International online support to process optimisation and operation decisions

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Abstract The information level at all technical facilities has developed from almost nothing 30–40 years ago to advanced IT – Information Technology – systems based on both chemical and mechanical on-line sensors for process and equipment. Still the basic part of information is to get the right data at the right time for the decision to be made. Today a large amount of operational data is available at almost any European wastewater treatment plant, from laboratory and SCADA. The difficult part is to determine which data to keep, which to use in calculations and how and where to make data available. With the STARcontrol™ system it is possible to separate only process relevant data to use for on-line control and reporting at engineering level, to optimise operation. Furthermore, the use of IT makes it possible to communicate internationally, with full access to the whole amount of data on the single plant. In this way, expert supervision can be both very local in local language e.g. Polish and at the same time very professional with Danish experts advising on Danish processes in Poland or Sweden where some of the 12 STARcontrol™ systems are running.

Keywords Biological nutrient removal; data handling; online control; online measurements; STAR

Information comes from data

Several years ago information from wastewater treatment plants was very limited, as the main interest was to keep the pumps going and the investment in "data availability" was low priority. Today in Northern Europe, the desire for information on the wastewater systems has raised remarkably, but it is still very difficult to extract the needed information from the available data. The most obvious way is to use the data directly in online control as reported by Nielsen and Önnerth (1996).

Looking at the amount of data produced at a wastewater treatment facility, these can be divided into a number of categories. One part of data comes from manual analysis either on an external laboratory facility or locally at the plant, at a time scale in weeks or months. Another part of data comes from the automatic systems in PLC and SCADA, at a time scale that differs from seconds to hours, dependent on whether it is quick valve regulation or registration of operation time of dosing pumps. The third kind of data is the calculation and tuning of process operation from a superior tuning and reporting system like the STARcontrol™. This kind of system both has to react online in direct control setpoint within minutes and also calculate and reduce data to information on a daily, weekly or monthly time scale. A general view of the different types of data is shown in Table 1.

When establishing on-line metering of nutrients, it becomes possible to improve the operational performance of wastewater treatment plants, as the ammonia, nitrate and phosphate concentrations are the directly involved and very sensitive parameters of the biological processes. However, the improvement implies learning new ways of handling the data, which are no longer derived from a few daily, weekly or monthly mean samples, but from online presentation of concentrations each minute. If handled correctly, the online data will give information on process load and capacities as for instance a daily average of ammonia

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Table 1 Use of data for different purposes

Useful for information for	1–4 per months Lab. Analysis inlet, outlet, few points in plant	week/month Manual analysis e.g. SV, visual depth	day SCADA mechanical counters of operation time	seconds/ minutes PLC on-line regulatory signals	minutes/ hours SCADA operation signals and calculations, alarms	minutes/ hours STAR process operation and setpoints	days/weeks/ month STAR reporting
Process operation		X					X
Administrative process reporting	X						X
Mechanical service			X	X			
Plant operation/SCADA control				X	X	X	
Process control/STAR					X	X	X
Design	X						X

concentration, that can be statistically compared to weekly manual analysis (Carstensen *et al*., 1994).

Interpretation of the many online data can be performed in various ways or through different levels of control (Bundgaard *et al*., 1993). Long experience has shown that the most efficient way to benefit from online measurement is to establish a combined process control and calculation program, instead of single control loops on each parameter (Nielsen and Önnerth, 1995).

Right data to right decision maker

The handling of data and exchange of information in water and wastewater systems are based on the so-called vertical and horizontal axes. The vertical axis stands for the handling of existing data all the way from the sampling of online meters, blowers, flow meters etc. all over the wastewater treatment plant to reduced information in only a few key figures on e.g. energy consumption, daily effluent and load to the plant.

