EXPERIENCES WITH ON-LINE TOXICITY ANALYZERS IN MUNICIPAL AND INDUSTRIAL WASTE WATER TREATMENT PLANTS

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One of the most urgent problems in water pollution control as in all fields of environmental protection is the protection of biosphere from toxic substances.
Forecasting the effect of toxic substances on living organisms still is extremely difficult as depending on the complex environmental situation. Even substances having a direct and not delayed effect cannot be directly detected but have to be interpreted form the reaction of the organims affected. An evaluation therefore has to combine susbtance, reaction and organism.
For on-line monitoring of waste water the respiration rate of bacteria as reaction on toxic subtances seems to be generally accepted because of its quick reponse. Still the consideration of the entire test conditions is of fundamental importance. For this type of toxicity measurement a certain reduction of respiration rate is looked upon as a toxic effect and as indication of a concertration of toxic substances in the water sample. The variation of respiration rate because of changing substrate therefore must be excluded. Also adaption could influence the toxic effect to the test organisms. Even such a rather simplified definition of toxicity shows the relation in a complex net of conditions. Against all these restrictions toxicity tests using microbes have proved their pratical relevance in various applications.

REQUIREMENTS FOR TOXICITY TESTS WITH MICROORGANISMS

The respiration activity of a test biomass will be influenced by type and concentration of toxic subtances as well as quantity and selection of test organisms, contact time, substrate (BOD, C:N:P-ratio), temperature and PH. Also adaptation could reduce or even suppress a toxic reaction of the biomass. Up to a certain concentration level toxic substances could even stimulate the biological activity. Parameters like pH or temperature can be easily controlled and will not be discussed furthermore, but substrate and selection of test organisms turn out to be the key problems that have to be solved. The choice of a specific detection system therefore depends on task and type of application.
For protecting biological stages in waste water treatment plants and adapted test biomass should be used. A higher sensitivity of the test organisms in this case even could confuse when detection toxic events although the biomass of the treatment plant might ot be

affected. In some cases tensides have been recognized causing toxic effects on non adapted microorganisms, while the activated sludge in a treatment plant did not react. A similar sensitivity of test biomass and biomass to be protected is of course appropriate.

A special selection of highly sensitive microorganisms can be used for exemple for classification of substances or waste water samples. A higher sensitivity can be used for some applications in a special low concentration range as with river monitoring.

BIOX-1010, A BIOLOGICAL ANALYZER SYSTEM FOR ON-LINE MEASUREMENT IN WASTE WATER

As manufacturer of autoanalyzers for BOD or toxicity measurement since more tha ten years, STIP has experiences in an extremely wide field of applications. For highest flexibility the biosensing analyzers today are based on the same instrumentation and can be easily adapted to different applications only be yse of different software or by minor changes of the measuring system.

