THE FIRST YEAR OF OPERATION OF THE BOTNIA FRAY BENTOS PULP MILL IN URUGUAY

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ABSTRACT

The Fray Bentos pulp mill was started up in November 2007. This presentation will discuss the experiences during the first year of operation.

The Fray Bentos pulp mill is one of the most modern pulp mills in the world. With its capacity of 1 million tons/a of fully bleached eucalyptus market pulp it is also one of the biggest single line pulp mills ever built.

Basically the entire raw material supply of the mill comes from the eucalyptus plantations of Forestal Oriental from usually within the maximum distance of 200 km from the mill. When having reached the full capacity, the mill will use more than 3 million solid cubic meters of eucalyptus, mainly *Eucalyptus Grandis*.

The fiberline process will be presented. The cooking of eucalyptus is performed to kappa number 18 by using two-vessel downflow Lo-Solids cooking process. Oxygen delignification is performed in two stages to bring kappa number down to the level of 10. Pulp is bleached to the full market pulp brightness of 91 % ISO by using the sequence A/D-EOP-D-P. The fiberline will be presented in detail and particularly the process technical motivation of the selected bleaching sequence will be discussed.

The recovery process is commenced by black liquor evaporation in seven effects to reach the dissolved solids concentration of 80 %. The recovery boiler has the combustion capacity of 4450 tons solids/d and the steam values are 94 bar (g) and 490 ^{o}C.

The main supplier of the fiberline and recovery island process is Andritz. The entire process and all the areas of the pulp mill have been designed and implemented according to the IPPC BREF to comply the Best Available Techniques for chemical pulp manufacturing.

In the presentation we will discuss the development of the start-up curve to reach the current production rate of the mill. The realized process technical values as well as the reached quality level of the produced pulp will be presented. In addition, the environmental impact regarding the air emissions as well as the effluents will be discussed based on the realized levels measured and reported, and monitoring activities for operation and environment will be presented. The environmental permit for Botnia Fray Bentos mill is one of the strictest in the world for pulp mills.

Keywords: Pulping, bleaching, eucalyptus

INTRODUCTION

Oy Metsä-Botnia Ab or shortly Botnia is Europe's second largest pulp producer with five pulp mills in Finland. Entering into a project to build a pulp mill in Uruguay was initiated early 2003 when Botnia agreed to purchase 60 % of Compañia Forestal Oriental. Forestal Oriental has its background in the extensive eucalyptus planting activities which were started in Uruguay by Shell and UPM-Kymmene in the 1990's. At the beginning of the 2000's, Forestal Oriental owned 48 000 gross hectares of land in the western part of Uruguay with plantations mainly of *Eucalyptus Grandis* and *Eucalyptus Dunnii*. Setting up the Uruguay –based company Botnia S.A. in October 2003 put forward an extremely intensive period of pre-engineering of the mill with the consulting company Pöyry. Simultaneously the preparation of a study for Environmental Impact Assessment (EIA) and a Socio-economic Study was launched. The environmental permit was later on applied from the Uruguayan environmental authorities (DINAMA). Finally in February 2005 DINAMA granted the Preliminary Environmental Authorization for building a bleached pulp mill in the Province of Rio Negro. The project for constructing the Fray Bentos pulp mill could be officially started.

The initial start-up schedule was set to be the third quarter of 2007. It could be announced at the beginning of September 2007 that the mill was "technically nearly completed", which practically meant the readiness to start. After obtaining the final environmental permit from the Uruguayan authorities, the start-up of the mill could be commenced on 9 November 2007.

Why then Uruguay and the city of Fray Bentos to locate one of world's largest pulp mills? First of all, such a mill requires a significant amount of wood raw material – 3,5 million cubic meters annually. The availability of good quality raw material is one of the most essential prerequisites for any modern pulp mill. Forestal Oriental with its pioneering eucalyptus cultivation and seedling program can supply approximately 70 % of the wood raw material needed by the mill. Today Forestal Oriental owns directly or through majority ownership about 170 000 hectares of land in Uruguay, of which about 60% is plantable. The rest of the wood raw material comes from outside suppliers against long-time delivery contracts. Forestal Oriental's own plantations have received FSC (Forest Stewardship Council) certification. From the sustainability point of view, the efforts of the Uruguayan government to support forest plantation in the areas of grasslands with low agricultural value is a very significant factor.

In this presentation we are not going to comment on the well-known public discussion that has been conducted around the mill and based on experience on older mills, particularly on the anticipated environmental effects. However, it might be worthwhile to repeat the message from the Cumulative Impact Study (CIS) released by the International Finance Corporation in October 2006. According to the study, the mill and its process technology can be considered to IPPC-BAT or better. The CIS states that there will be no negative impact on the environment or human health, but on the other hand there will be significant socio-economic benefits to the entire area. For example, odour will not be detected during normal mill operations. The cumulative assessment of water quality in Rio Uruguay indicates that no water quality standards or guidelines will be exceeded as a result of the effluents from the mill.

There is more information about the environmental and other studies as well as the mill project in the following references /1 -5/.

In this paper we will first present the process technological solutions selected for the mill. After that the main operational data will be discussed. The experiences from the start-up period and the obtained process performance will be shown. The development of the most important environmental parameters will be discussed. The mill data covers the span from November 2007 to August 2008.

FRAY BENTOS PULP MILL

General

The capacity of the mill is 1000 000 ADT/year of fully bleached eucalyptus pulp (target brightness 89 – 92 % ISO). The mill uses the kraft process and the pulp is bleached without elementary chlorine (ECF). The entire process is selected according to the recommendations of IPPC BREF that defines the Best Available Techniques (BAT). This set of norms is used in the European Union for defining the BAT by the pulp and paper industry /6/.

In order to justify the selection of the process technology from the environmental, economical and product quality point of view, extensive laboratory studies were conducted by the equipment supplying companies during the pre-engineering phase. In addition, particularly the bleaching process was very carefully scrutinized in connection to a large scientific research project at the Helsinki University of Technology. It is also worth mentioning that the same Uruguayan eucalyptus wood mixture as the Fray Bentos mill uses was processed in full scale at two Finnish pulp mills owned by Botnia and UPM-Kymmene. The mill trials were extensive enough to produce several tens of thousand tons of similar type eucalyptus pulp as the mill was designed to manufacture. The obtained process technical and product related experiences were benefited from during the start-up of the mill.

The entire fiberline and chemical recovery process has been delivered by Andritz.

Woodhandling

The wood comes to the mill from the plantations as debarked logs selected according to the eucalyptus species. There are two parallel chipping lines at the mill woodyard. Figure 1 shows a simplified diagram of the chip preparation system at the woodyard.

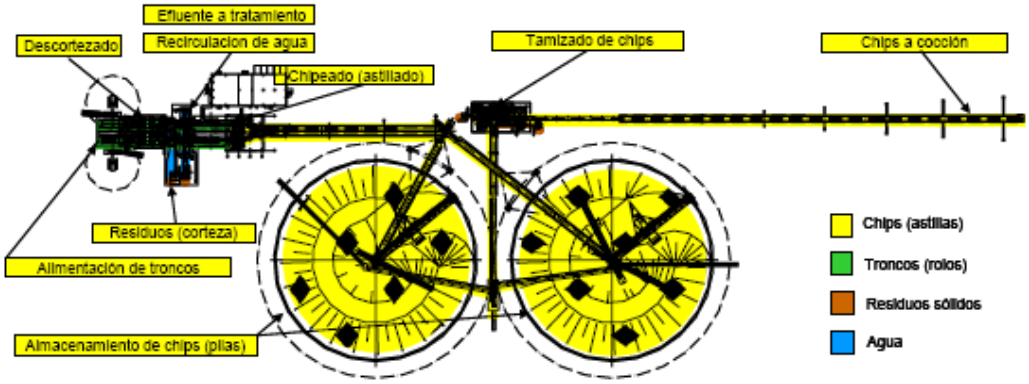


Figure 1: The general layout of the woodyard

Brown Stock Fiberline (Cooking, pulp washing, oxygen delignification and screening)

The entire pulp mill fiberline process is presented in Figure 2.

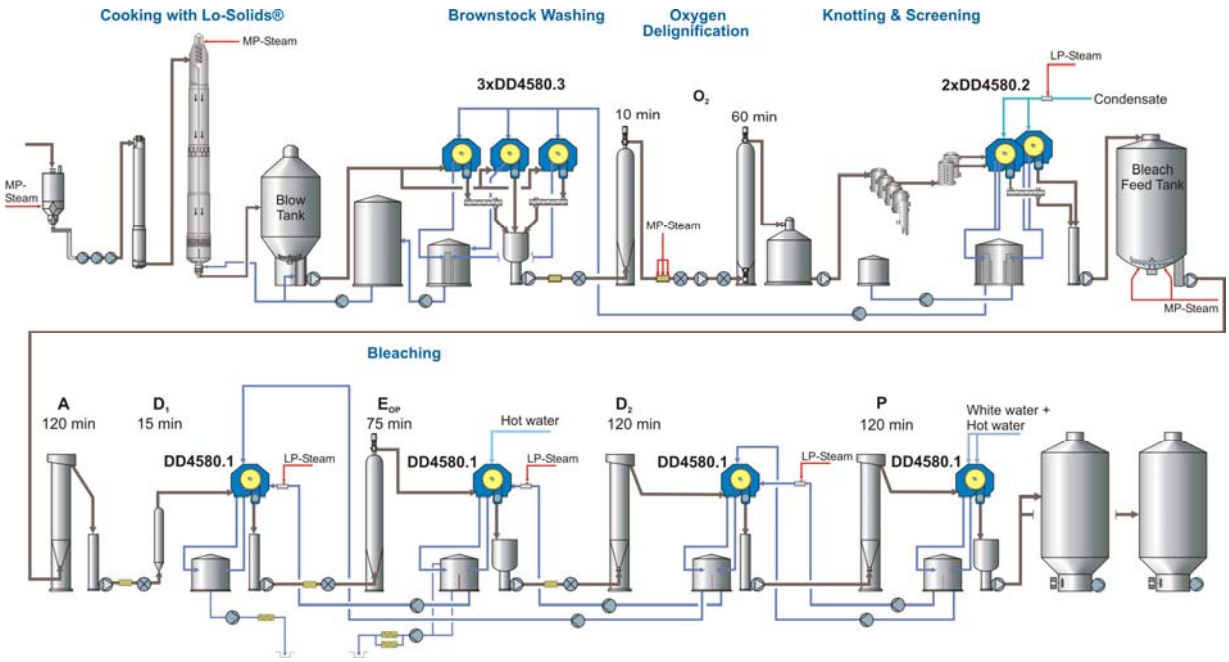


Figure 2. Fray Bentos pulp mill fiberline

The principal environmental and pulp quality related aspects to consider when designing the brown stock part of the fiberline are as follows:

- The kappa number profile in the brown stock area needs to be optimized: the lower the kappa number entering bleaching the better from bleaching chemical and bleaching effluent point of view but high enough to guarantee the desired paper technical properties for the product. In case of the Fray Bentos mill, the target kappa number after cooking is 18 and after oxygen delignification 10, respectively.
- The total washing efficiency of the counter-current washing system prior to bleaching shall be high. In our case the design value for the total washing efficiency is E_{10} =23 measured using the equivalent Nordén number at 10 % pulp consistency.
- The entire black liquor system is closed. All the black liquor, the possible spills included, is taken to black liquor evaporation.