Decisions of "How to run this water facility the best way" have to be made on different levels, both regarding time scale and information for the plant operator, engineer or administrator as shown in Figure 1. At the plant the operator level decisions for the direct control

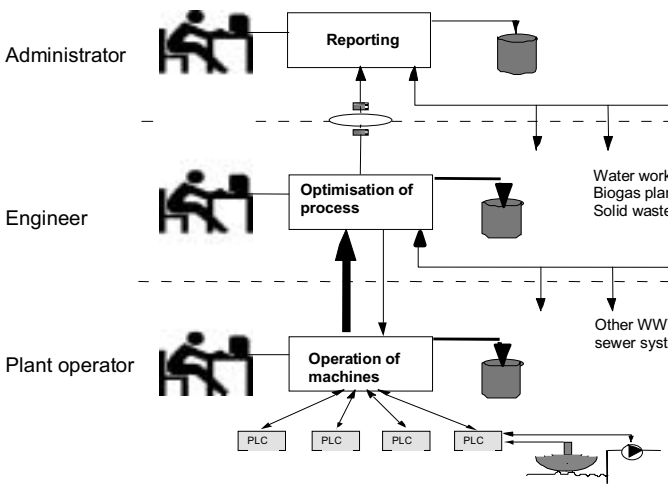

Figure 1 Vertical flow of data from large amount at machine operation level to few data at administrator level carrying the important information

actions are based on online measurements and control strategies on a time scale in seconds and minutes. Evaluation and effective decision support at this level of specific control implies information on a very detailed level as in SCADA.

The engineering level is the level for online process optimisation between the different parts of the water system e.g. degree of pre-precipitation versus addition of carbon source in the following denitrifying step. Information for this decision level has to be derived from the many data on operator level to online data in hourly, few per day or daily values, to decide whether this control action should be reduced/increased with regard to a better performance of the total plant.

At the administrator level, the economic aspect is important information for making the right decision concerning the optimal overall optimisation in the water systems and related systems. Data from engineering level should here be related to the simple economic costs e.g. cost per kWh or per kg chemical, but also another kind of "soft costs" as the environmental impact of phosphorus on the recipient should be considered.

Gässlösa treatment plant with online control

In the town of Borås in Sweden, the wastewater treatment plant Gässlösa has a capacity of 130,000 PE with mixed load from household and industry. In 1998 a necessary extension of the plant capacity was made by the process optimisation system STARcontrol^{TM}, Superior Tuning And Reporting in the existing process tanks, instead of traditional construction works (Thornberg *et al.*, 1998). Increased capacity by control makes heavy demands on availability and correctness of data from both the specific unit and from parallel units at the plant for overall control.

The plant has one inlet shown on the left in Figure 2, which after passing the grit chamber and pre-precipitation chemical dosing, is split in two directions for treatment in either the gravel filter line (upper part of Figure 2) or the BNR line (lower part of Figure 2). The STAR system optimises the inlet pre-precipitation, the BNR process line as well as the flow distribution between the two lines. The overall optimisation strategy is to achieve best combined effluent results along with reporting of key figures to the plant manager. The process lines are operated with online control based on a mix of online meters e.g. oxygen, ammonia, nitrate and phosphate and optimised by the STAR.