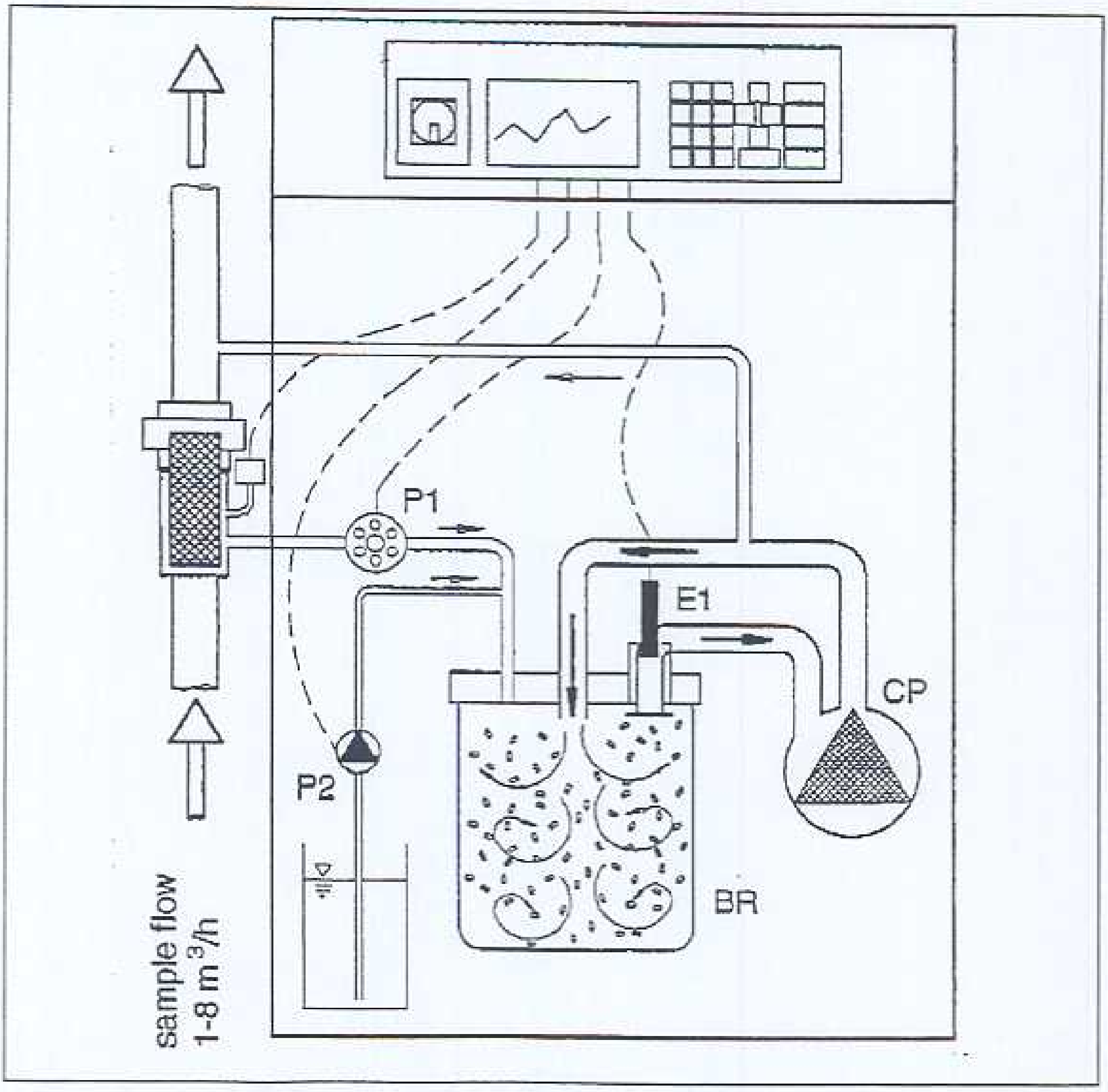

Fig n°1 : Schematic of BIOX-1010 BOD and toxicity analyzer

The basic system is the BIOX-1010 continuous on-line BOD-analyzer generating results within 3 minutes. The BOD M3 procedure utilises microbes which are growing in a turbulent mixed bioreactor within small plastic rings where they are protected from mechanical abrasion. Biomass respiration is kept constant by a feedback control system that dilutes waste water to a constant LOW BOLD level. If the BOD increases, the dilution will increase correspondingly, and vice versa. In the schematic relation of MICHAELIS /MENTEN as shoxn in fig n° 2 the operational point is shown at a constant low concentration of only 5 mf BOD/1. When used as BOD-analyzer in crude waste water, a very high dilution rate protects the adapted biomass from toxic effects. The respiration rate then only depends on the substrate concentration.