The cooking process is the Andritz Lo-Solids® Downflow system /7/. Brown stock washing starts by the digester washing zone in the bottom of the digester. The main task of brown stock washing prior to the oxygen stage is carried out by three Drum Displacement Washers® (DD-washers) in parallel.

Oxygen delignification is performed in a typical two-stage system having the retention times 10 and 60 minutes, respectively. Oxidized white liquor is used as the main source of alkali in oxygen delignification.

Knot separation and brown stock screening is located after the second oxygen delignification reactor and prior to the post-oxygen DD-washers. The separated and washed knots are returned back to the chip feeding system to be re-cooked while the final reject comprising mainly of such impurities like sand is removed from the system as a solid waste. It is estimated that the amount of removed rejects is only about 1 ton/d, i.e. roughly 0,03 % of the produced pulp. The post-oxygen washing is also carried out by means of DD-washers.

The pulp bleaching process

The pulp bleaching system is critical from the point of view of reaching the required pulp quality in terms of brightness and cleanliness as well as maintaining and fine-tuning the paper technical properties of the product. However, the bleaching plant is also the location of opening the mill water circulations; a modern pulp mill typically discharges 20 – 25 m^3/ADT bleaching filtrates to be treated in the mill effluent treatment system. For this reason, the selection and usage of the bleaching

chemicals in a proper way is of primary importance. According to the BAT, bleaching without elementary chlorine or in other words by means of chlorine dioxide (ECF) is required in order to manage the level of chlorinated organic compounds and to prevent totally the formation of the highly toxic polychlorinated aromatic compounds.

Considerable effort was put to select the best version of ECF-bleaching that can take on the other hand into account the specific characteristics of eucalyptus pulp as well as optimizes the usage of bleaching chemicals from the economical and environmental point of view. The selected bleaching sequence in the Fray Bentos mill is (A/D)-E_{op}-D-P.

One of the key features in case of bleaching eucalyptus pulp is the generation of hexenuronic acids (HexAs) in the cooking process. As pointed out eg. by Colodette et al /8/, the share of HexAs in the brown stock pulp may vary a lot from case by case which mainly influences the kappa number reduction in the oxygen stage. In any case, oxygen delignified eucalyptus pulp contains a significant amount of HexAs. The removal of HexAs can be performed basically by means of three alternative concepts: acid treatment (A-stage), hot chlorine dioxide stage or an ozone stage /8/. There is a number of alternative ways to combine these HexA-removal stages into the bleaching sequences. Vuorinen et al. /9/ have concluded that combining the A-stage and the delignifying D-stage (D_0-stage) together without intermediate washing (A/D) can give the best bleaching performance from the total chemical consumption point of view. Botnia has participated the research consortium referred by Vuorinen et al.

Reducing the HexA-content also reduces the consumption of chlorine dioxide. In other words, chlorine dioxide can be specifically used for removing residual lignin. The other effect where the HexAs can play a significant role is the colour reversion of the bleached pulp. Removing HexAs eg. by means of an A-stage improves brightness stability. Having a peroxide stage at the end of the bleaching sequence is another way to prevent post-yellowing. In addition, having peroxide in the sequence further reduces the chlorine dioxide demand.

The designed total chlorine dioxide consumption in the bleaching process of the Fray Bentos mill is 20 kg act. Cl/ADT.

Drying of pulp

The bleached pulp is dried by means of two parallel drying machines (capacity 2 * 1800 ADT/d) delivered by Andritz. The wet end forming is performed by means of Twin Wire Formers and the press part comprises of three press sections to reach the pulp dryness above 50 % before entering the drying section.

Chemical recovery

The weak black liquor from the fiberline is taken to the evaporation plant comprising of 7 effects. The nominal evaporation capacity is 1100 tons water/h. The black liquor is concentrated to 80 % solids content to be fired in the recovery boiler.

The Andritz recovery boiler has the combustion capacity of 4450 solid tons/d. The vapour pressure and temperature are 94 bar (g) and 490 ^{o}C with the vapour generation capacity of 182 kg/s.

Electric power is generated by two 80 MW turbines, of which one is an extraction back up pressure turbogenerator and the other an extraction back pressure turbogenerator with condensing tail. The power generation is based on the 31/11/3 bar(g) nominal steam pressure levels extracted from the turbines, being the average generation over 120MW .

The white liquor preparation system (causticizing and the lime kiln) is a typical Andritz system of today. The green liquor is filtered by means of X-Filters^{TM} instead of clarification. The white liquor filtration is performed by using a disc filter. The lime kiln has the nominal capacity of 830 tons CaO/d. The kiln is heated by using heavy oil as well as the by-product methanol from black liquor evaporation and hydrogen from the chlorate plant of the chemical island.

Effluent treatment

The design value for the effluent flow from the mill is 25 m^3/ADT, i.e. about 73 000 m^3/d. The main part from the effluent comes from bleaching but there are also smaller effluents streams eg. from woodhandling, pulp drying, evaporation (secondary condensates) and causticizing in addition to the water taken from the cooling water circulation.

The effluent treatment takes place by means of an activated sludge biological treatment system presented by Figure 3.

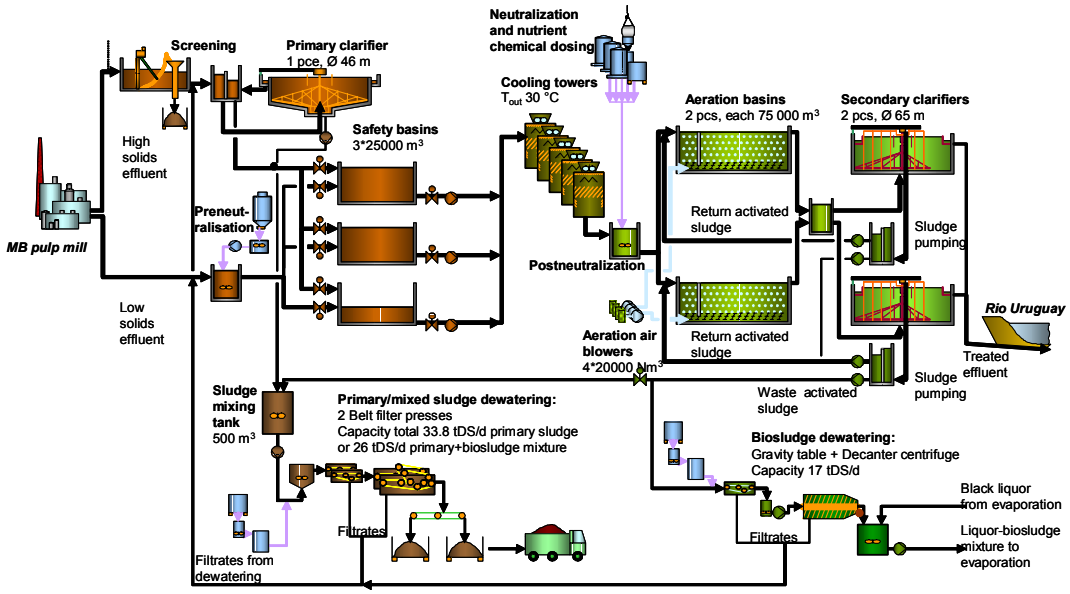


Figure 3. Effluent treatment plant

The main equipment and stages are as follows:

- Coarse screening to remove possible bigger solid particles
- Primary clarifier to remove the solids (primarily fibres) from the high solids content stream
- Safety and equalization basin system, comprising of three 25,000 m^3 basins in parallel
- Cooling tower for maintaining the right temperature level from the biology point of view
- pH adjustment and nutrient addition
- Aeration basins (two units in parallel)
- Secondary clarifiers (two units in parallel, diameter of each 65 meters)
- Excess sludge disposal system

The treated effluent is taken to Rio Uruguay through diffuser pipe.

OPERATIONAL EXPERIENCES

Start-up phase

Chip feeding to chip silo was started 10th of November 2007 after midnight, and in 62 hrs time drying machine 1 was fed. First FRB Euca bales were produced 12th of November.
The nominal capacity of the pulp mill (1.000.000 tons/year with 350 operating days), as 30 days average, was reached in 145 days from the start-up of the mill. This can be considered as a world record even though such records are not officially registered. The last two best marks achieved by other mills of similar type have been 171 and 174 days. Figure 4 shows start-up production curve.

