EARLY WARNING SYSTEMS AT WASTEWATER TREATMENT PLANTS

Paper Presented by :

John Berkelmans

Author:

John Berkelmans
Manager Operations Support STEP

South East Water Ltd

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John Berkelmans, *Manager Operations Support,* South East Water Limited

ABSTRACT

Recently South East Water won an Australian Quality Award for Business Excellence from the Australian Quality Council. The award is based on seven categories of business performance; one of these categories is Information and Analysis. This paper deals with measures South East Water took in improving the collection of information from waste water plants and the application of that data to improve treatment plant management. The concept is based on lead and lag indicators. Lead indicators tell what is happening now and are an immediate measurement, lag indicators tell what has happened and what the end result is. In Treatment Plants clearly the lead indicators are the process stream internal monitoring measurements and the lag indicators the EPA license testing. In simple terms it is the daily test and flow recording performed by the operator and the result of samples sent to NATA laboratories.

KEYWORDS

Precursor indicators, parameters, trending, charts

1.0 INTRODUCTION

1.1 Treatment Plant Management.

South East Water Limited has eleven Waste Water Treatment Plants. The Sewage Treatment and Environmental Protection (STEP) Division run these plants. Each plant has a designated Lead Operator who is responsible for four main areas.

- Ensure compliance with EPA licence.
- Safe operation of the Plant.
- Control of Plant budget.
- Keeping the neighbours happy.

He reports to the Manager Operations Treatment Plants who in turn reports to the General Manager STEP. There is also the Plant Asset Management group in the division; their responsibility is to ensure that the plants are adequate to enable the Lead Operator to meet the four basic requirements. They also assist the operators with process advice. In order for both groups to operate efficiently the effectiveness of the Treatment Process must be properly measured. In sewage treatment plants this consists of measuring the performance of the Plant against EPA licence parameters. This involves collecting the required samples, dispatching to a NATA lab, awaiting the results and then measuring the results against the licence. The whole process can take up to ten days. In a plant that has lagoon disinfection all it would show you that you had a problem a month ago. In parallel with this, the performance of individual sections of the process train must be measured. These measures can be physical and on line such as pump hour's run, DO and pH levels. They can clearly be labelled lead or precursor indicators.

With today's technology these can be recorded and trended and reports prepared with little operator input. They can also be used to control the process, as various parameters can have set points at which changes will be made. They can also be alarmed to alert operators.

Large plants can have more complex in line monitoring for parameters such as Suspended Solids, nutrients including phosphorous and Nitrogen Compounds. These again can have control set points at which PLC's and control stations make changes.

The Sewage Treatment Plants operated by South East Water range in flow capacity from 14 Megalitres a day to 11 Kiloliters a day. Complex and expensive on line equipment is not an option for process control with plants in this size range.

2.0 PAST AND PRESENT

2.1 Past Procedures

When SEWL was formed in 1995 the standard procedure for monitoring plant process was for the operators to take samples on EPA sampling day of not only the final product but also to send in samples from the plant inlet and the various process components. These were then sent to the lab. The results from the lab were then available some time later on an office based UNIX system. These results would be downloaded by a series of cryptic and obscure commands known only to a privileged few. The results would not be available to the operators unless some kind hearted process engineer would bother to send them out. This method had only one advantage; the operator did not have to spend a lot of time on monitoring. All he had to do was fill the bottles once a week and organise the courier. One disadvantage was the total cost of sampling.

There was not a lot of emphasis of internal testing, some tests such as Mixed Liquor Suspended Solids were carried out. These results were collated on a Quality Assurance form, which was forwarded to head office on a monthly basis, where the details would be transferred to a spreadsheet and graphed to show trend lines. These then would be sent back to the operators by hard copy or made available on the LAN. The whole process involved about four transfers of information either manually or digitally on PC's. The whole process took time and effort and often the relevant information was a month old. One problem we had was operator indifference to first of all getting results and then putting them in a format that could be easily interpreted. The main reason was the fact that operators had little input into either the sampling program or the set out of the forms used. Something else was needed, a system that would be more relevant and meaningful.

