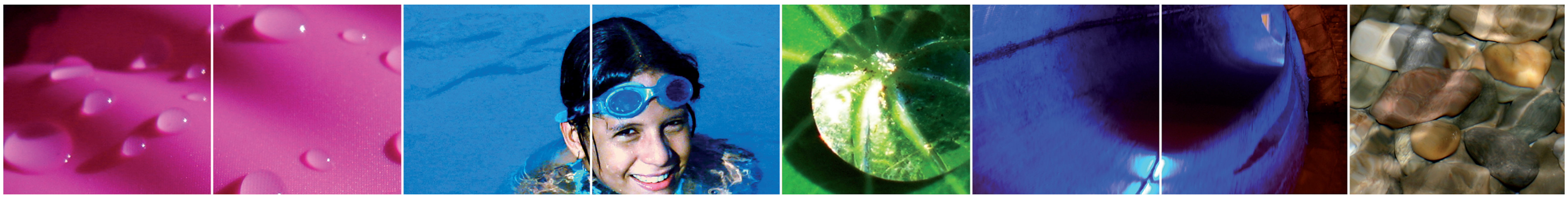


Control of active biomass in biological waste water treatment systems through new generation of ATP-metry: improving effluent toxicity monitoring and optimization of performances in bioreactors

Claude Delporte, Ondeo Industrial Solutions – Veliana Todorova, Aqua-tools

INTRODUCTION

A new pilot bioreactor has been installed in a chemical plant in order to study the possible optimization of the treatment processes. During this trial, a new generation of ATP-metry technique was used, in parallel to classical parameters, for operating the performances of the bioreactor and monitoring toxicity of industrial primary effluents. This new technology is based on the Total Control Biological (TCB™) kit (commercialized in Europe by Aqua-tools, France). TCB™ kit is measuring the concentration and health of living biomass through the quantification of intracellular Adenosine Triphosphate (ATP) molecule. This new tool was used for following the pilot installation over two months period. During this period an investigation of the toxicity linked to the products manufactured by the company was implemented. An intensive monitoring program with analysis three times per week on different points of the pilot installation was lead. The possibility to have an early detection of toxicity present in the primary influent and its effect on the active biomass was studied.

ACTIVE BIOMASS QUANTIFICATION USING TOTAL CONTROL BIOLOGICAL (TCB™) KIT

The Total Control Biological (TCB) kits (developed by LuminUltra™ Technologies Ltd (Canada) and commercialized in Europe by Aqua-tools) allow monitoring of concentration and health of active biomass and early detection of toxicity problems linked to influent water. This method is based on the quantification of the molecule Adenosine TriPhosphate (ATP). Intracellular ATP is the energy stock of all living cell and is degraded within minutes when released in the environment. The tests take 15 min to be performed in field conditions.

The principle of ATP measurement is based on a bioluminescence technique, in which one photon of light is produced in the enzymatic reaction between Luciferase and an ATP molecule. Intensity of light is measured with a luminometer. The quantity of produced light is directly proportional to the active biomass present in the sample.

$$ATP + luciferin + O_2 \xrightarrow[\text{luciferase}]{Mg^{++}} AMP + PP_i + oxyluciferin + \text{LIGHT}$$

ATP measurement is directly proportional to living microbial flora: it allows quantifying rapidly the concentration, heath and activity of the microorganisms contained in a water sample.

There are two main ATP-related parameters that are used for waste water process control:

- cATP™ (ng/mL) – Intracellular ATP; a direct measure of the activity of active biomass and its concentration. cATP shows a relatively stable level in an optimized, well performing bioreactor.
- BSI™ (%) – Biomass Stress Index (ratio between Extracellular ATP issued from dead microorganisms and Total ATP); represents the relative stress experienced by the biomass. The higher the BSI, the higher the stress of the bacterial population. Changes in influent quality (e.g. toxic substances, nutrient deficiencies) will increase BSI. BSI should be optimized to stay below 30 % in activated sludge, thus showing a microbial population not submitted to external stress.