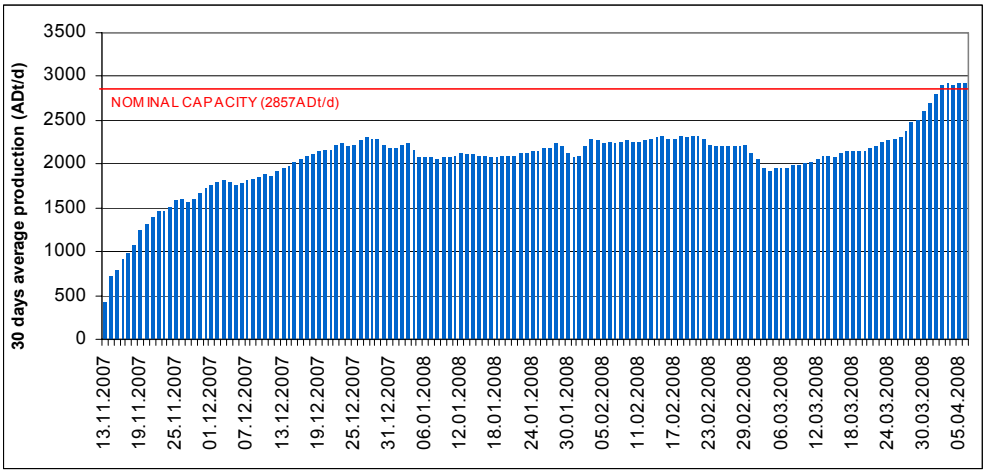


Figure 4. 30 days sliding average production

Pulp quality was prime soon after the start-up: from second month of production prime % as monthly average has been over 98%.

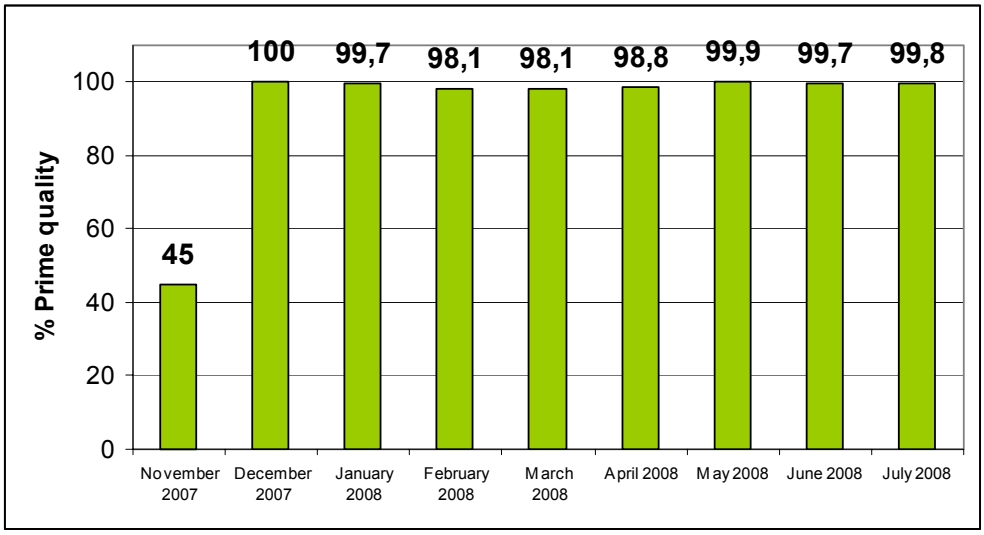


Figure 5. Prime quality % per month

Pulp brightness has been stable after initial adjustments, and most of the time inside the specifications.

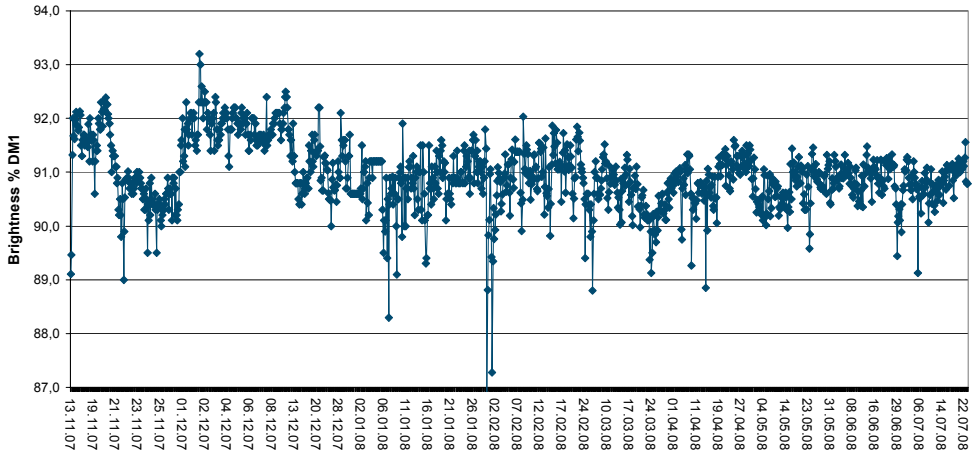


Figure 6. Final product brightness

Dirt counts amount have been low and matching expected values: pulp cleanliness has been good. Extractives content, measured as acetone extracts, increased at the beginning (concentration of the white waters in the nearly closed circulation) and then stabilized in a low and expected value (normal <0,12%). Extractives composition analyses show that extractives in pulp are mainly fatty acids and sterols.

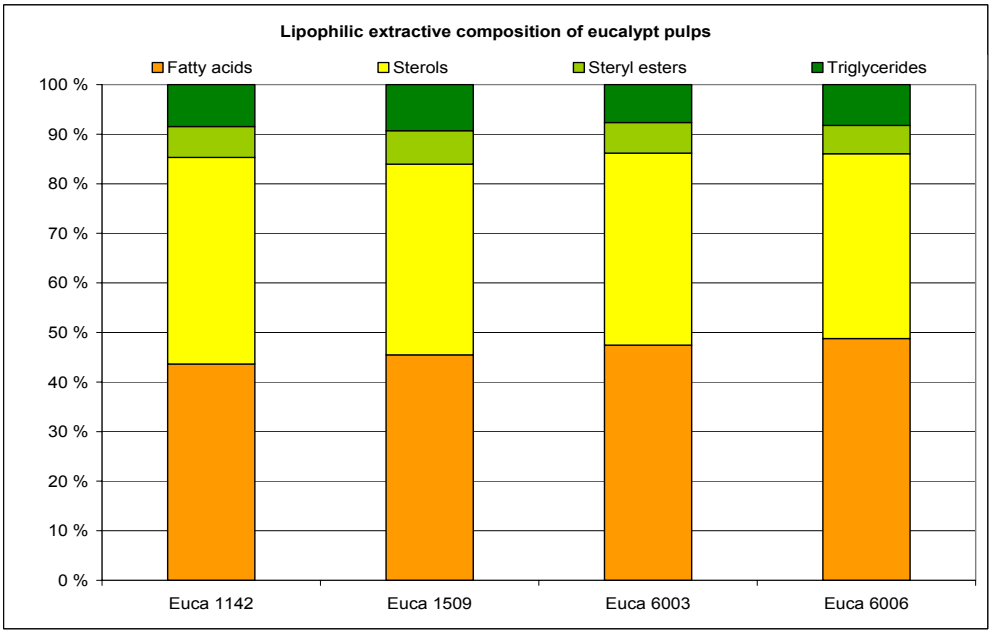


Figure 7. Lipophilic extractives composition of Botnia Fray Bentos Euca pulp

Performance of the fiberline

The typical raw material for Fray Bentos consists of a mixture of E. grandis ,E. dunnii and E. maidenii. As shown in figure 8, E. dunnii and E. maidenii have similar basic density, and higher than E. grandis. E. grandis fibers have lower coarseness, giving thus easier refinability and better strength to the pulp, while E. dunnii and E. maidenii contribute to higher bulk and porosity.

Chips dry matter content has been in the range 65-73%. The low moisture content is explained by debarking in plantations and long storage periods of the wood before chipping (average storage time when entering the mill is 3 month).

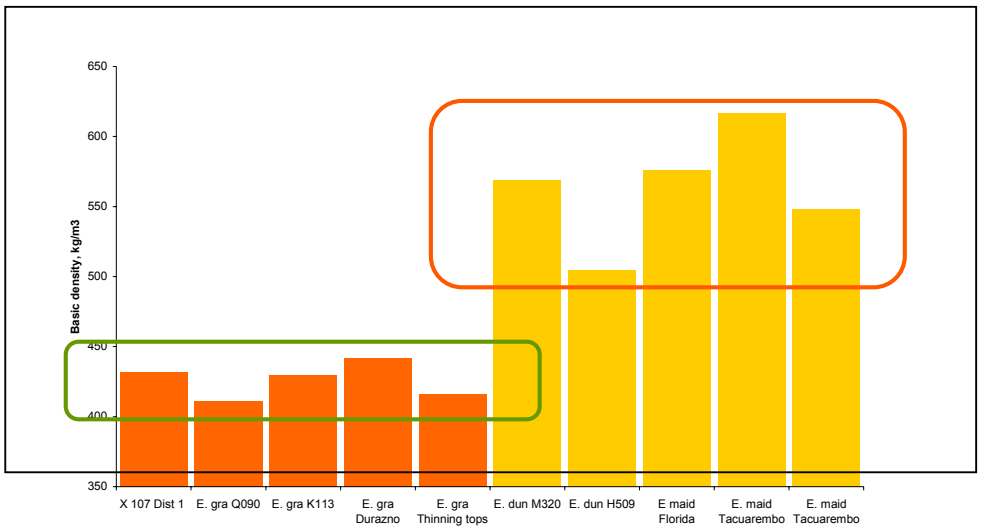


Figure 8. Basic density of samples from different E. grandis, E. dunnii and E. maidenii plantations

Wood consumption (from storage balance) has been around 3,5 m3/ADt, which means the total yield on pulp of about 53%.

The cooking blow line kappa target has been kept since the start up in 18, and the usual standard deviation is about 0,6 (without the upper level control). Cooking temperatures are: impregnation temperature 99-100ºC, cooking temperature for nominal capacity 140ºC in upper cooking zone and 150ºC in lower cooking zone (measured at cooking circulation heat exchanger outlet).