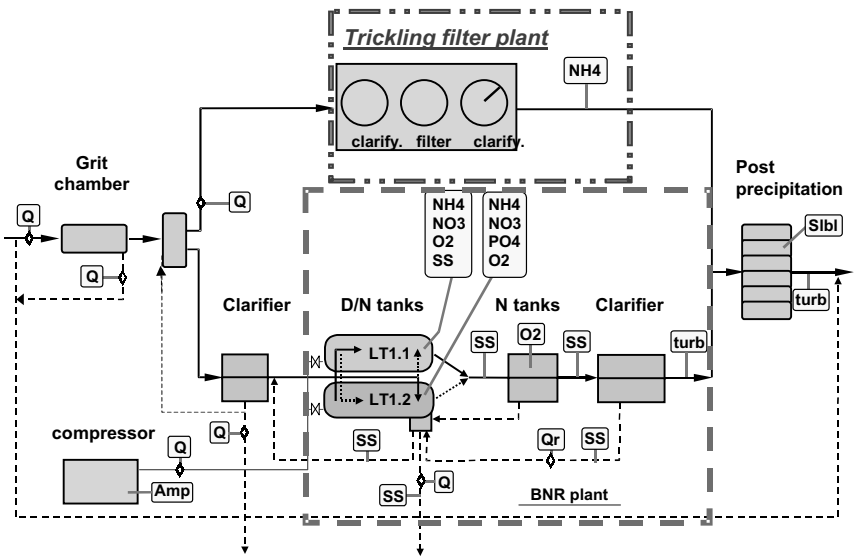

Figure 2 Flowsheet of Gässlösa WWTP in Borås, Sweden

At the plant, a large amount of data is produced daily e.g. online values of ammonia and nitrate in the aeration tanks, flow of excess sludge to digester, manual COD analysis from laboratory and operation hours on blowers. Divided in categories, the data can fit into 7 different types, each useful for different unit operations at the basic level, as shown in Table 1. Some of these different types of data may, however, be so strongly related that with a proper statistic handling on the engineering level it is possible to correlate difficult analysis to simple – or even online measurements. For instance it is possible to calculate a daily influent concentration of COD/BOD/Total-P on the easily determined daily average of Suspended Solids from the online measurement values. The traditional weekly 24-hour samples are then used to calibrate the estimates of the daily average from the online measurement.

Communication using IT

Once the desired information has been generated from basic data, the next task is to distribute these information data to the right persons or at least make the information available. In the STAR system, the user interface is available with appropriate password and login features by modem call and Internet browser program from any location. This distributed interface means that the operator, supporters and responsible people all have access to the same data and the information at the same time. Information can even be presented in different languages for the instructors and the local users maybe as they are talking on the phone. Figure 3 shows the STAR user interface in different languages – Polish, Danish and English – observing the same set of data from Poznan WWTP, Poland. The connection to the Poznan interface is made by modem call and Netscape browser (other browsers can be used). The interface shows to the left online updated curves from the latest 6 or 8 hours; in the middle are different lights to show controlling status in the three process lines for each control (phase, oxygen setpoint . . .) and to the right are buttons with access to historic data and reports, change in configuration and not least the STAR Journal.

A part of the interface is the common Journal, where the different operation shifts or other associates can note their reasons for making changes in the different control modules,

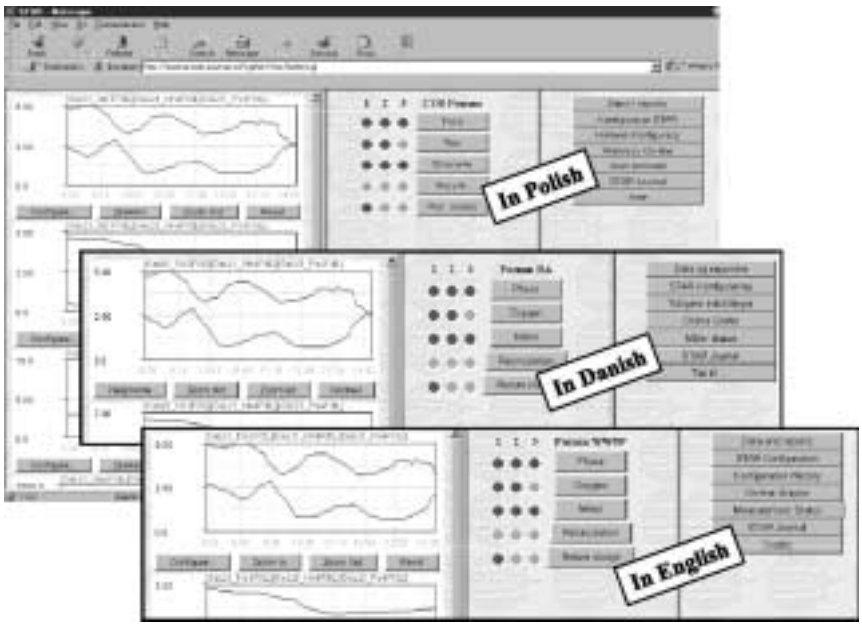

Figure 3 STAR user interface in different languages observing same set of data from Poznan WWTP, Poland