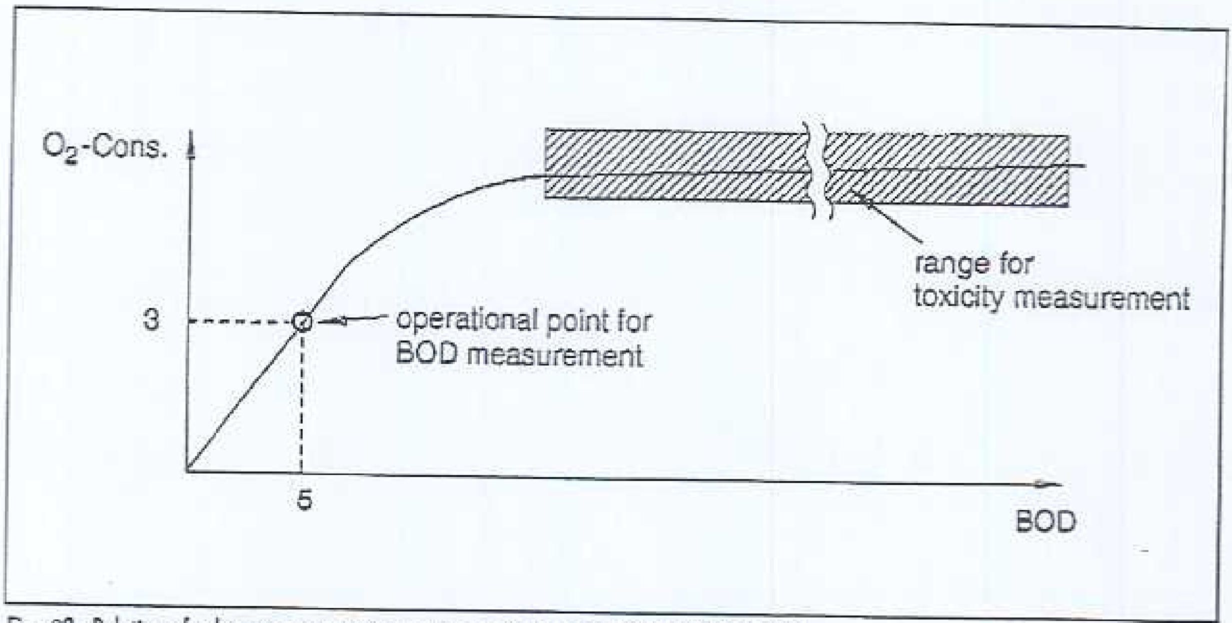

Fig n°2 : Relation of substrate concentration versus respiration rate (MICHAELIS/MENTEN)

PROCEDURE OF TOXICITY MEASUREMENT WITH TURBULENT BED BIOREACTOR

The identic measuring system can be used as toxicity analyzer by moving the operational point to a high level of BOD where substrate concentration has reached a level of saturation. By this, a sample stream is supplied to the bioreactor at a preset low dilution rate and therefore toxic loads also are applied almost undiluted. At the high level of substrate supply a maximum respiration rate will be reached and will only be diminuated by toxic effects or inhibition. Taking a constant base line of oxygen consumption granted for a non toxic sample, any relative reduction of respiration is automaticly evaluated as toxic effect. A result can be given as respiration rate or as toxicity (%) related to the normal (non toxic) level.

To prevent a total breadkdown of the microorganisms in case of strong toxic effects, the sample dilution system is automatically activated. After a reduction of the respiration rate by e.g. 20 % a continuously controlled increasing dilution of the sample will stop a further reduction of respiration. The dilution rate then is directly taken into account to calculate the corresponding respiration rate. Thus, even under strong toxic shocks the biomass will not collaps but keep the ability to react directly on the decrease of the toxic concentration and will regain its normal activity level. The sensitivity of the analyzer can be easily adjusted to the requirements by setting of the standard dilution rate. For some applications a higher dilution rate could be necessary as with a relatively small test biomass the reaction will always be much more sensible compared to the biological stage in a treatment plant which is buffered by its huge tank capacity.

With a 20 mA output, a serial computer interface or an alarm contact the toxicity signal can be directly transmitted tot a central control or monitoring system.