Total alkali charge has been optimized from initial charge of around 18% in start-up phase, and residual alkali targets have been reduced in upper and lower extractions from initial supplier recommendations without observing major changes to bleaching chemicals consumptions.

The combined washing efficiency of the digester bottom washing and the brown stock washers measured as E_{10} efficiency has been 11 - 16. Explanation for occasionally low washing efficiency at the brown stock DD washers has been calcium carbonate and pitch scaling.

Kappa number after oxygen stage is 10,5 – 11. Chemicals doses to oxygen stage are around 20 kg/ADt for oxidized white liquor/ NaOH and 15 kg/ADt for oxygen. The measured E_{10} washing efficiency for post oxygen washers, for dilution factor 2 – 3 m^3/ADt has been 7 – 8. The washing loss to bleaching is 7 – 10 kg COD/ADt.

Bleaching chemicals consumptions for July 2008 are shown in Table 1. The chlorine dioxide consumption is near its target value of 20 kg act Cl/ADt.

Table 1. Bleaching chemicals consumptions, average July 2008

Chemical	Consumption (kg/ADt)
ClO2 as act Cl	20,5
H2O2	6,3
O2	2,2
H2SO4	12,2
NaOH	22,9

Kappa and brightness development is shown in Figure 9.

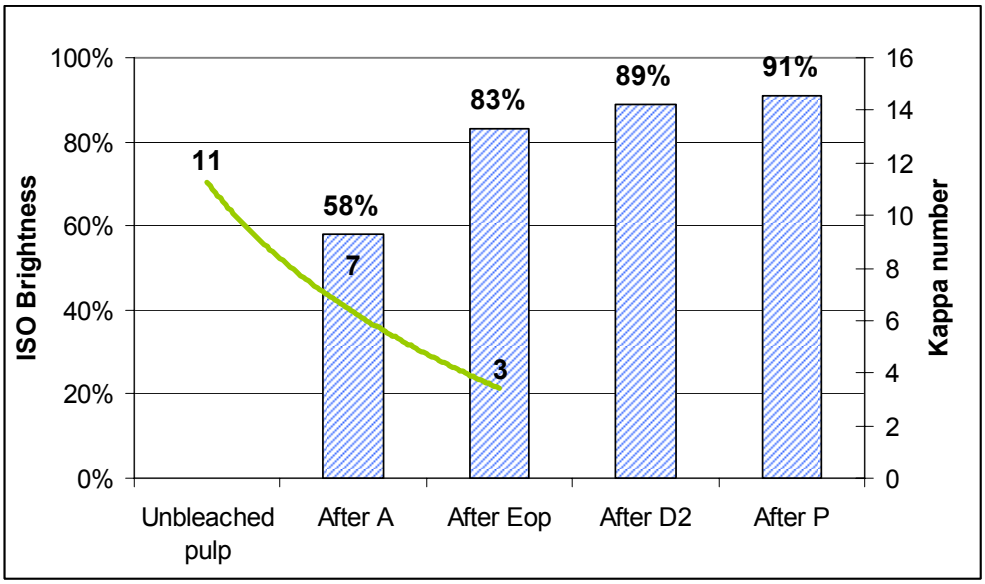


Figure 9. Kappa and brightness development in bleaching, average July 2008.

The biggest problem for the fiberline to overcome during the the start-up phase was the chip feeding to the impregnation vessel, due to the dry wood that had been stored from months before. The chip tube level was at the beginning difficult to control. The chip feeding was improved by minor modifications to the chip tube (putting liquor to the top part) and by water showers after chipping lines. Brown stock screening also caused some difficulties. The main mechanical problems in the fiberline were a leakage in digester top steam nozzles, a leakage in D2 – tower drain and a severe damage in chip pump 3.

Performance of the recovery

Evaporation plant is designed to evaporate 1100 tons of water per hour from incoming weak black liquor with 14,5% dry solids. In average the plant has been working at a lower production rate than the design (average 7 t H_2O/ADt) due to higher dry solids content at weak black liquor than expected (16% vs. 14,5%).

The temperature difference is followed at every effect as a parameter of dirtiness. For the effects 1A, 1B and 2 the temperature differences have been increasing from start up. During may the evaporation plant capacity was limiting the fiberline production. An inspection of the effects 1A, 1B and 2 was performed, finding that burkeite had precipitated on the effects' 1A and 1B surfaces and probably carbonate scaling over the effect 2 surface. The whole plant was washed. 1A and 1B temperature differences came down to 0ºC but effect 2 did not go below 5ºC. Washing frequency was increased to 1 washing per day and a boil out per week with no success for effect 2. At the end of June, evaporation plant was stopped for hydroblasting and acid wash of effect 2 finally increasing evaporation plant capacity.

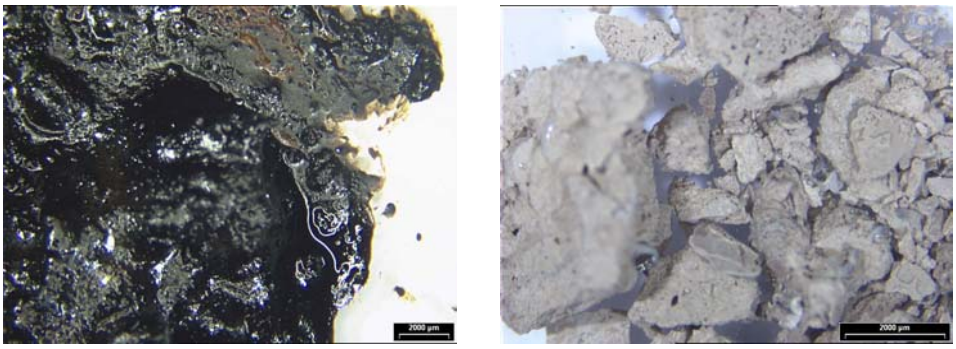


Figure 10. Left: Effect 1B scaling, may 2008. Right: Effect 2 scaling, may 2008.

Figure 11. Effect 2 scaling, june 2008.
Left. Plugging between lamellas. Right. Scaling over lamellas surface.

Scaling analyses showed that effect 1B scaling was probably burkeite (87% inorganic material, mainly sodium carbonate 52 % and the rest most likely sodium sulphate). However, effect 2 surface scaling was most likely calcium carbonate (90% inorganic material, which was mostly calcium carbonate 80%) on sample taken on May. When inspecting effect 2 on June, scaling appearance was different from the one observed on the previous month. Additionally to calcium carbonate scaling over surface, there was a plugging problem between lamellas.

Recovery boiler has been able to run firing liquor burning over design values with raw green liquor quality and flue gases composition according targets. The only period with production lost days was during January, when a leakage was found in Economizer I and repaired.

Turbines and steam distribution system have showed highest availability due to excellent design of fast opening at reduction station during turbines trips. The turbine availability has been excellent as well.

As the electricity surplus production is biomass-based, the pulp mill is thus reducing CO_2 emissions by replacing fossil fuel based electricity in the grid. The estimation of emission reduction is in average 50000 tO_2/year. The mill project has been approved by UNFCCC (Unated Nations Framework Climate Change Convention) and the generated credits are on certification process (http://cdm.unfccc.int/Projects/DB/DNV-CUK1199485759.25/view).

The white liquor plant production is below the design value (average 7116 vs. 10000 m^3/d), due to the alkali charge optimization at the fiberline, which made it possible to reduce specific white liquor consumption. The average parameters of white liquor quality are: TTA 168gNAOH/l, AA 146gNaOH/l, EA 116gNaOH/l, S 37%, CE 80%.

The lime kiln has been working below the design capacity (average 570 vs. 830 t CaO/d).
The only periods with production lost days were on March and June. The fuel oil consumption has been close to the design value (average 148 vs 149 kg/t CaO). Methanol and hydrogen are not burnt continuously, because both of them produce too high temperatures for actual bricks' resistance.

Non process elements figures

Uruguayan Eucalyptus plantations contain high amounts of calcium. Depending on the species, eucalyptus calcium content can vary between 1000 - 2700 mg/kg. The high calcium amounts in the wood raw material can explain DD washers scaling as mentioned before, and it can also be related to the evaporation scaling.

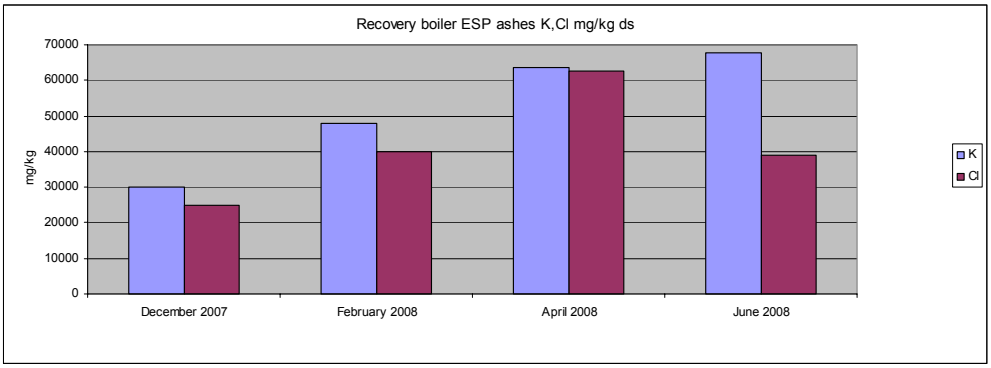


Figure 12. Potasium and chloride in recovery boiler fly ashes.

The chlorine content has increased fast from start up until now with the maximum value at the recovery boiler ashes of 6%. In order to reduce the chlorine amount in the liquor circulation, around 20 tons/day of ashes have been dumped during around 20 days total. A project for implementing chlorine removal is in the pre-engineering phase now.

Development of environment

The performance of the Fray Bentos mill is very closely monitored by Botnia itself, through external experts (mainly LATU) and by the Uruguayan authorities, DINAMA. DINAMA is National Office for Environmental Affairs in Uruguay (www.dinama.gub.uy) and LATU is the Technological Laboratory of Uruguay (http://latu.org.uy).

