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319241 Intuitive Visual Communication of Temporal Data

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1. Introduction
Energy and resources are important cost factors for wastewater treatment (Hernandez-Sancho & Sala-Garrido, 2008) and should be optimised. On a daily basis, operation optimisation requires a sharpened awareness about process characteristics and energy consumption of any wastewater treatment plant. However, limited thought has been given to effective visualisation of the relevant data. In our case, visualisation does not only refer to methods to process data such as principal component analysis (PCA, e.g. Maere et al., 2012) or self-organising maps (SOM, e.g.: D�rrenmatt & Gujer, 2012) but also to the communication of the processed data in an intuitive and relevant matter. For a broader and complex indicator set such as the ones on wastewater treatment plants (WWTPs), the actual visualisation and arrangement of the single graphical elements is a crucial step in addressing the operator's attention.
In our contribution we want to present ideas on accurate and intuitive visualisation of energy and process data in any facility. The visualisation is not limited to computational and graphical issues; we also have to handle topics such as data sources, data quality and data quantity. With our visualisation tool we want to support the operators in optimising the performance of WWTPs. Currently the initial version of the visualization tool is being evaluated in one plant, i.e. WWTP Hard (Winterthur, Switzerland). A second plant (WWTP Pfungen, Switzerland) has been selected for further testing and to ensure general applicability of the software.
2. Data preparation
2.1 Data quality
An important aspect of data visualisation in wastewater treatment and any other engineering practice is that the displayed data must be of guaranteed quality in order to prevent errors in the decision-making process. Therefore any data should already be processed by a data quality assurance tool. This is not the topic of this paper however.
2.2 Data granularity
During development of a data visualisation tool, several aspects of full-scale data have to be addressed. One is that not all data are measured at the same frequency. As such, it is very obvious that the update interval for visualisation cannot be lower than the update interval for the data which are visualised. However a too frequent computation may render an erroneous picture to the operator, further leading to aggressive actions or mistrust in the visualisation tool. This applies especially to systems with long delay between inputs (control signals) and outputs (measurements). Conversely a too low frequency is to be bargained against a potentially slower response of the operator if important events are missed.
3. Results & Discussion
3.1 Visual design elements
3.1.1 Colour bar
Two graphical elements help to visualise relevant data; the "colour bar" and the "calendar view" (Wicklin & Allison, 2009). The colour bar (c.f. Figure 3.1, b) includes two scales. One is the numeric scale of the indicator with the online measured (M) or calculated value and corresponding guideline (G) and ideal (I) values, if available. The second scale is the gradient colour fill of the bar from red to yellow to green. This colour gradient does not include additional information since the colours of the colour bar are fixed to specific numerical values for each indicator. However, this additional colour scale is intended to enable a faster and more intuitive understanding of the plant's status. In addition, the colours of our colour bar are basically matched with European Union energy label for household appliances (European Union, 2013), which is also an official label in Switzerland and therefore well known (c.f. Figure 3.1, a).

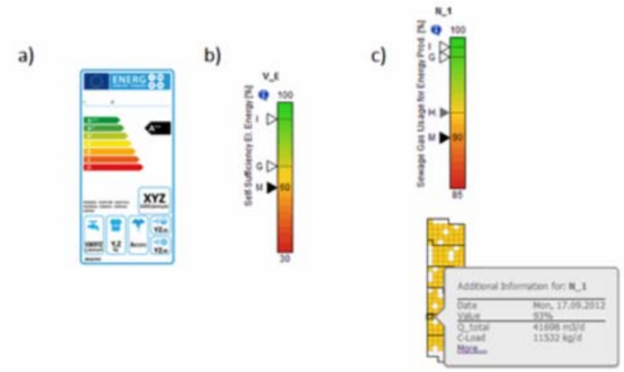

Figure 3.1
a) European energy label for household appliances (European Union, 2013)
b) Colour bar component. I: Ideal value, G: Guideline value M: Measured value
c) Calendar view with the interactive mouse hover information frame. I: Ideal value, G: Guideline value M: Measured value, H: Historical value

Each colour bar has filled background information including a description of the calculation, used data sources and the time of the last calculation value. If the data do not allow a new calculation it will be indicated next to the colour bar.

3.1.2 Calendar View

The "calendar view" consists of a calendar where weekdays are arranged in columns and where each row represents a week (c.f. Figure 3.2, c). Each day is a small box coloured according to the characteristic day value (e.g. daily average). However also weekly or monthly colouring is possible. The colour scale corresponds to the one in the colour bar. If an indicator is not calculated the day remains uncoloured. The form and arrangement of the calendar view elements supports the operator to find weekly or even monthly patterns within one or among several indicators. Moreover, the calendar view offers interactive options (e.g. mouse hover effects cf. Figure 3.1 c) to understand the indicated value in relation to plant loads and special events. In addition to that, the calendar view value will be displayed on the corresponding colour bar (H).

3.2 Indicators

The data chosen for our visualisation can be separated in two groups, energy indicators and process indicators. For the energy indicators we consider existing guidelines from the Swiss Water Association (VSA, 2008) and from the German Association for Water, Wastewater and Waste (DWA, draft). Both associations define energy efficiency indicators for WWTPs. These indicators help operators with ideal and guideline values to benchmark their plants. Also in many other industries, associations define key performance indicators allowing benchmarking the performance within the industry (e.g. facility management cf. ISA 2011).

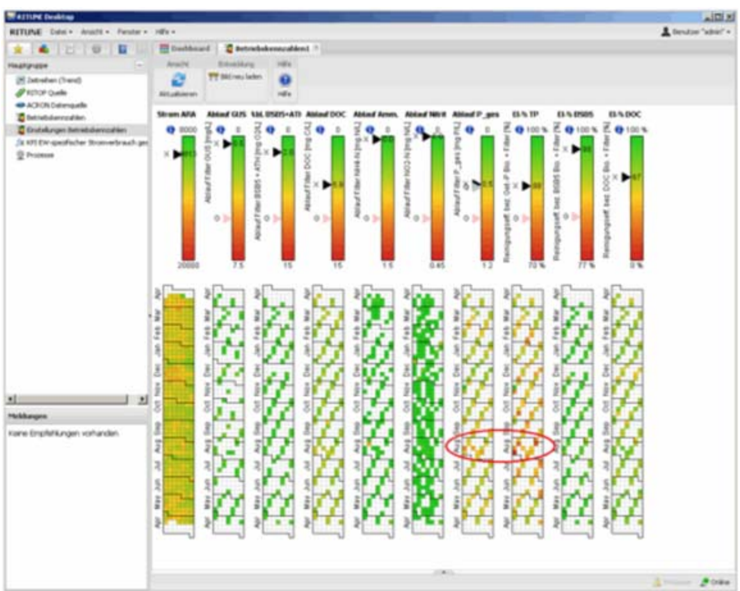

Figure 3.2
Screenshot of the dashboard. Notice the red circle: "Calendar views" of two indicators show problems with phosphorus precipitation caused by limited capacity due to a longer maintenance period last August.

4. Conclusion

A new tool to visualise energy and process data is presented. It combines two graphical elements. One to assess the current state of the plant, one to track and compare historical data. In combination they enable the operator to analyse the relevant indicators. The tool is currently tested on a WWTP. The WWTP plant staff will be consulted to make further versions of the tool more relevant and intuitive. Further roll outs to other plants are planned.

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