Letter to the Editor: The pollution load caused by ECF Kraft Mills, Botnia-Uruguay: first six months of operation

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Abstract: The pollution load caused by Kraft Mills with and without bleaching is analysed. Particularly, the mill emissions of Botnia Fray Bentos S.A. over the first six months of operation are reviewed just as they are presented by the EcoMetrix report dated July 2008, at the request of the International Finance Corporation, World Bank. Regardless of the opinions expressed there, from the numerical values it is absolutely clear that Botnia has discharged great quantities of solid, liquid and gaseous dangerous pollutants into the Uruguay River and into the atmosphere. This pollution load, according to the background known, will cause serious and irreversible damage to the flora, fauna and health of the inhabitants of the basin within a few years.

Keywords: Kraft process; ECF/TCF bleaching; environment; pollution load; bioaccumulative compounds; Botnia-Uruguay.

Reference to this paper should be made as follows: Matta, E.J. (2009) 'The pollution load caused by ECF Kraft Mills, Botnia-Uruguay: first six months of operation, *Int. J. Environment and Health*, Vol. 3, No. 2, pp.139–174.

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1 Introduction

Some years ago, powerful transnational companies started building the new 21st century factories in the tropical and subtropical areas of our planet, far from their countries of origin. Mega forestry and industrial enterprises to produce market pulp aimed at supplying raw materials to the paper machinery of the USA, People's Republic of China and the European Union. The product is always the same: cellulosic chemical pulp 90–92% brightness, industrially known as Elemental Chlorine Free Bleached Kraft Pulp (ECF-BKP).

All the projects were greenfield mills, and according to the current trend in the industry regarding the size of modules for future mills, they were designed with a capacity of 1.3–1.5 million air dry metric tons a year (ADMt/year) or above. Each of them required 140,000–200,000 hectares of eucalyptus forest in full exploitation exclusively aimed at producing pulp. One of these carefully chosen sites is the South American Cone, in the territories belonging to the Brazil Republic, the Eastern Republic of Uruguay (hereinafter Uruguay), the Chile Republic and the Argentine Republic (hereinafter Argentina).

The installation of these projects has undoubtedly an economic connotation, based on the growing demand for cellulose and paper worldwide (Lindstrom, 2008; MacLeod, 2008). The existence of inexpensive lands to grow eucalyptus, of an extraordinary yield in these countries, a great availability of freshwater, cheap workforce and other comparative advantages are economic factors (Grafström, 2005; Grafström, 2007).

However, there may be a second interpretation regarding the South Cone and these modern factories: each and every project contaminates at a large scale, and they could not be set up anywhere in the world where there are strict environmental laws which are enforced without concessions. Unfortunately, in Latin America, there are no operative regulations which in case of conflict could establish an effective limitation. Conditions are very different in Europe and North America. Europe has three important instruments that were already implemented in the past. These are the Convention on Long-range Transboundary Air Pollution, the Convention on Environmental Impact Assessment in a Transboundary Context (United Nations Economic Commission for Europe, UNECE) and the Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Convention Aarhus of 1998) (Council of the European Union, 2008; UNECE, 2006; EU European Commission, 2004). In North America, the 1994 North American Free Trade Agreement (NAFTA) incorporated all the legislation on Transboundary Pollution, which also has a long history in solving conflicts, particularly between the USA and Canada (UNEP, 1998; NAFTA, 2008a; NAFTA, 2008b). Would these mega-projects be allowed to be located in Europe or North America? Would they be authorised to operate close to border rivers, or to discharge in freshwater sources?

Until 2007, Uruguay owned a single cellulose manufacturing mill of 180,000 ADMt/year. At present, the country has already authorised the installation of two huge mills for the production of cellulosic Kraft pulp from eucalyptus, bleached with chlorine dioxide (Elemental Chlorine Free Bleached Eucalyptus Kraft Pulp, ECF-BEKP), for a total 2.0–2.5 million ADMt/year. An indefinite number of similar mills are still subject to the official position.

In 2005, the installation of the two mills mentioned above in the territory of Uruguay on the Uruguay River generated a serious institutional and social conflict with Argentina, that has filed the case before the International Court of Justice (United Nations) as a claim against environmental pollution and the violations of the Bilateral Statute regulating most issues concerning this frontier river (ICJ, 2006a; ICJ, 2006b). So far, the Court has not issued an order.

