customer water meters of "Class B" at *Vestel* DMA were replaced by more accurate ones of "Class C". As a result, water revenue has shown an average increase by 20% while the SCADA system showed no noticeable increase in the water supply to the *Vestel* DMA. Consequently, ASAT plans to replace the existing inaccurate customer water meters by more accurate ones in the near future.

Efforts to reduce both physical and apparent water losses in Antalya city are still going on. Total water losses were reduced from % 65 to % 42.5 in Antalya city since the completion of the SCADA system in 2007 (ASAT, 2010). Additionally, daily energy consumption was reduced from 208,000 kW to 138,000 kW (Reduction is %33.65). This agrees with the fact which states "save water save energy".

Conclusions

The SCADA system proved to be very useful and effective in monitoring and controlling both water quality and water quantity. For example, free residual chlorine levels were maintained within suitable limits along the water distribution system. Also, supply from water springs were stopped automatically after turbidity increase following heavy rainfalls. Moreover, the water in the reservoirs was kept fresh and overflow from the reservoirs were prevented. The established on-line monitoring and SCADA system provided numerous data sets that are currently used to built and apply hydraulic and water quality models to manage the water distribution system in Antalya City. Consequently, Akdeniz University has launched a project in 2008 with ASAT for this purpose. The project is supported by the Scientific and Technological Research Council of Turkey named as TUBITAK.

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