2.2 Use of Australian Quality Council Criteria

South East Water adopted the Australian Quality Council (AQC) Criteria as a basis for achieving its Vision to "build customer loyalty by providing exceptional service and continuously improving" during 1995. Several of the key ideas implicit in the AQC criteria are

Continuous improvement is achieved through a cycle of:

- Determining the "APPROACH"
- "DEPLOYMENT" of the plans required to implement the Approach
- Measurement of "RESULTS" to determine the success of the Approach
- Implementation of "IMPROVEMENT" following review of results.

Results should be based on objective measurement of performance indicators rather than determined by a qualitative assessment.

The criteria also introduce the concept that there are two different types of performance indicators:

Lag Indicators Lag indicators demonstrate when a particular process has failed to achieve its objective.

Lead Indicators Lead indicators are intended to provide a warning that a particular process is likely to fail to achieve its objective some time in the future.

The variability of both lag and lead indicators is also important and the criteria argue that there are two types of variability. The first type is labelled "Normal Cause" and embodies the concept that within a normally operating process there is an acceptable range of variability in both sets of indicators. The second type of variability is labelled "Special Cause" and embodies the idea that we must be able to identify when an indicator moves outside the acceptable range encountered during normal operations. In this case a problem has occurred which needs to be addressed.

2.3 The Requirements

- A sampling program that would reflect the operating conditions.
- A straightforward robust system which operators would want to use.
- A quick and efficient reporting arrangement.
- Uncomplicated, visible and real time results.

2.4 The Solution

The main problem was the sampling program. The operators themselves organised the new sampling programs. The starting point was "What are we doing now". This was then put into a QA procedure. Although this probably did not cover all requirements most of the needed parameters were being analysed with the results being immediately available to plant operators.

South East Water plants now perform in-house analysis on parameters such as suspended solids in Mixed Liquor, pH in aeration basins, nitrogen levels in final effluent, volatile acids in digesters and Total P from secondary settling tanks at waste water treatment plants. In order for this to happen 5 Hach Spectrophotometers and associated equipment were purchased for a total cost of $20,000, however outside laboratory cost saving for the fist year alone was $26,000. Experience in operating Sewage Plants by South East Water has shown that trending of results is vital.

A simple graph is more effective in showing how a plant may be performing rather than a list of tabular results. There are many amongst us who first hand drew graphs in our training at the Water Training Centre.

The Bolivar incident in SA highlighted the fact that trending is an important part of sewage treatment operations. Although we did do trending, all it enabled us to do was to see where things might have gone wrong some time in the past.

If we are going to use trends then these must be available quickly. Also there must be limits or operating envelopes. These can be set points within which the plant should operate The limits we use were arrived at by consultation between the operator and the appropriate process engineer and are a reflection of the best operating conditions for that particular plant based on previous history. In a lot of cases these can be upper or lower limits for a particular parameter.

The parameters we measure could best be described as our precursor indicators. A shift in the value of these indicators could mean the process is changing and some adjustment may be needed. Just as an example the limits for these parameters for our Mornington Plant are listed below.

Mornington WWTP	Lower Limit	Upper Limit
Aeration Basins Mixed Liquor Suspended Solids	1600 mg/l	2400 mg/l
Aeration Basins pH	6.0 units	8.5 units
Digester Tanks Volatile Acids	50 mg/l	300 mg/l
Primary Sludge Solids	4.2%wv	5%wv
DO in Aeration Tank	1.0 mg/l	2.5 mg/l
Sludge Age	6 days	8 days.
SVI	75ml/g	200 ml/g
Chlorine Residual	0.6	1.0 mg/l

DAF Sludge	3%vw	4%vw
Digester Temp.	33 deg.	38 deg

2.5 Measurement

It was all very well having these operating envelopes but there had to be a quick and easy way to collect the results and turn them into a visual form. The best starting point seemed to be the initial collection of data at the completion of the test performed by the operators. Most operators used a pro forma spreadsheet on Excel to record and calculate Suspended Solids results. They also had sheets to record test results such as Ammonia N and Total P. They would then print them out and paste them in the plant diary. There was never any effort to save them on disk as the next time the sheet was used it was merely written over on the PC.

One of the operators had combined all his recording and calculating sheets into a single sheet. The next step was to turn this into a template. The purpose of the template is to turn a set of tabular data points into a straight line on a database.

All plant computers are connected to the Head Office Network either by normal phone lines or high speed data lines. All the operator needs to do now is have a hard copy recording sheet were he records things such as filter weight before and after and the results of any chemical tests. The next step is to log onto the LAN. He then opens the template on his computer, each time he opens he is presented with a sheet in which the data inputs are blank. He then enters the appropriate data and closes the template.