The first approved project, corresponding to the Spanish company Ence S.A. (Ence), considered the riverbanks of the Uruguay River its original point of settlement. This location is approximately 10 km from the Uruguayan city of Fray Bentos. As a result of the negotiations between the company and the governments of Argentina and Uruguay, the firm started construction works in Punta Pereyra, Uruguay, on the northern end of the Río de la Plata, at the mouth of Uruguay River, 30 km from the Paraná delta and only at 45 km from Buenos Aires, the capital city of Argentina. Originally designed for 500,000 ADMt/year, the mill will produce 1.3–1.5 million ADMt/year on its new location.

The second project, Orión, by Botnia Fray Bentos S.A. (Botnia or Botnia-Orion), producing 1 million ADMt/year has been in operation since November 2007, in spite of the fact that, as it was mentioned before, the order to be issued by the International Court of Justice (United Nations) is pending, and this might demand the disassembling of the mill. Botnia is a subsidiary of Oy Metsä-Botnia Ab, a Finnish company owning forestations and five mills in Finland.

Botnia-Orión is located by the Uruguay River (33°06´53"S, 58°15´30"W), downstream from the international bridge that links Fray Bentos (Uruguay) and Puerto Unzué (Argentina), less than 4 km from Fray Bentos (Figure 1 and Figure 2). On the Argentinian side, the riverbank is less than 2 km away and Gualeguaychú is at only 25 km. This city has a population of 90,000 inhabitants and it is the main city of an important rural area devoted to producing foods (farming and cattle raising). All the area and the river itself are an important tourist site.

Figure 1 Botnia Fray Bentos Kraft Mill (Uruguay) seen from the Argentina-Uruguay International Bridge

Scale: The main chimney (120 m tall) is a good reference.
Courtesy: Norberto Guruciaga (Argentina).

Figure 2 Uruguayan Kraft Mills location

Courtesy: Original image from NASA World Wind.

Before the Ence project was relocated, the distance Botnia-Ence was barely 5–6 km. Other companies interested in setting up market-pulp Kraft mills, some of which do already own lands and forests in Uruguay, are Stora-Enso (Finland-Sweden), International Paper (USA), Nippon Paper (Japan), Portucel (Portugal) and Tapebicua, a multinational company controlling forests and several mills in Argentina and Uruguay (Helsingin Sanomat, 2007; PPI, 2007; Ministerio de Defensa Nacional, 2008; Presidencia, 2008; US Commercial Service, 2008).

In principle, the economically suitable areas for forestation and the installation of mills in Uruguay would be limited to three. The most important two, about 70,000 km^2 (40% of the area of the country) are located on the riverbank of the Uruguay River and in the Negro River valley. The latter flows into the Uruguay River, at only 50 km from Fray Bentos. The third zone, much smaller, is located in the north of the country, on the Atlantic coast. Therefore, the possibilities of new mega-mills coming to the valley of the lower Uruguay River are high.

In the following lines we will deal briefly with the environmental characteristics of these enterprises in general and the case of Botnia-Orión in particular (Figure 1 and Figure 2), considering that the World Bank has recently issued a document in an attempt to explain the 'environmental performance' of the mill in its first six months of operation (EcoMetrix, 2008).

A Glossary of terms and abbreviations is included at the end, aimed at providing assistance as to an accurate interpretation of this paper.

2 Kraft mills environmental profile

2.1 Producing Kraft pulp involves a very serious responsibility

Bleached Kraft cellulosic mills are chemical plants where the only harmless elements are the incoming pulpwood and the outcoming cellulose. The whole process along the fibre line, from the impregnation of the chips to the pulp bleaching, is a sequence of unit operations environmentally dangerous, where there are permanent emissions (controlled or uncontrolled) and manipulation of risky chemicals. The same applies to the recovery line (burning of waste and recovery of inorganic compounds) and the satellite plants, which produce the main bleaching supplies such as oxygen (O_2), hydrogen peroxide (H_2O_2), sodium chlorate (ClO_3Na_2) and chlorine dioxide (ClO_2). Even the management of primary and secondary treatment of effluents produces uncontrolled, environmentally harmful emissions and consumes tonne of chemicals.