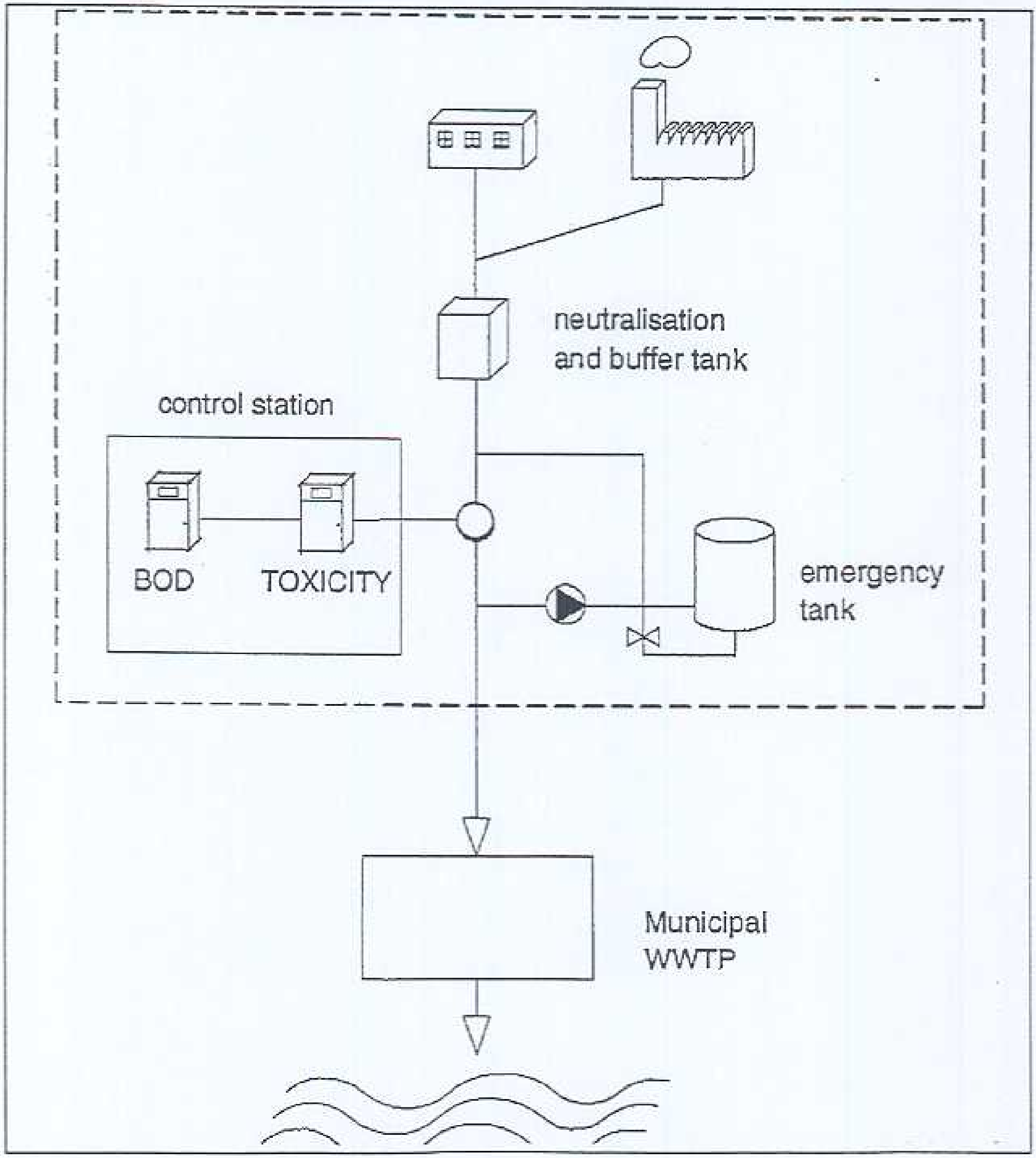

Fig n°3 : Installation of a STIPTOX analyzer at a municipal treatment plant

A TYPICAL APPLICATION CONTROLLING HOLDING TANDS AT CHEMICAL INDUSTRY

Environmental incidents today are not only recognised for their directly effected costs but also for the severe damage to the public reputation of a compagny.
Therefore, many industrial companies are undertaking serious efforts for environmental protection.

At least after the accident at SANDOZ in Switzerland, which caused a heavy toxic pollution of the Rhine down to Holland, bid holding tanks became obligatory for all major chemical industrial plants in Germany. Automatic control by toxicity monitors is required.

