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Data utilization at finnish water and wastewater utilities: Current practices vs. state of the art

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A B S T R A C T

This paper analyses the current role of data assets and information systems at water and wastewater utilities in a context where most utilities are small to medium sized. Special focus is put on big data and open data, and existing information systems for their management. Based on a survey and the available literature, we conclude that water utilities could benefit from developing their data assets, and that increasing amounts of data will require utilities build in-house competencies related to management, technology, and security.

1. Introduction

The aim of this article is to study the role and usage of different datasets and information systems at water and wastewater utilities in an environment where most utilities are small to medium sized. An emerging literature highlights the potential that these data hold for improving the operation, management, and control of water systems. More efficient use of these data sets would therefore benefit utility operators, owners, and managers as well as policy makers and regulators. However, in many cases there appears to be a gap between the state-of-the-art solutions and the reality at many water utilities. This paper analyses the current status and provides suggestions for improvement.

This study was carried out in Finland, where municipal water and wastewater services are provided by numerous autonomous utilities, which are either municipality owned or small co-operatives. Finland has a population of around 5.5 million people, of which 92% are connected to centralized drinking water supply and 82% to centralized wastewater treatment. Requirements for drinking water and wastewater treatment are rather stringent and thus the quality of the operations and outputs can be considered high. The total number of water or wastewater utilities in the country is more than 1,400, of which around 400 are owned by municipalities and about 900 by cooperatives. The majority of the utilities have fewer than 20,000 customers, while 20 of the largest utilities provide service to some 80% of all customers (Water Association Finland, 2016). The situation is similar to many other European countries, such as Sweden, Austria, and Portugal. Nearly 50,000 water utilities operate in the US, the majority of which serve smaller communities (EPA, 2008).

Currently, network asset data together with water quality measurements at treatment plants (which are required by environmental authorities) and customer information form the core datasets that all utilities have in some format. The format can be digital, but as Grigg (2012) describes, the smallest utilities may only have paper records on their assets. Utility-specific information and control systems in use at water and wastewater utilities cover:

- Customer information systems (CIS)/customer care and billing systems (CC&B), customer relationship management (CRM), for customer care and billing purposes. This is a mandatory system needed for charging on water consumption, wastewater, connection fees and in some cases also stormwater fees.

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- Computerized maintenance management system (CMMS) for maintaining an asset and equipment register and planning and scheduling maintenance activities, often missing from small utilities.
- Geographical information systems (GIS) and network information systems (NIS) for network information management. These are currently used by larger utilities but not by all small utilities (Jordan, 2010; Grigg, 2012).
- Supervisory control and data acquisition systems (SCADA) for receiving data on the networks and the treatment plants.
- Other systems tailored for the sector such as benchmarking and reporting systems.

At present, the extent to which existing datasets and modern information systems are used by Finnish utilities still varies very much. This is reflected by a recent regulation requiring that utilities must have their network datasets in digital format by the end of 2016 in Finland (Act 681/2014 on the Amended Water Services Act 2014).

In the future, the amount of data available can be expected to grow thanks to digitalization. Brynjolfsson and McAfee (2014) suggest that "everything that can be digitized will be digitized and everything that can be automated will be automated". The ongoing digitalization has been predicted to become as significant a change as industrialization was (Frey and Osborne, 2013). The emergence of inexpensive sensor devices and intelligent communication networks will bring new opportunities to utilities but also new challenges with respect to (among other things) data management. The concept of the Internet of Things (IoT) envisions that objects will collect and exchange data over the Internet, radically increasing the amount of data in many fields, including the water and wastewater sector.

In this article, examples are given based on the literature review on advanced cases of data utilization. The potential and challenges water and wastewater utility managers see in emerging new datasets are studied with a survey. Following the Survey Methods and Survey Results sections, we provide a Needs Assessment focusing on the competencies that will help utilities that wish to benefit from the presumably growing amount of available data. The Discussion section brings the findings together.