Process	Parameter	Good Control	Preventive action required	Corrective action required
Process Influent	BSI (%)	<50	50 o 75	>75
Bioreactor	cATP(ng/mL)	Process specific*		
	BSI (%)	<30	30 to 50	>50
	ABR (%)	>25	10 to 25	<10
Process Effluent	cATP(ng/mL)	<50	50 ot 250	>250

*The optimum cATP control guidelines for your process will depend on reactor typeand influent qualities. In general, deviation from previous values by +/- 25% should be considered a preventive guideline and +/- 50% should be considered corrective.

The monitoring of ATP concentrations in waste water over the time conducts to having a good alarm system for identifying degradation of the operation conditions of the installation and the presence of toxicity in the primary influent.

RESULTS OF THE TOXICITY STUDY ON DIFFERENT PRODUCTS MANUFACTURED BY THE CHEMICAL COMPANY

	cATP – Active biomass concentration (ng/ml)			BSI- Biomass Stress Index (%)		
Tested products and samples	Calculated T0	T30	T24	Calculated T0	T30	T24
1	2554,91	644,58	261,07	15,47%	34,23%	43,51%
2	2549,12	1231,13	1531,30	16,12%	46,04%	35,23%
3	2571,96	1477,54	1190,48	15,55%	47,95%	46,65%
4	2564,16	642,98	285,51	15,31%	22,54%	53,64%
5	2567,17	587,25	890,44	15,31%	56,48%	41,59%
6	2566,15	777,30	709,10	15,64%	59,99%	56,78%
Starvation control	2564,63	1953,93	910,50	15,61%	34,89%	46,62%
Toxicity control	2556,71	860,63	599,97	15,43%	44,25%	43,90%

Table 1: Results of the toxicity study on 6 products

Six different products were selected for the study of their toxicity impact on the active biomass composing the bioreactor. Solutions of each product were prepared and added to active biomass from the bioreactor. The concentration of active biomass and the stress of the biomass were studied using the TCB ATP-metry kit at three different times: before, 30min and 24 hours after the addition of the toxic products. The test at 30 minutes indicates the acute effect of the products on the active biomass, whereas the 24 hours test indicates the long term impact. Two control solutions were also followed during the study:

Starvation control - containing active biomass and treated water

Toxicity control - containing active biomass and a mix of the six products at the same concentration as the individual products solutions.

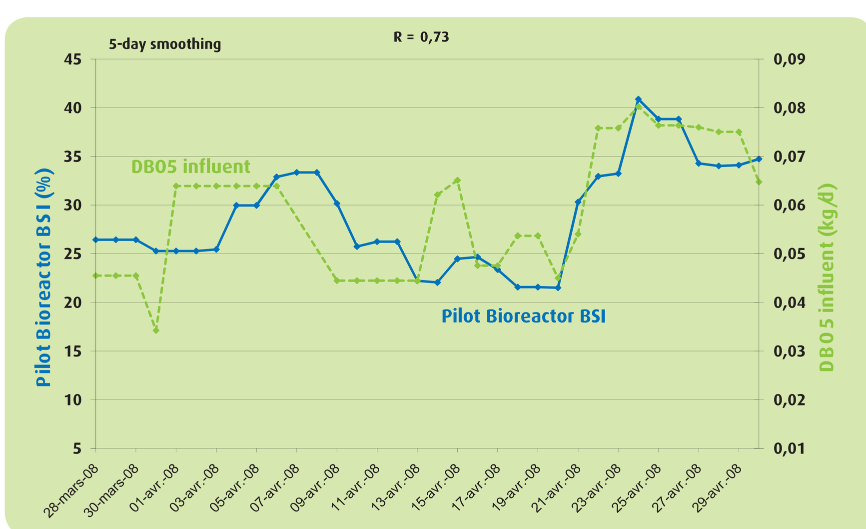
Interpretation of the results and classification of the toxic products