If he has any problems with the NetWare connection he merely emails the sheet to head office were it would be loaded unto the database. It actual labour terms he would be putting in less effort than in the past.

2.6 Calculation

The relevant values are calculated automatically and transferred to a database. This database is then used to automatically produce charts. These charts are available to any one connected to the LAN. At present only one value is displayed per chart. The next step is to compare various values, we have all ready experimented with some and have found an interesting link between Mixed Liquor Suspended Solids levels and Final Effluent solids levels.

In order to access the various charts a simple front page has been designed with hyperlinks back to the various databases. As the initial input of information was by the operator he is usually the first to have a look at the resulting chart.
At most plants the charts are printed out and pinned up on a designated area. The availability of colour printers enables production of very visual charts.

In addition to the process results being charted the operators also chart their EPA compliance results and display them in the same area. This clearly builds a relationship between the lead and lag indicators. One of the clearest lead indicators has been the pH of the Aeration Tanks. It is always the first indication that the process is changing.

There is a management procedure in place, which requires the operator to notify management if a particular parameter is outside the range and is likely to affect plant performance. The procedure allows the declaration of an incident if the event will have a major implication on final effluent EPA compliance or discharge into South East Outfall which is operated by Melbourne Water.

2.7 Accuracy

If test results are to have any meaning they must be accurate. The best indicator of accuracy is the

lack of wildly fluctuating results. Must of our charts do not have irregular results because of the time and effort put in by the operators. We also have an extensive QA calibration program.

3.0 SUMMARY

3.1 Benefits

Initial benefits were obvious:-

- Up to date results.
- Greater compliance with internal process monitoring schedule.
- Problems were identified at a stage were rectification was effective.
- 100% EPA license compliance 97/98.

One of the greatest paybacks has been the continual upgrading of operator's computer skills. It also has made them more aware of the big picture.

This has eliminated the isolation they may have felt in the past. It has also given them more confidence in handling other tasks that have a high degree of IT involvement.

The main plants will have or already have been fitted with screen based control systems. Operators have taken to these like ducks to water. Some can even remotely monitor and control their plants by the use of a laptop and mobile phone.

3.2 Problems

One annoying difficulty is the continual upgrading of software. Each time there is a partial or major upgrade a lot of the links are lost. Often the plants that are connected to the LAN by public phone lines have connection difficulties, however that can be overcome by Email.

3.3 What Next?

At present only the mechanical plants are providing full information. The next move is to work out what information we need from our lagoon plants. At present we have basic information such as DO's , pH and temperature.

Even with this limited information we have been able to make improvements. In one of our plants which only supplies a turf farm during the summer we overcame an E.coli problem by a few simple operating changes. This was after we gained an understanding of how exactly the lagoons were performing. One of the changes involved operating them in a batch mode thus eliminating short-circuiting and stratification.

The whole data collection system is based on having simple arrangements to download data from waste water treatment plants. Many people would say that it is fairly unsophisticated, as the use of web servers and browsers would make a better arrangement. We have always felt that it would be better to get the data collection right before we tackled the best way to display it. We have engaged a consultant to provide us with a workable system. They have had meetings with operators to ascertain what they would like from a system. The prototype has been developed and is based on a local Intranet setup. It also involves the setting up of a complex database. This will enable us to generate dynamic reports. Eventually all relevant plant data will be accessible on this system. This includes items such as contingency plans, operating manuals and maintenance schedules.

Once we get the data collection updated it will be time to look at our laboratory procedures. Modern equipment enables the down loading of results such as filter weight or specto results direct to a PC. Even DO readings can be stored on the meter and later downloaded. We firmly believe that

we have the horse before the cart in getting our data generation happening before we tried to do anything fancy with it.

4.0 CONCLUSION

4.1 Continuous Improvement.

South East Water operates in a continuous improvement environment and this project has been one of many to improve the service we can give to our customers. The customers in this case being internal and external. It has enabled us to run the plants in a more responsive manner as evidenced by our 100% EPA licence compliance. It also enables our planning people to have ready access to historical data without having to search for information. Our operators are now more valuable members of our business as they have an efficient tool for contributing to the improved performance of our company.