The first six months of any pulp mill are referred to as the initial start up phase. During that time the production is periodically interrupted mainly by typical failures of erection work quality and human errors. For this period the performance shows short term variability and it is premature to consider long term average performance projections.

Monitoring of environmental parameters

The mill's effluent and air emissions as well as the state of the surrounding environment are measured on a regular basis and data has been collected since before the start of operations. As an example, there are four measuring points, for river water quality, both upstream and downstream from the mill and two air stations are located in Fray Bentos city and its surroundings (one installed by Botnia and the other one by DINAMA). The following picture shows those monitoring points in the area of Fray Bentos. As it was mentioned before, DINAMA and Botnia have almost parallel monitoring plans, and LATU is the external laboratory responsible for most of the monitoring activities.

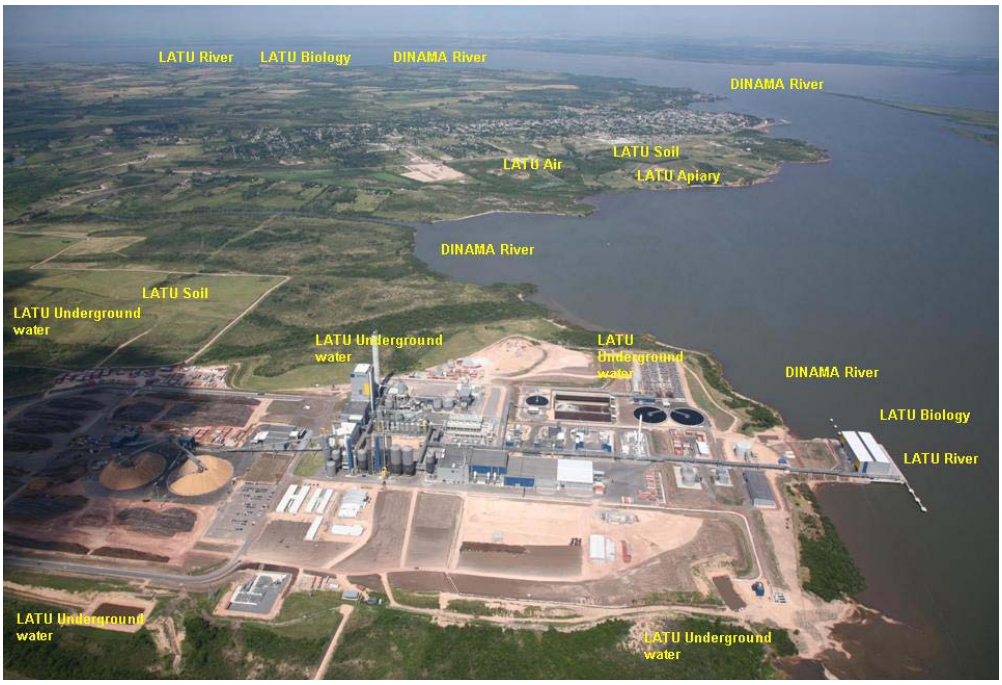


Figure 13. Environmental monitoring points in Fray Bentos.

Table 2 shows environmental parameters monitored in Fray Bentos surroundings.

Table 2. Summary of environmental monitoring activities included in Botnia's monitoring plan (characteristics of the monitoring activities can change in time).

Environment	Parameter	Nº of parameters	Nº of monitoring points	Frequency	External entity
Río Uruguay	physico-chemical	more than 60	4	monthly	LATU
Río Uruguay	sediments, plankton	more than 20	3	3 months	LATU
Río Uruguay	fishes	more than 10	3	6 months	LATU
Air	SO_2, NO_x, CO, TRS, PM, TPM	6	1	on line	LATU
Groundwater	physic chemical	24	11	3 months	LATU
Soils	physic chemical	11	2	once a year	A.Durán / LATU
Fauna	production and quality of bee honey	11	2	Monthly	LATU
Flora	presence/absence of *Tillandsia*		2	variable	Geoambiente
Social	anthropological studies, demographic figures	more than 13	Fray Bentos	twice a year	E.Gallichio / Equipos Mori

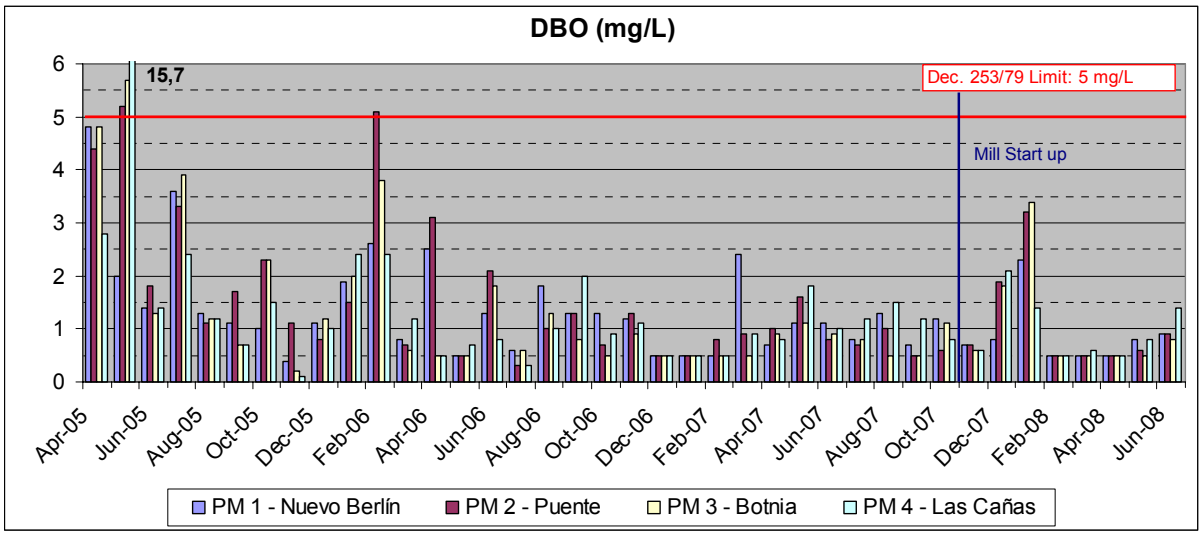
The collection of environmental data was started well in advance before the mill started operations and as expected, it does not shown negative effects in the environment. In some cases (e.g., river water quality), significant natural variation has been observed.

Monitoring of Río Uruguay

The values are measured at four monitoring points shown in Figure 25 by LATU.

Figure 14. Río Uruguay monitoring points by LATU.

As an example, the development of biological oxygen demand (DBO) and the total phosphorous content are shown.



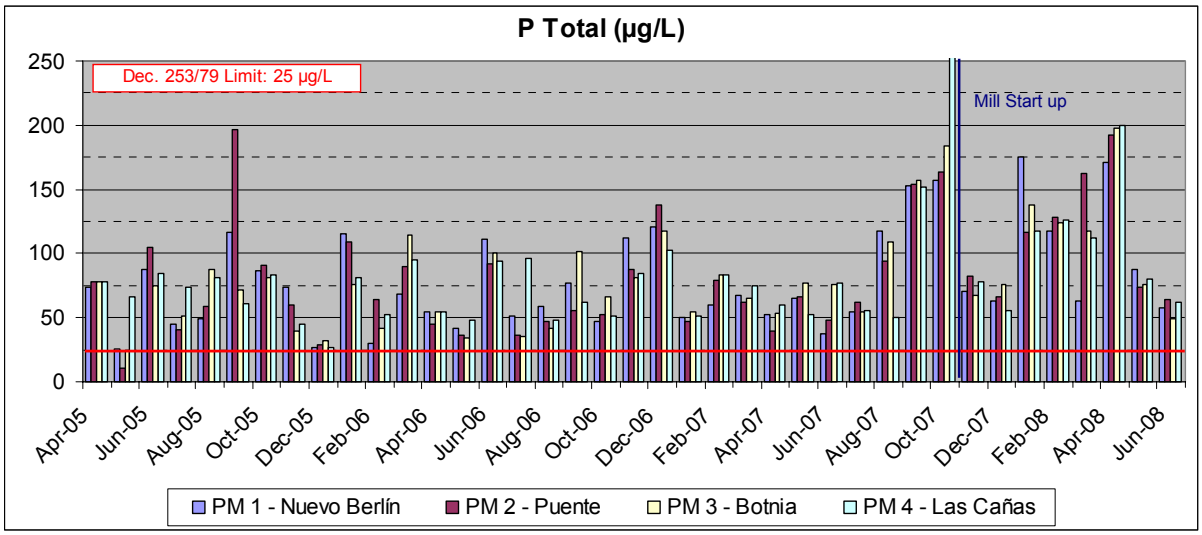


Figure 15. Measurements of biological oxygen demand and total phosphorous in the sampling positions of Rio Uruguay

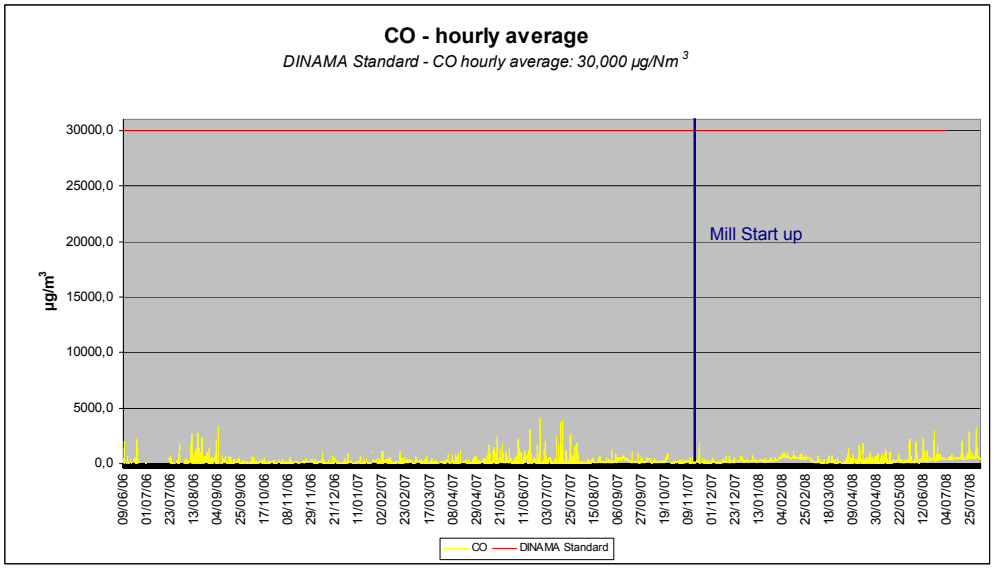
Río Uruguay water is considered of high quality since the concentration of most indicator parameters are below the most restrictive Uruguayan and CARU standards, including pH, dissolved oxygen, BOD_5, nitrate, turbidity, fluoride, chloride, sulphate, cyanide, arsenic, boron, copper, chromium, mercury, nickel, zinc and total phenols. Bacteria, total phosphorous and iron exceeded standards limits previous to mill commissioning due to natural sources.