The entire chemical complex requires not less than 22–25 chemical supplies (Abrams, 1996; EcoMetrix, 2007), most of which are exceptionally hazardous and must be transported to the plant and manipulated at the mill. The process also generates a dozen of harmful by-products, and a very long list of contaminants is created by undesirable reactions, mainly during the Kraft process, bleaching and combustion (CEPA, 1991; Uloth and van Heek, 2002; U.S. EPA, 2006).

These mills are of the continuous process type. They operate 340–350 days a year, 24 h a day. Their useful life is 40 years or over. Since they produce continuously, the main emission of pollutants is also continuous. Sporadic emissions should neither be neglected nor minimised: they can be generated during operative incidents or they may be accidental. The incidents in these two latter categories are rare in well-designed and maintained mills, but can be catastrophic for the river.

The current technological level cannot avoid that Kraft mills, with or without bleaching, continuously release these compounds of a well-known risk and toxicity to all living organisms. It is a known fact that the emission of toxics is directly proportional to the level of production, regardless of the fact that the ratio pollutant/production (kg/ADMt) may improve from mill to mill and in the same mill, as the parameters of the process are adjusted (Veracel, 2006). In the case of mega-mills like Botnia, dimensions also magnify the sporadic emissions, and increase accidental risks (U.S. EPA, 1997; Furley et al., 2001; Pasanen, 2003; Toland, 2005; Raverty, 2007).

As to the environmental impact of these mills, scientific expertise of over 30 years has highlighted the fundamental role of the pollution load discharged into the receptor (Scott Huff et al., 1976; Marmorek et al., 1992; Sandström, 1996; Solomon, 1996; Farmer, 1997; Aucott et al., 1999; Ali and Sreekrishnan, 2001; Helsinki Commission, 2004a; Helsinki Commission, 2004b; Jawjit et al., 2006; McMaster et al., 2006; OECD, 2006; U.S. EPA, 2006; Helsinki Commission, 2007; IDRC, 2007) (see also Section 2.4). The concept encompasses the quantity and toxicity of emissions, but also the synergistic effect of the combination of the several toxics, concomitant factors (i.e. BOD-water temperature) and the relative quantity of persistent bioaccumulative substances (U.S. EPA, 2006; Tiku et al., 2007; U.S. EPA, 2008). It is a fact, generally ignored in regulations, that the pollution load thrives, adds and accumulates contaminants from other emission sources, especially the closest ones (NIAR, 2001; Cohen, 2007; U.S. NPCA, 2008). Even though atmospheric depositions of a large scope must be added, these account so far for only a minor percentage in this part of the planet (UNECE, 2007).

Stating that this type of mill 'complies with the best regulations' is unacceptable. Standards are merely norms established by the political power to maintain certain order and control over emissions, without seriously affecting the economic system, applying the criterion of 'environmentally reasonable costs' (Harrison, 1996; Ederington and Minier, 2003; Copeland and Scott, 2004; Graya and Shadbegia, 2004; U.S. NPCA, 2008). No standard is good enough while it does not avoid the degradation of nature and the health of human beings.

The regulation for the Pulp and Paper Industry already established or to be set up in the European Union, in particular for Kraft mills, constitutes a typical and paradigmatic case. In 1996, the European Union adopted common basic standards for industrial activities, the Integrated Pollution Prevention and Control (IPPC), known as the IPPC Directive. The IPPC issued for each industrial sector the Document Reference or BREF, which includes regulations to design plants (BAT or Best Available Techniques) and also limits for emissions regarding a basic list of pollutants.

The BREF for the Pulp and Paper Industry was published in 2001. As it can be found in the web page of the European IPPC Bureau, the Reference Document was written by a forum, which '…consists of representatives from Member States, industry and environmental non-governmental organisations. Each sector of work is addressed by a specific Technical Working Group' (E.U. EIPPCB, 2001).