whereas the actual change of control parameters are logged in the control system itself. A nice example is the running in of Poznan WWTP in Poland, where only one man at the plant is familiar with communication in English; all other written or spoken communication has to be translated. The day-to-day communication is now handled by STAR Journal in English.

For the local operator teams at the plant, it is crucial that the operator interface appears in local languages, here Polish (at Gässlösa WWTP in Swedish), otherwise the system will be considered "only for foreign experts" and not watched in daily operation. On the other hand, the Danish process supervisor can only handle a user interface in Danish (the developing language) or English. By using Internet technology for the interface, it is rather easy to make the same data appear in different languages, depending on the login procedures.

An example of valuable international process support is taken from Poznan WWTP, where Figure 4 shows one of the stories from the STAR Journal.

Another case would be from Gässlösa treatment plant, where a mechanical problem in a submerged valve was detected from irregularities in an otherwise very strong correlated set of data. Suddenly the sludge balance calculated from 3 on-line Suspended Solid meters and two flow meters didn't fit together anymore on the daily reports at the supervisor. The operator had no alarms to investigate but due to data analysis in the STAR database the supervisor in Denmark could guide the operator to localise the problem within the day and no severe problems in sludge dewatering operation was caused by the incidence.

International contact and exchange of experience

The Journal is first of all a valuable tool at the local plant as the notebook for all kinds of information about the process, the handling of online meters, disturbances in operation etc. Another effect of the open way of communication is the possibility for effective online process support from either the plant engineer to the daily operation team, or from an external supervisor.

The open way to communicate also makes online exchange of information between other water treatment facilities possible. Contact between plants with the same kind of loading or same kind of STAR controls will make it possible for the single operator to put questions and good advice to fellow operators through a "User group", as illustrated in Figure 5. In this way, the advanced data handling and control system will give benefits to