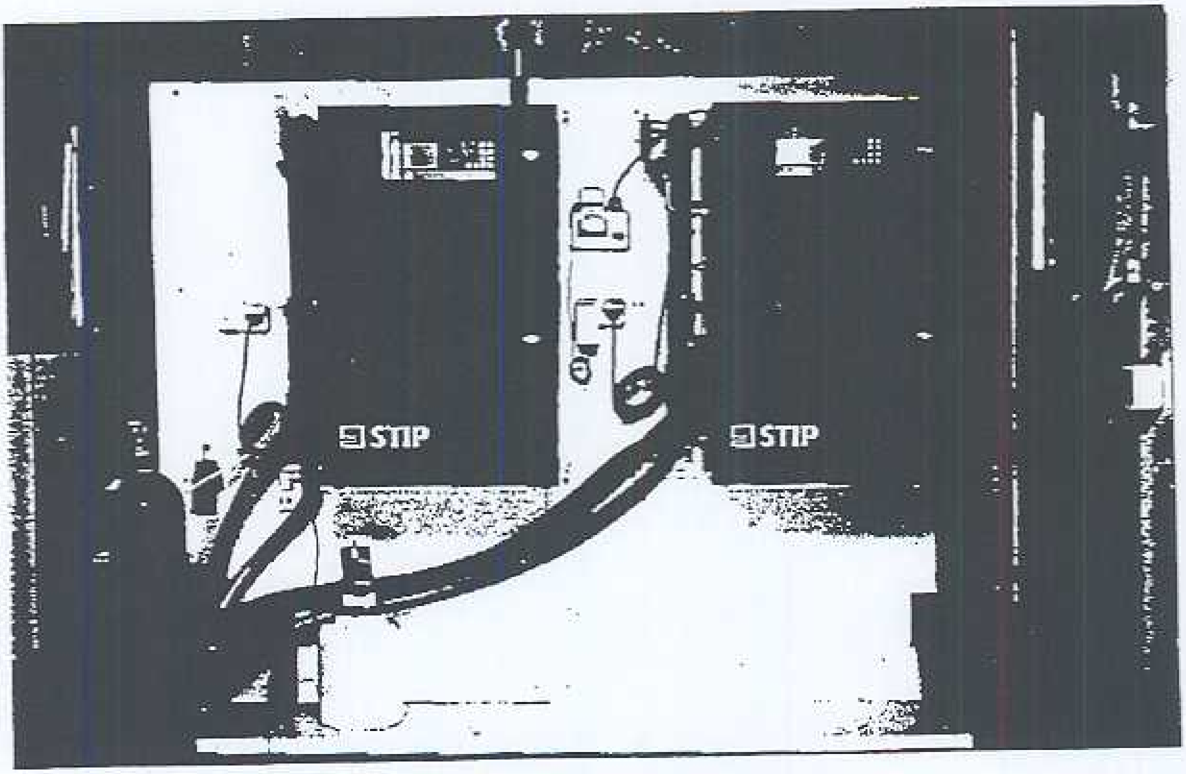

Fig n°4 : Control system for emergency tank at pharmaceutical industry

At a pharmaceutical industrial plant in Germany the waster water is collected in a neutralisation tank. Coming from the neutralisation tank with a pH of 6 to 7.5 it is led to the municipal waste water treatment plant at a distance of about 2,5 km.
But still on the industrial site water quality is monitored in a control station including a continuous measurement of BOD and toxicity. The BOD-concentration combined with the measured flowrate is taken for automatic limitation of the BOD-load by using the retesnsion capacity of the neutralisation tank.
In case of an alarm given by the toxicity analyzer the complete effluent finally can be pumped into a holding tank which has a capacity for a water amount of more than 4 hours. During this time the toxic pollution can be stopped or all waste water spending production has to be turned down.

When the toxic level is reduced, the waste water can be passed on again to the municipal treatment plant.

The toxic effluent being separated in the emergency tank now can be analysed, directly treated and the run of to the main sewer, where it is again passing the control station.

If a direct treatment in the emergency tank is not possible, the toxic water has to be transported by trucks to a qualified treatment facility.

By this installation a permanent monitoring of all plant effluents is always quaranteed and toxic effluents beyond a significant level can be kept away from the municipal waste water treatment plant.

Various tests have also been made by connecting the toxicity analyzer to a 50 l container to which a constant flow of normal plant effluent is pumped. By addition of special toxic components of certain quantities of production water for which a toxic pollution is suspected, accidents can be simulated or the real effect of production waters ca be examined. An example of such a test is shown in figure number 4.