Beyond the recommendations on the processes and technologies to be used (BAT), finally the only restriction to the emission in this BREF is just limiting the amount of the compound per tonne produced (kg/ADMt). Considering that the production of each mill is not conditioned, and that the number of mills discharging into a given ecosystem is not defined (E.U. EIPPCB, 2001), the regulation does not restrict the pollution load in a particular environment. The fact that most mega-mills and mega-projects claim to comply with the BREF is not a mere coincidence. Botnia and Ence in Uruguay (Malcom Pirnie, 2005; Toven, 2005), Veracel in Brazil (EIB, 2004) and Gunns in Tasmania (SWECO PIC, 2007). Other projects are not so intrepid, but claim to use 'state-of-the-art technology' as Arauco Valdivia in Chile (PPI, 2005), or the 'state-of-the-art industrial technology and effluent treatment' as Suzano Mucuri in Brazil (Suzano, 2008) and 'strict… environmental standard' like Hainan Jinhai in APP China (PPI, 2006).

2.2 Emissions into the atmosphere

Knowledge on distribution and deposition of the pollutants released into the atmosphere indicates that, very particularly for stationary emission sources like Kraft mills, most contaminants deposit and accumulate around the source, decreasing exponentially with the distance. Most are found within a radius of 20–30 km. Part of the remaining material spreads up to 50–70 km, according to local conditions. Possibly 8–12% out of the total quantity may become aerosols, affecting the entire region at the climatic level (Yoshida et al., 2001; Nilsson et al., 2003; Olson et al., 2004; Gilliam et al., 2005a; Gilliam et al., 2005b; Aiuppa et al., 2006; Stenchikov et al., 2006; Cohen, 2007).

There are two factors controlling this behaviour in Kraft mills, rendering them distinctive from most industrial releases. The first factor is the pollutants deposition in the form of liquid particles (wet deposition), independently from the rain (Aiuppa et al., 2003; Saïda et al., 2005). This phenomenon is magnified by the high moisture content in combustion gases (up to 10% of water on leaving the chimney) (Green and Hough, 1992; Adams et al., 1997) and the significant uncontrolled emissions at ground level (up to 10 metres high), including a mixture of air and water from cooling systems (Figure 3). The second factor is the deposition of solid particles by gravity (dry deposition), originated in the combustion systems, particularly in the recovery boiler. The amount of particles is important, even under normal conditions of operation, and includes particulate matter smaller than 20 microns, mainly PM_{10} and $PM_{2.5}$ (Cardoso and Zarrebini, 2001; Nadim et al., 2001; Ohlström et al., 2006). The 'dry deposition' of particulate matter must not be confused with the phenomenon bearing the same name used by the specialists in dry atmospheric deposition of toxic pollutants, generally used to describe the transference of gaseous pollutants to the ground, mostly by the absorption of gases on surface water (Cohen et al., 1997; Cohen, 2001). In a broad sense, deposition of solid particles by gravity is also included in the concept of atmospheric deposition, but this is not the case for particles $PM_{2.5}$, PM_{10} or over, discharged by a Kraft mill.

Figure 3 Botnia Fray Bentos Kraft Mill (Uruguay) seen from the middle of the Uruguay River

A normal autumn-winter day in 2008, with a relatively high dew temperature

Courtesy: Norberto Guruciaga (Argentina).

In brief, pollutants released into the atmosphere are deposited and accumulated through three basic mechanisms: absorption in moisture drops which are subsequently deposited (including gases such as SH_2, SO_2 and others) (Kerminen et al., 2000; Nadim et al., 2001; Ye et al., 2007); deposition by gravity of solid particles and dry atmospheric deposition for the gaseous phase that was not absorbed by humidity nor adsorbed on the surface of solid particles. It is important to notice that many pollutants are partially or totally insoluble in water. Given the high relative humidity of gases, the adsorption phenomenon on the solid surface of this fraction is enhanced, even before leaving the chimney. As a result, the pollutant load carried by PM_{10} and $PM_{2.5}$ becomes important here (Spillane and Elsum, 1983; Schatzmann and Policastro, 1984; Bidleman, 1988; Presottoa et al., 2005; Briois et al., 2007).

2.3 The behaviour of pollutants in the river

There are two main issues to highlight regarding Botnia and its geographical location. Firstly, since the Uruguay River presents a very soft slope, the astronomical tides and the winds affecting the Rio de la Plata force the waters of the Uruguay River to stop its North-South-bound flow and eventually flow in reverse. This truly ‘reverse flow’ can carry the whole mass of water along over 30–40 km in the South-North direction. The result is that a great quantity of sediment and fine sand carried by the river normally end up on the low Argentinian river banks, constituted by beaches and large wetlands. This is a historical phenomenon, and it is visible to the naked eye. Secondly, all the pollutants partially or totally insoluble in water entering the river in a way or another end up in adsorption on organic or inorganic particles (surfaces), which cluster in ‘flocs’ suspended in water or deposited in the bottom sediment.