2. State of the art in data utilization at water and wastewater utilities

2.1. Advanced examples presented in the literature

Currently, data is produced mainly from measurements of different physical or chemical attributes of water at different points in the water supply and sewerage supply chain. The new potential data utilization technologies include online water metering, continuous water quality monitoring, leakage and event detection, pipe condition monitoring, real-time modeling of networks, optimization of water and wastewater treatment, and network asset management.

Online water consumption metering is an example of an existing technology not yet widely in use in the water sector. Smart electricity meters are being deployed widely already, while at the same time smart meters for water are not yet installed on such a grand scale (Stewart et al., 2010). Even though there are differences between the water and energy sectors, potential benefits exists for the water sector as well. Beal and Flynn (2015) found evidence that the awareness of the benefits of smart metering is increasing at the utilities in Australia and New Zealand. Smart online meters are able to deliver real-time data and thus help in understanding for water consumption patterns (how much, when, and where water is delivered to the consumer). Water demand estimation through smart meters can be used to optimize demand patterns even when just a part of the consumers are monitored in real-time (Aksela and Aksela, 2011; Gurung et al., 2014). Gurung et al. (2014) found that enhanced modeling and optimization of the water supply network provides financial benefits in terms of avoided system costs. Another benefit of smart meters is the large amount of data points they enable. These data can be used in the same way that network flow and pressure measurements are currently used, such as for leakage detection.

Smart water consumption meters can also provide new kind of services to customers. Britton et al. (2013) showed that smart meters are able to identify post-meter leakage. This information may be of interest to insurance companies in terms of the potential to significantly reduce water damages to property and ensuing insurance compensations. Nguyen et al. (2013) propose a model where water consumption can be measured and analyzed at the household level. The proposed architecture uses data from smart meters and pattern recognition to profile residential water consumption. The algorithms used can detect and categorize events like the use of washing machines, toilets, or showers automatically. Customers can access their water consumption history on a web site and compare their consumption to benchmark information from similar consumers. The detailed history data, trends, and up-to-date information help utilities to plan and manage the networks as well. The analysis of such data could also provide a chance to new services such as closure of connection in case of a leak inside properties. Fischer (2011) studied the overall potential of smart metering. The benefits include more efficient water use and the subsequent reduction in energy and chemicals needed in water and wastewater treatment. Despite the higher initial investment costs, smart meters are expected to prove more cost-effective in the future (Fischer, 2011).

Another relevant domain for utilities is water safety planning. Thompson and Kadiyala (2014) present a continuous monitoring system for water quality. The system is an integrated solution combining sensors and analyzers in the distribution system, data from other sources, such as customer feedback and security monitoring, data analysis, and visualization software. The results of their study show operational enhancements, such as early alerts of pipeline breaks or water quality monitoring trends, which were earlier unavailable. Examples are given of how the system has helped in locating the causes of water quality problems. An additional benefit reported in their study is improved regulatory compliance.

Preventive maintenance is another important utility activity. According to Matsuoka and Muraki (2007) preventive maintenance is the systematic care and protection of equipment and machines and the reliability of the process depends on systematically scheduling. In the most advanced cases, predictive maintenance uses sensor feedback information from equipment to make data-driven decisions, improve quality and production performance, and prevent more expansive repair costs (Fraser, 2014). The maintenance system can also be integrated through a geographical information system (GIS) platform that brings different types of data together based locational components for more efficient management of water, wastewater, and stormwater systems (Shamsi, 2005).

Continuous monitoring is also of high value in the hydraulic operation of water distribution. Many studies have been conducted on event recognition in water supply networks (e.g. Vries et al., 2016; Romano et al., 2014). For example, Romano et al. (2014) portrayed an operational event recognition system which can be used to detect and analyze pipe bursts and leakages with accuracy and reliability. The benefits reported in the study include reduced