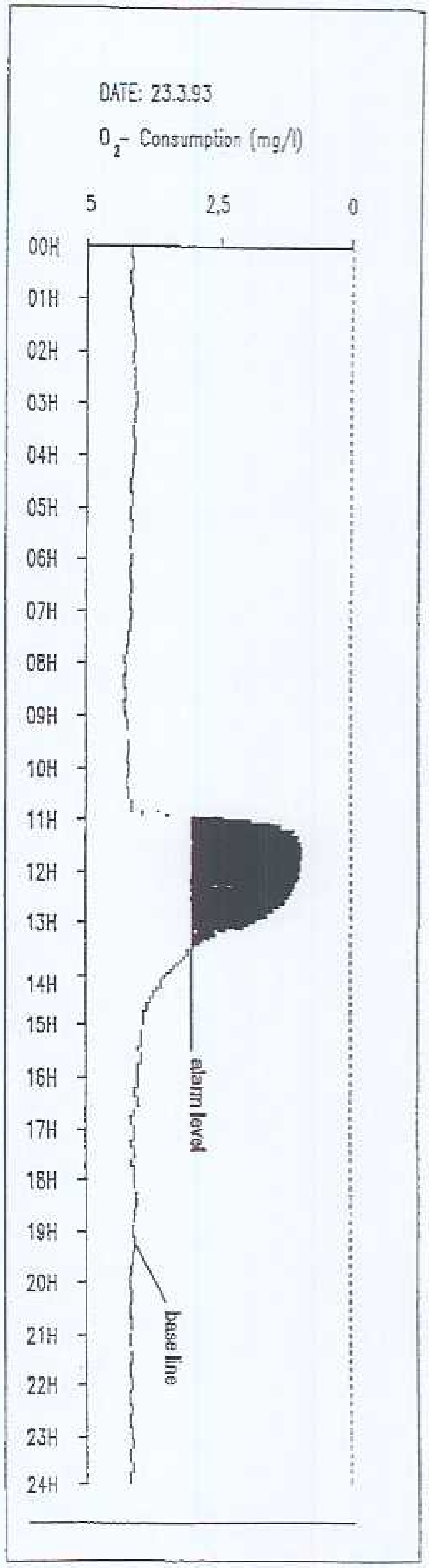

Fig N 5 : Continuously measured results during test with toxic components shown in a curve.

DIFFERENT VERSIONS OF ANALYZERS FOR SPECIAL APPLICATIONS

Other measuring procedures can be used depending the requirements of special applications.
If the direct use of activated sludge from the treatment plant is necessary a permanent dosage of activated sludge into the bioreactor can be made. The plastic rings for the immobilized biomass the have to be removed (version STIPTOX-adapt B). Changes in the concentration or in the specific activity of the activated sludge would effect a certain band of basic respiration which will indicate a non toxic sample.
Biomass with selective sensitivity can be created by additionnal dosage of substrate solutions to the bioreactor (version STIPTOX-norm). This version can be used for applications where an especially high sensitivity is required for example in river monitoring.

ON-LINE TOXICITY MEASUREMENT, AN INCREASING DEMAND

Because of the general environmental situation and sensibility most of the installations of STIP analyzers are still found in Germany. Another reason of course is, that STIP is a German manufacturer an Interntional marketing always is delayed by one to two years.
The distribution to other European and International countries is shown in table 1.

Germany	60 %
France, Great-Britain, Holland Italy, Switzerland	32 %
USA, Japan, Australia	8 %

Table n° 1 : Distribution to different countries

The strongest use of STIP analyzers of course is to be found in industry for monitoring of industrial effluents or on industrial waste water treatment plants. But more and more municipal treatment plants are investigating their incoming waters for toxicity or effects of reducing the sludge activity in the biological stage.

Industry	77 %
Municipal WWTP	21 %
River Monitoring Stations	2 %

Table n° 2 : Distribution to type of application

According to the development in Europe during the last five years a strongly increasing demand for automatic toxicity analyzers is to be expected for the future.