The effect of both phenomena is an important quantity of pollutants accumulating on the Argentinian river bank.

According to these experiences, all the emissions (effluent and emissions into the atmosphere) from Botnia Fray Bentos will cause serious transboundary pollution load starting from the Uruguay River, but also inland, polluting cities, crop fields, wetlands, grasslands and areas for cattle to drink water in the Argentinian territory. Given that an important part of the pollutants are persistent and bioaccumulative as it can be seen below, on the medium and long term all the food chain of the region will be affected.

2.4 The current site of Botnia

The lower Uruguay River basin is one of the most beautiful and biologically diverse ecosystems of our planet (Zaniboni Filho and Schulz, 2003; Valencia, 2004). Botnia has never shown any scientific-technical research or submitted a credible technological support to guarantee not affecting seriously and irreversibly this ecosystem. The company, merely sustained on its compliance with international regulations, never made a serious study of emissions and their possible impacts. Unfortunately, the World Bank and some European organisations have supported this criterion (OECD Watch, 2006; Swedish NCP, 2006; Análisis, 2007; EcoMetrix, 2007). Apparently, none of them is seriously concerned about the long-term effects on the environment. However, the scientists knows very well which are the resulting effects, when the pollution load largely exceeds the limits of an ecosystem (Marmorek et al., 1992; Gomez, 1999; Kautsky and Kautsky, 2000; Thornton, 2000; U.S. EPA, 2001; Marttunen and Hellsten, 2003; Nilsson et al., 2003; Helsinki Commission, 2004a; Helsinki Commission, 2004b; Karasov et al., 2005; Santucci et al., 2005; McMaster et al., 2006).

Disturbing questions remain unanswered: What will be the impact of Botnia’s operation after 15–20 years? What will be the magnitude of the cumulative effects of Botnia, Ence and a third mill of similar dimensions? The figures shown in the following sections certainly do not answer the questions but just increase the concern.

3 EcoMetrix report, July 2008

In early July 2008, the *International Finance Corporation (IFC, World Bank)* issued a report requested to EcoMetrix (Canada). It was an 'environmental performance' assessment of the first six months of operation of Botnia-Orion (EcoMetrix, 2008).

Like other reports requested by the World Bank to study the Orion and Ence Project (Malcom Pirnie, 2005; EcoMetrix, 2006) (see also Section 3.3.2), the evaluation is intentionally biased in its definitions and technically inadequate, both in data quality and use. It has omissions and hides information of the outmost importance. Nevertheless, analysing the report is relevant. It is the first official report at the international level, recording Botnia emission values. *It is not the case, as in previous documents, of promises or prior estimations. They are values measured and officially disclosed by Botnia and the Uruguay government.*

Beyond EcoMetrix words and conclusions, which optimistically mentions *"... everything indicates that the mill is performing to the high environmental standards predicted…, and in compliance with Uruguayan and IFC standards"* (EcoMetrix, 2008), the severe transboundary pollution load generated by the mill, emerge convincingly as a result of the same figures included in this report.

There follows an analysis mainly of the data stated about the quality of liquid effluent and those, extremely scant, related to emissions to the atmosphere. They are the best and most reliable information available in the report. As it is said there, they were measured directly by Botnia or by the official high complexity laboratory subsidised by the company, the 'Laboratorio Tecnológico del Uruguay' (LATU), Uruguay's technological laboratory.

EcoMetrix has also attempted to assess the environmental conditions by means of some measurements made by the national environmental agency of Uruguay (DINAMA, according to its initials in Spanish) and other official organisations, as mentioned in EcoMetrix report: atmospheric air determinations, at different points, not less than 1500 m distant from the emissions source; water measurements at various locations in the Uruguay River, most of them 1500 to 6000 m distant from the effluent pipe (diffuser or emissary) that spreads out this flow into the stream (Botnia, 2008). As it will be briefly explained, the results of this environmental monitoring are not important; on the contrary, the assessment is only a great simplification of the problem, lacking in scientific and technical validity.