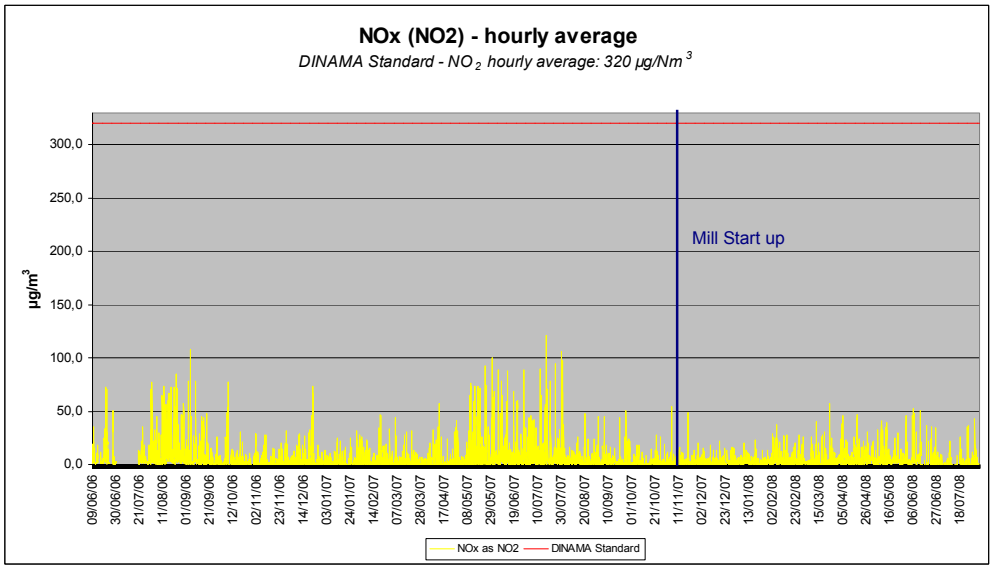
According to studies water quality has not changed as a result of the mill, except for small increase of conductivity and AOX very close to diffuser.

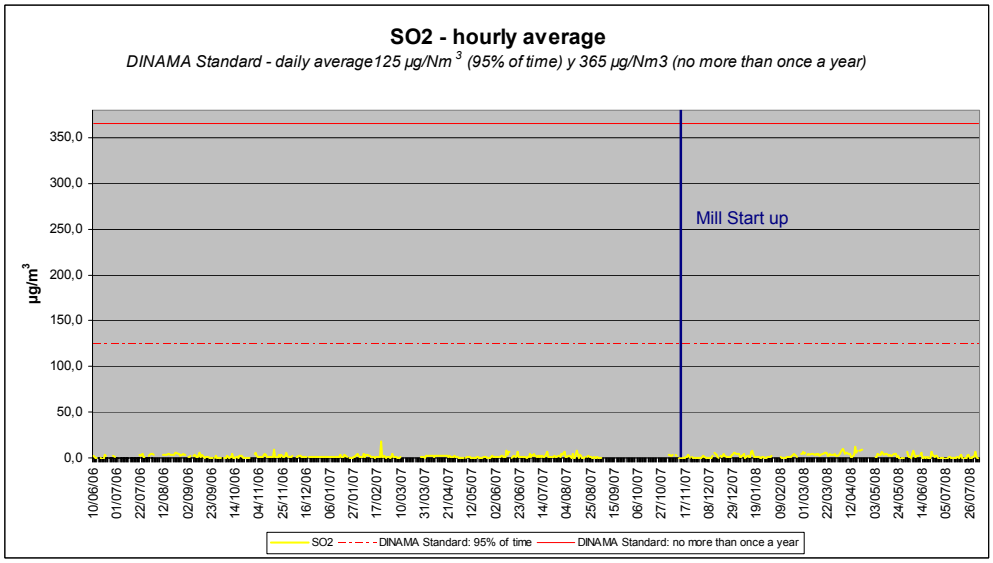
Monitoring of Ambient air

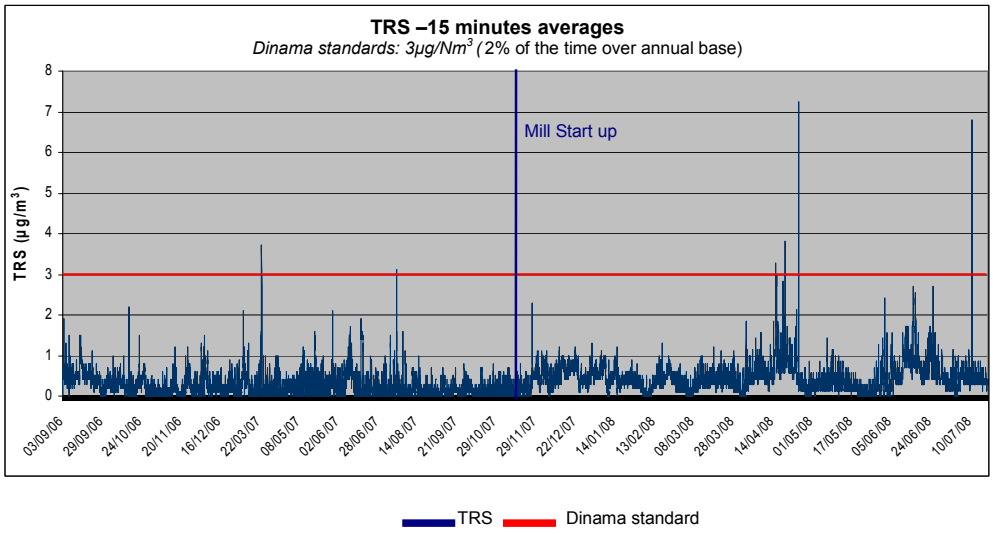
The parametering values are measured at the measuring point shown in Figure 16 by LATU.

Figure 16. Air emissions monitoring point by LATU.


CO - hourly average
DINAMA Standard - CO hourly average: 30,000 µg/Nm 3
µg/m3
30000,0
25000,0
20000,0
15000,0
10000,0
5000,0
0,0
Mill Start up
09/06/06
01/07/06
23/07/06
13/08/06
04/09/06
25/09/06
17/10/06
08/11/06
29/11/06
21/12/06
11/01/07
02/02/07
23/02/07
17/03/07
08/04/07
29/04/07
21/05/07
11/06/07
03/07/07
25/07/07
15/08/07
06/09/07
27/09/07
19/10/07
09/11/07
01/12/07
23/12/07
13/01/08
04/02/08
25/02/08
18/03/08
09/04/08
30/04/08
22/05/08
12/06/08
04/07/08
25/07/08
CO
DINAMA Standard


NOx (NO2) - hourly average
DINAMA Standard - NO 2 hourly average: 320 µg/Nm 3
µg/m3
300,0
250,0
200,0
150,0
100,0
50,0
0,0
Mill Start up
09/06/06
30/06/06
21/07/06
11/08/06
01/09/06
21/09/06
12/10/06
02/11/06
23/11/06
14/12/06
03/01/07
24/01/07
14/02/07
07/03/07
28/03/07
17/04/07
08/05/07
29/05/07
19/06/07
10/07/07
30/07/07
20/08/07
10/09/07
01/10/07
21/10/07
11/11/07
02/12/07
23/12/07
13/01/08
02/02/08
23/02/08
15/03/08
05/04/08
26/04/08
16/05/08
06/06/08
27/06/08
18/07/08
NOx as NO2
DINAMA Standard


SO2 - hourly average
DINAMA Standard - daily average125 µg/Nm 3 (95% of time) y 365 µg/Nm3 (no more than once a year)
µg/m3
350,0
300,0
250,0
200,0
150,0
100,0
50,0
0,0
Mill Start up
10/06/06
01/07/06
22/07/06
12/08/06
02/09/06
23/09/06
14/10/06
04/11/06
25/11/06
16/12/06
06/01/07
27/01/07
17/02/07
10/03/07
31/03/07
21/04/07
12/05/07
02/06/07
23/06/07
14/07/07
04/08/07
25/08/07
15/09/07
06/10/07
27/10/07
17/11/07
08/12/07
29/12/07
19/01/08
09/02/08
01/03/08
22/03/08
12/04/08
03/05/08
24/05/08
14/06/08
05/07/08
26/07/08
SO2
DINAMA Standard: 95% of time
DINAMA Standard: no more than once a year