Classification	Product	Observations	Interpretation
1 (the most toxic)	6	The biomass stress is very high at short term (30 minutes) and long term (24 hours).	Acute toxicity
2	5	The stress induced by the product is very strong at 30 min showing acute toxicity, but is reduced at 24 hours -the biomass seems to adapt well on long term.	Acute toxicity
3	4	Acute biomass stress is low, but at 24 hours the stress of the biomass is significant, showing a high toxic impact on the active biomass on long term.	Moderate toxicity
4	1	Product inhibiting the activity of the biomass. There is no effect of acute stress, but the toxicity has a long term impact.	Moderate toxicity
5	3	Product with moderate stress impact at 24 hours. The activity of the biomass is correct at 30min. and 24 hours.	Low stress
6	2	A slight acute stress is detected at 30 minutes, but the long term stress is comparable to the controls.	Low stress

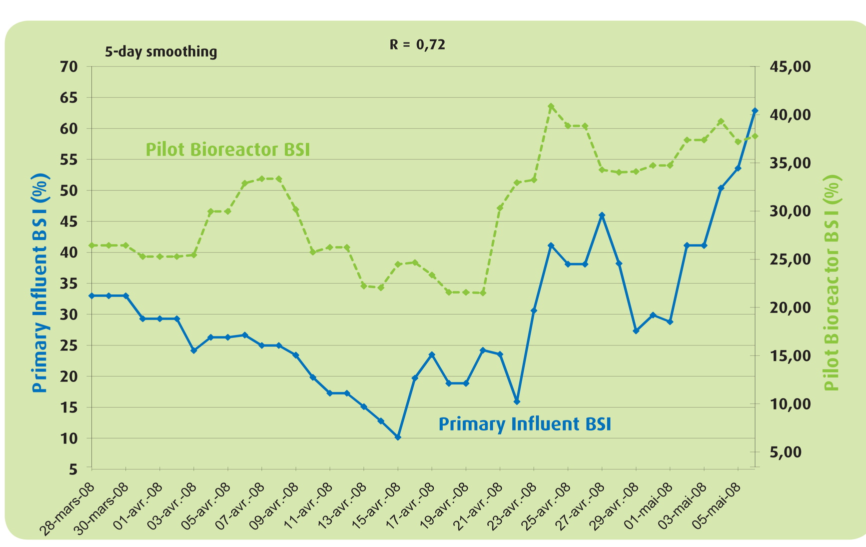
Table 2: Classification of the 6 products based on their toxicity effect on the active biomass of the bioreactor

ANALYSIS OF A TOXICITY EVENT OCCURRING DURING THE FOLLOW-UP OF THE INSTALLATION

Over the two months period surveillance of the installation, we could observe very good correlation between COD and BOD5 of the primary influent and the BSI measured on the active sludge. The correlation coefficient was at 57% for the COD – BSI correlation and 73% for BOD5 - BSI correlation *(Graph 1)*. These observations indicate that the primary influent is the principle source of stress for the active biomass present in the bioreactor, comforted by the strong correlation (72%) existing between the active biomass stress present at the level of the primary influent and the stress in the bioreactor *(Graph 2)*.



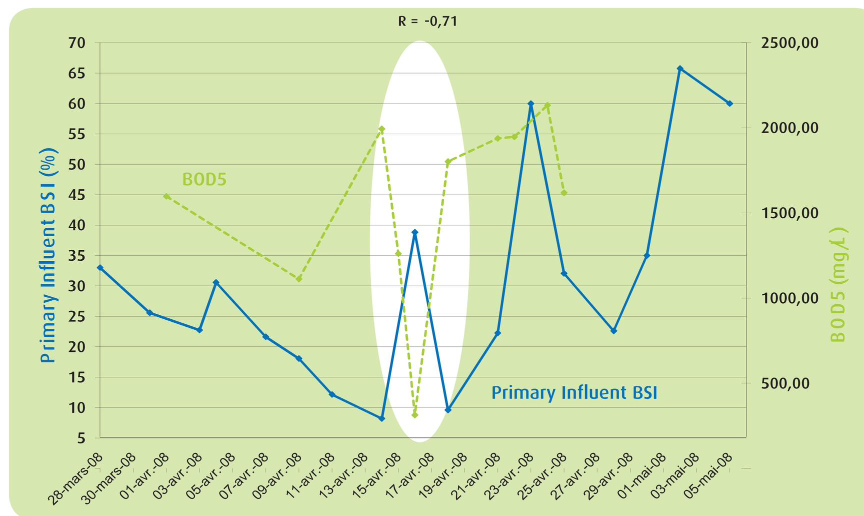
Graph 1 : Relation between TBO5 in the influent and stress in the Biorector