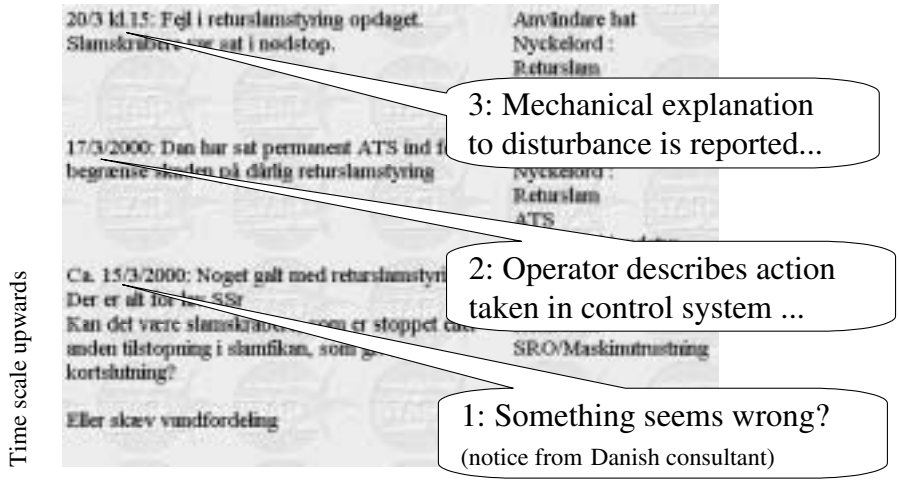

Figure 4 Dialog from STAR Journal

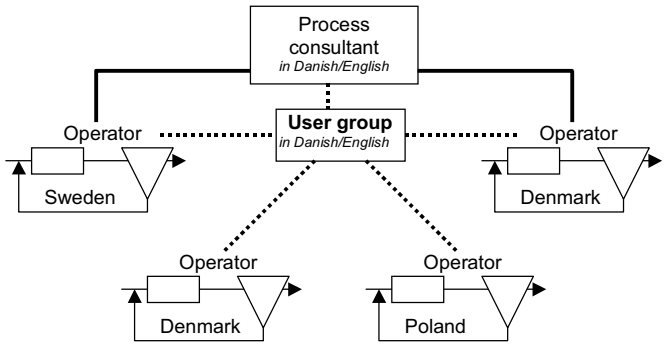

Figure 5 Distributed interface and Journal makes it possible for process consultant and operator to communicate online on the same set of data and information – even in different languages

both the daily operation and – if proper permission is given – open for access to valuable and realistic online data for further development and science.

Conclusion

The information level at all technical facilities has developed from almost nothing 30–40 years ago to advanced IT systems based on both chemical and mechanical online sensors for process and equipment. Still the basic part of information is to get the right data at the right time for the decision to be made. Today a lot of operational data is available at almost any European wastewater treatment plant, from laboratory and SCADA. The difficult part is to determine which data to keep, which to use in calculations and how and where to make data available. With the STARcontrol^{TM} system, it is possible to separate process relevant data to be used for online control and reporting at engineering level to optimize operations. Furthermore, the use of IT makes it possible to communicate internationally, with full access to the whole amount of data on the single plant. In this way, expert supervision can

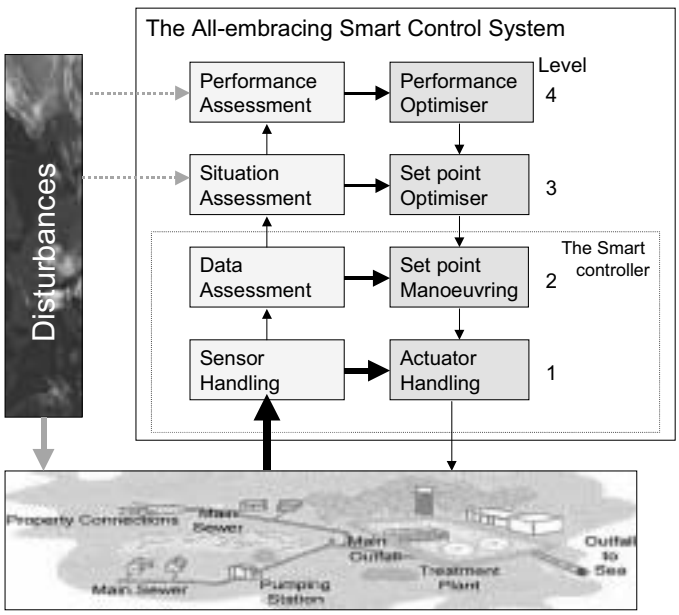

Figure 6 The future needs more all-embracing analysis of situations to optimise performance of the total wastewater system

be both very local in local language, e.g. Polish, and at the same time very professional with Danish experts advising on Danish processes in Sweden.

In the long term both integration of the technical systems as well as the operation and management will increase the need for structured data handling right from the bottom to make sure the right information is derived and accessible for the right decisions in the organisation. At the point we are at now, it is possible to gather information at the levels of the operator and the engineer from Figure 1 and make an easy communication to support the operation decisions for set point manoeuvring described at Figure 6.

In the future this information may concern also the more general layers above as shown at Figure 6 with information from basic data all the way up to situation or even performance assessment. In this perspective the whole wastewater system is concerned as one and set points not only locally optimised but adjusted in a global perspective in both sewer system and wastewater treatment plant.

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