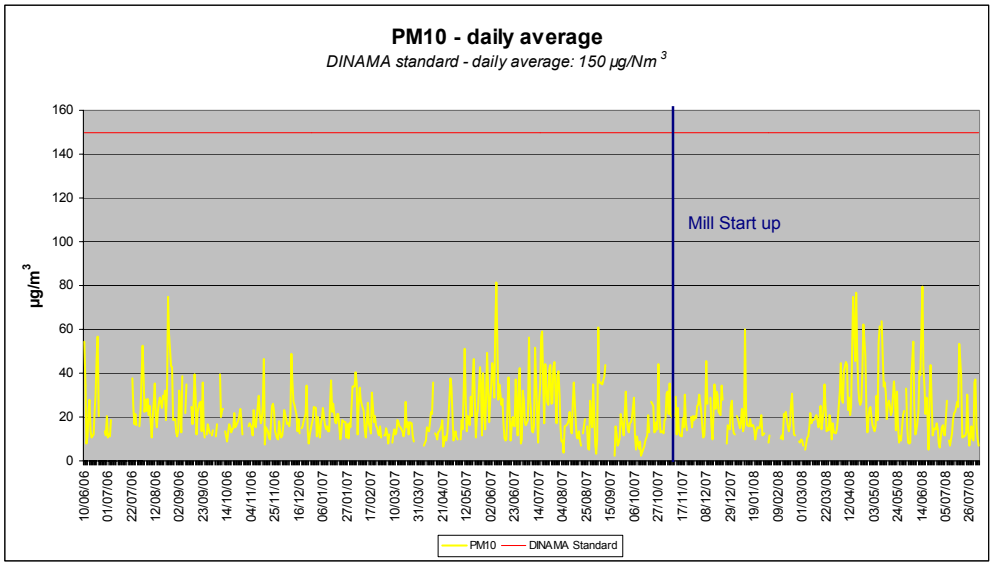


Figure 17. Quality of the air near Fray Bentos city

Air near Fray Bentos city is considered of high quality since the concentration of most indicator parameters are below the ambient air objectives specified by DINAMA, including CO, NO_x, SO_2, PM_{10}, TSP.

Only parameter that exceeded quality objective was TRS during April 2008. However these events cannot be attributed to the mill since mill emissions at that time were low and well within CIS projected range for normal operations. During that period, smoke coming from widespread fires at Río Paraná of Argentina was extended over Fray Bentos vicinity. Fray Bentos residents detected two odours events during November. CIS projected 10 odours events during first year of operation.

According to studies, slight variations in air quality near Fray Bentos between the periods pre and post start up are within the range of natural variability. The water quality shows similar parameters upstream and downstream of the mill.

Monitoring of mill operations

The control of the environmental aspects is an integral part of the operation and performance of the pulp mill. Environmental impacts are controlled as part of the production activities and are considered

in operational descriptions and instruction works. In the following graphs it can be seen the monitoring data reflecting mill's operation.

Monitoring of effluent to Río Uruguay

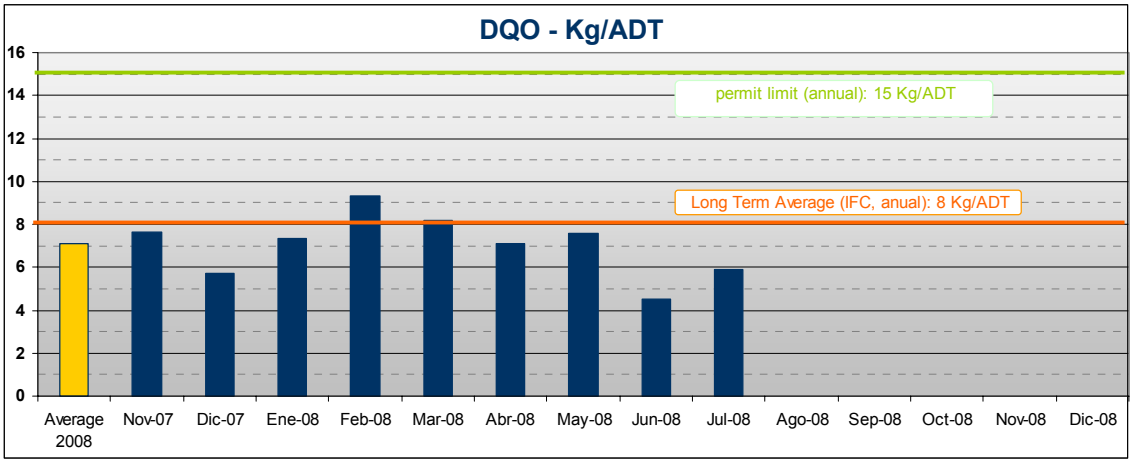
The following values are measured from the mill effluent discharge to the river after the biological effluent treatment process.
There are two ways of measuring particular values indicated in the environmental permits of pulp mills. Some indicators are measured both by discharged kilograms per produced ton of pulp and by total discharged kilograms per day. The permit for the Fray Bentos mill includes limits for both values.

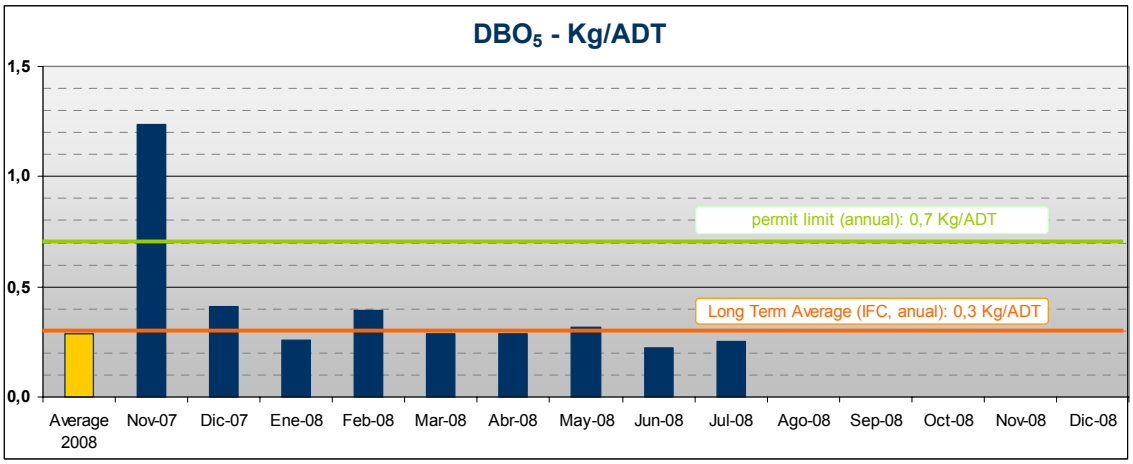
In the following graphs long term average (LTA) values estimated for mill emissions by the consultants of IFC are presented. These values correspond to internal targets for Fray Bentos pulp mill to be reached in about 3 years after start up; actual results for any given year can be higher, but should be near the estimated values when using longer averaging times. They are close to or even below the lowest values recommendations of BAT. As it can be seen from the graphs, after 8 months of operation, mill is closely reaching these LTA values for almost all effluent parameters. Table 3 shows BAT recommendation ranges and LTA values for effluent parameters.

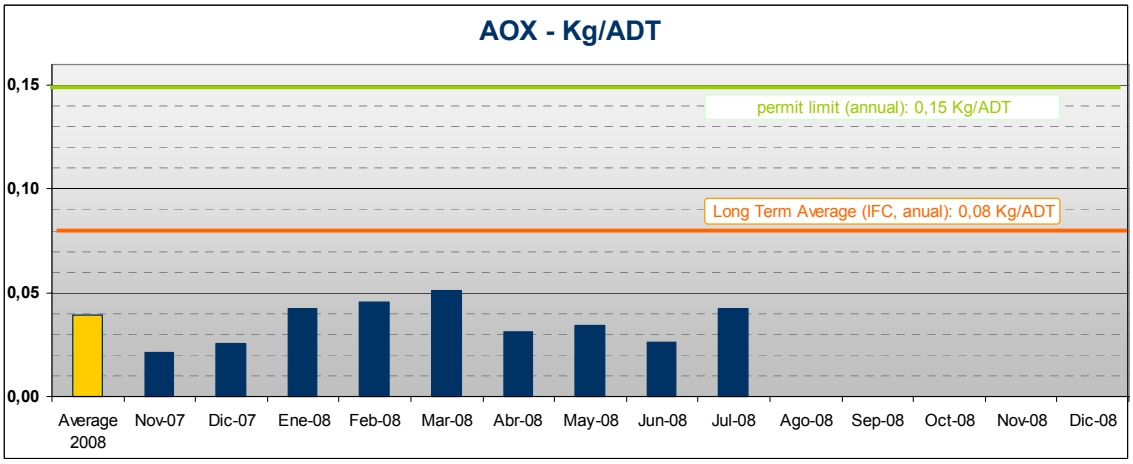
Table 3. Average effluent parameters

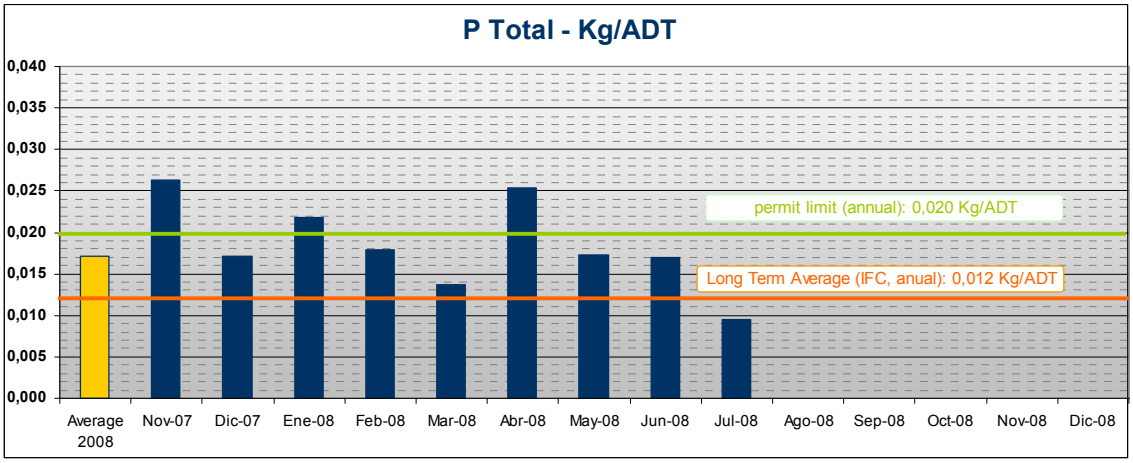
Parameter	Units	LTA	Fray Bentos[1]
COD	kg/ADt	8	7
BOD	kg/ADt	0,3	0,3
TSS	kg/ADt	0,7	0,65
AOX	kg/ADt	0,08	0,04
Total P	kg/ADt	0,012	0,013
Total N	kg/ADt	0,15	0,08
Flow	m3/ADt	25	30

[1] Averages for 2008, until July 31st.