Graph 2 : Relation between stress of the active biomass in the bioreactor and the primary influent BSI

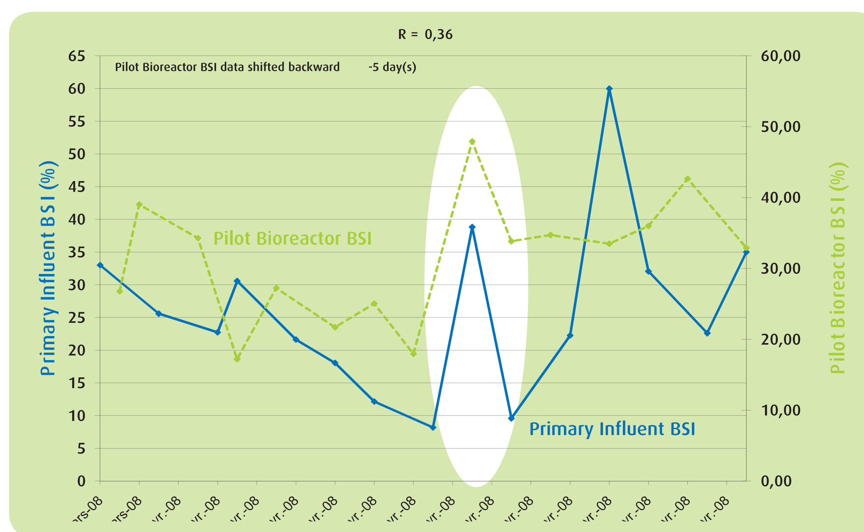
STUDY OF THE TOXICITY EVENT ON THE 16TH OF APRIL

On the 16th of April a strong increase of the BSI of the primary influent was observed. This toxicity was associated with an increase of the COD, COT and COD/BOD5 ratio on the same day. A strong decrease of the BOD5 was also observed *(Graph3)*. A specific influent, with supposed very low biodegradability, has probably been introduces in the treatment station this day.



Graph 3: Relation between BOD5 and BSI in the primary influent

The analysis of the Biomass Stress Index in the bioreactor showed a strong increase (BSI = 49%) five days after the event, which corresponds to the total retention time in the bioreactor. The stress is maintained at 35% over several days. At the same moment the activity of the active biomass in the bioreactor has decreased by 30%; leading probably to a less efficient treatment of water contaminations. This hypothesis was confirmed by the increase of the COD/ BOD5 ratio in treated water at the same moment.



Graph 4: Impact of toxicity present in the primary influent on the bioreactor

The toxicity phenomenon observed by ATP-metry on the primary influent on the 16th of April was the origin of disruption of the active biomass activity in the bioreactor with effect on the quality of the final effluent.

CONCLUSION

The aim of this study was to introduce a new, direct measurement of the concentration and activity of microorganisms in waste water treatment plants. Technologies used up to day such as MLSS and MLVSS measurements have their limits, whereas a lot of progress was made on analytical tools for microorganism's quantification. The Total Control Biological kit used during these two months trial showed very promising results in studying toxicity effects of influents on active sludge in the bioreactors. Early detection of the decrease of activity of bioreactors due to toxic influents becomes possible, and this tool can be used as an alarm for taking fast actions for avoiding disruption of the performances of the bioreactors.

Furthermore, it would be interesting to optimize performances of biological treatments using the ATP as indicator of the activity and health of the microorganisms. Optimization of the ATP control parameters such as cATP, BSI and ABR (Active Biomass Ratio), would lead to a more effective monitoring of the waste water treatment installations.

Tél. : 00 33 1 30 95 79 50
contact@aqua-tools.com