DBO5 - Kg/ADT
1,5
1,0
0,5
0,0
permit limit (annual): 0,7 Kg/ADT
Long Term Average (IFC, anual): 0,3 Kg/ADT
Average 2008
Nov-07
Dic-07
Ene-08
Feb-08
Mar-08
Abr-08
May-08
Jun-08
Jul-08
Ago-08
Sep-08
Oct-08
Nov-08
Dic-08


AOX - Kg/ADT
0,15
0,10
0,05
0,00
permit limit (annual): 0,15 Kg/ADT
Long Term Average (IFC, anual): 0,08 Kg/ADT
Average 2008
Nov-07
Dic-07
Ene-08
Feb-08
Mar-08
Abr-08
May-08
Jun-08
Jul-08
Ago-08
Sep-08
Oct-08
Nov-08
Dic-08


P Total - Kg/ADT
0,040
0,035
0,030
0,025
0,020
0,015
0,010
0,005
0,000
permit limit (annual): 0,020 Kg/ADT
Long Term Average (IFC, anual): 0,012 Kg/ADT
Average 2008
Nov-07
Dic-07
Ene-08
Feb-08
Mar-08
Abr-08
May-08
Jun-08
Jul-08
Ago-08
Sep-08
Oct-08
Nov-08
Dic-08

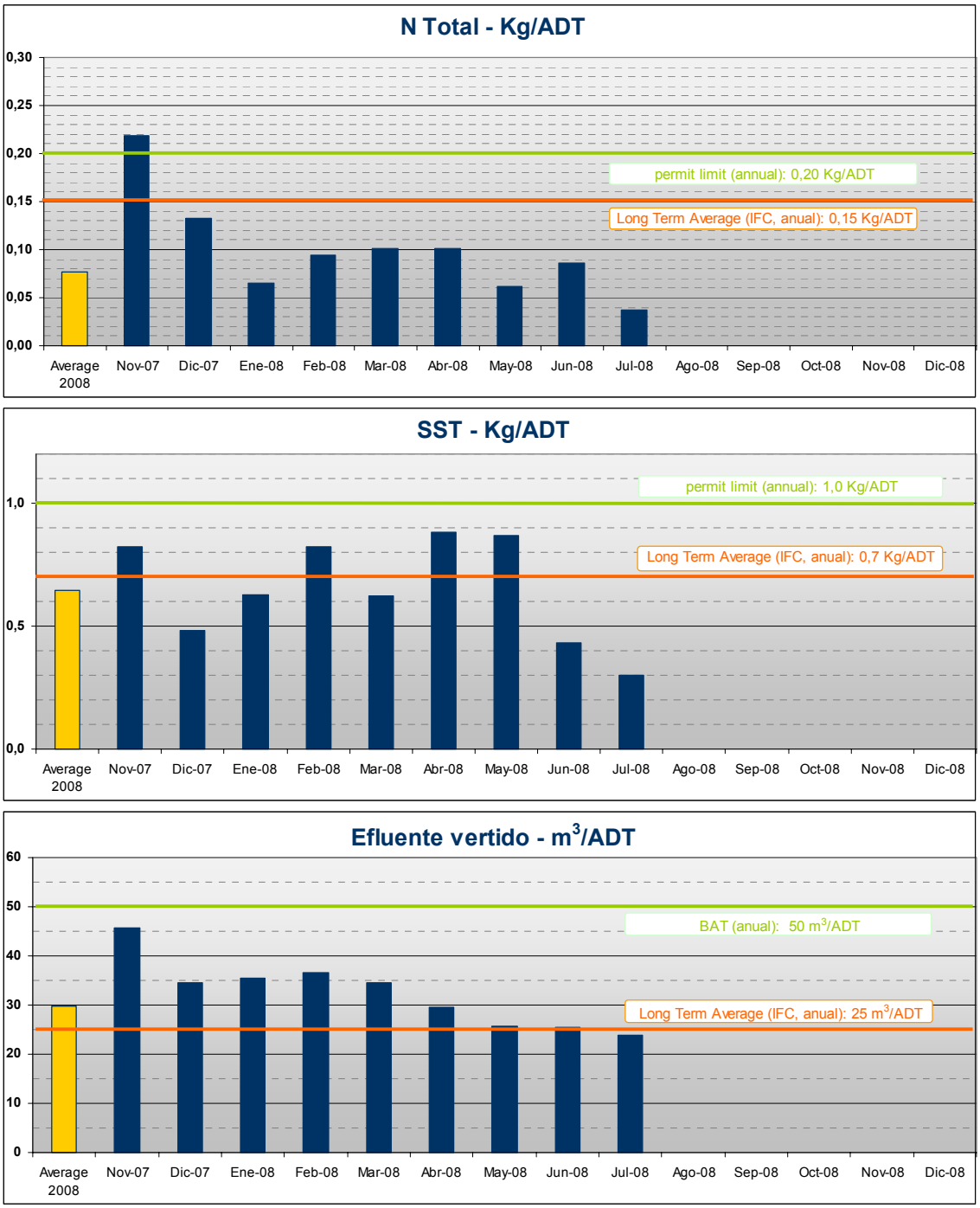


Figure 18. Mill effluent discharge to the river

The average discharge rate over the first 8 months of operation was 30m^3/ADt in comparison with 25m^3/ADt as CIS predicted. However, discharge average rate is still below the lowest values of BAT recommendations.

As it was said before, the mill has complied with the maximum concentration average annual limits specified by DINAMA and monthly maximum load limit.

P figures averages are both under permit (annual ton/ADt and monthly ton/d); as expected, discharge to the river is still higher than LTA values due to biological treatment start up phase. Improvements on biosludge treatment systems have been done reducing solids content at aeration basins which lead to P reduction to the river as well.

Monitoring of emissions to the air

The following values are measured from mill's stack. Air emissions indicators are measured by percentage of operating time over specified limits. DINAMA permit for the Fray Bentos mill is 10% of operating time over limits.

As it can be seen from the following graphs, after 8 months of operation,air emissions from the mill have remained well within the allowable permit issued by DINAMA and the tendency of total charges per ton of pulp is to decrease and improve over the months. Air emissions are expected to improve as the production of the mill increases to full capacity, and specially NO_x load due to optimization of the recovery boiler and lime kiln burning, which usually takes two years based on the experience with other similar modern mills.
In the following table DINAMA limits specification is presented.

Table 4. DINAMA air emissions limits specification.

Parameter	Units	DINAMA
Dust	mg/Nm^3	150
SO_2	$mgSO_2/Nm^3$	500
NO_x[1]	$mgNO_2/Nm^3$	300
TRS[2] Recovery Boiler	mgH_2S/Nm^3	10
TRS[2] Lime Kiln	mgH_2S/Nm^3	20

[1] NO_x emissions expressed as NO_2.
[2] TRS emissions expressed as H_2S

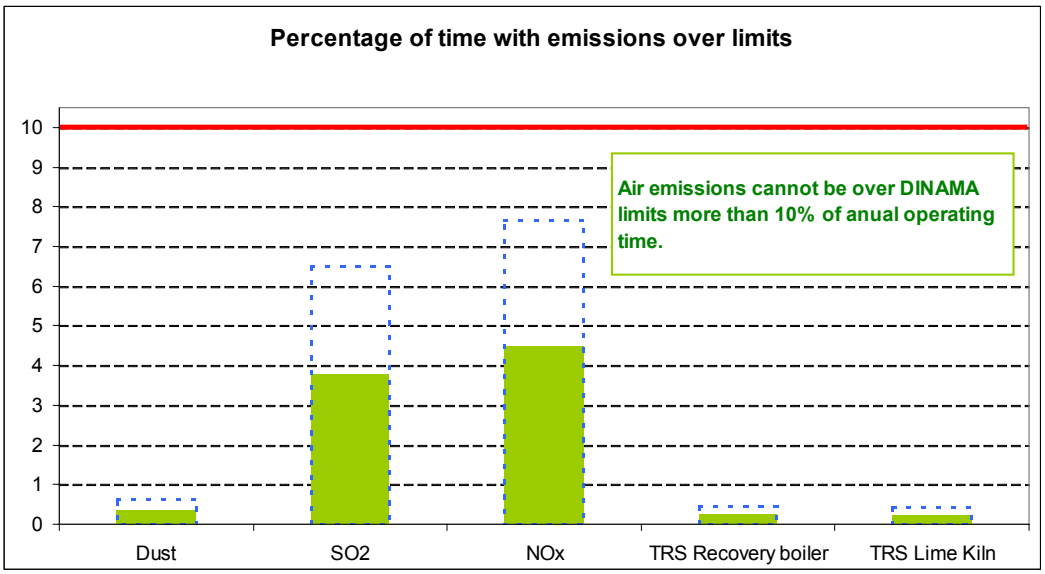


Figure 19. Percentage of time with emissions over limits

SUMMARY AND CONCLUSIONS

Botnia Fray Bentos pulp mill fiberline and recovery processes and mill experiences during the first year of operation were described.

Design production was reached in world record time and quality was prime soon after the start up. Fiberline operation problems during the first months were related to chips feeding and brownstock screening, while recovery operation problems related to concentration of non process elements in the cycle, especially calcium.

Environmental performance of the mill has been equal or even better than expected from the project phase. After 8 month of operation, the mill already reached some of the long term average values of emissions forecasted for 3 years after the start up.

Therefore, it can be considered that mill start up and first year of operation has been really successful from production, pulp quality and environmental point of view.

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