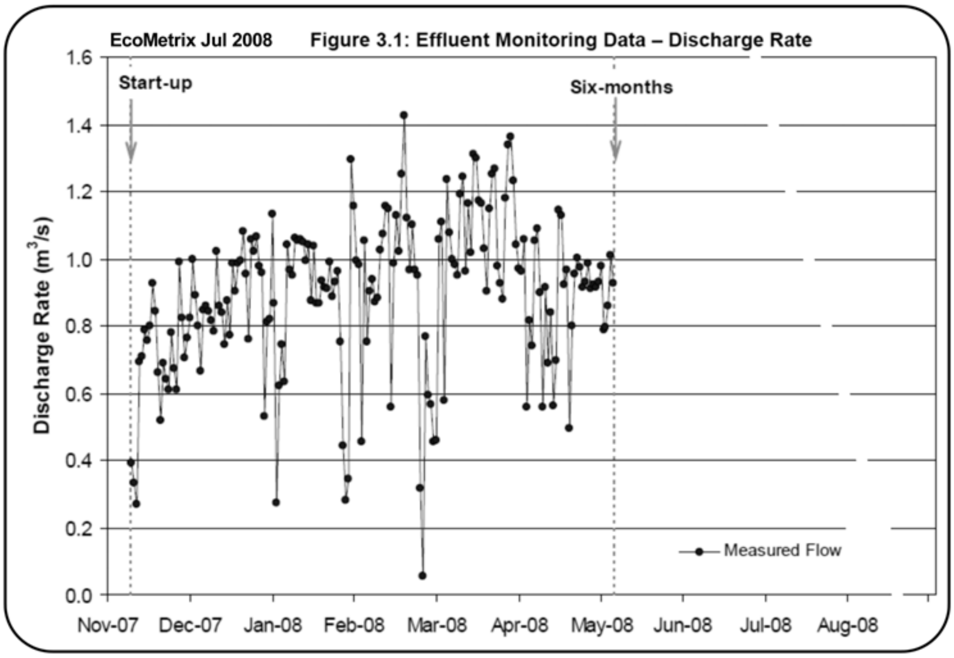
3.1 Fundamental data

The report covers the time period from 10 November 2007 (the official mill start-up date) up to 10 May 2008 (EcoMetrix, 2008). It is a 180-day period during which Botnia produced around 405,000 ADMt of pulp. Table 2.1 given by EcoMetrix (not shown here) displays the daily average production for each of the six months; the semi-annual average results in 2113 ADMt/day, which leads to a total production slightly above 380,000 ADMt. The difference between this calculation and the 405,000 ADMt mentioned by EcoMetrix indicates that in these cases the use of statistic data is less accurate than the cumulative values.

This poses the problem of calculating the flow of the effluent dumped by Botnia over the semester. The report mentions a semi-annual average of 0.86 m^3/sec (3096 m^3/h), which results in a total of 13,374,720 m^3, discharged during the period of six months.

The evolution of the effluent during this period, presented by EcoMetrix, is reproduced here as Figure 4. Working with Image Analysis Tools, a very precise way to measure the area under the points and lines in Figure 4 in detail, it is possible to calculate the cumulative volume from the figure, which results in about 15,400,000 m^3. Even if every possible error is taken into account (roughly 3%) a very significant difference of 2 million m^3, around 15%, still remains.

Figure 4 Botnia effluent discharge rate. First six-months of operation



These figures are very important because the total effluent volume, together with the contaminant concentration values, should be used to calculate the quantity of each pollutant discharged, in tonne, in the absence of better information.

Botnia and EcoMetrix *should have informed* the accumulated volume over the semester, not a mere average. A mill of these characteristics *should measure continuously* (and it surely does) not only effluent flow, but also the several related parameters, at least temperature, pH and conductivity.

Table 1 shows the six-month production and average daily design production or 'reference' according to EcoMetrix. The remaining data are inferred by simple calculation. As it can be seen from the figures, during the first six months Botnia would have operated on average at 81% of the design level. This value is highly unusual for a mill start-up and inconsistent with those stated in by EcoMetrix in Table 2.1 (not shown here).

Table 1 Botnia Mill production. First six months of operation

Category	Daily Average	Monthly Average	Six Months Production	Production Level Design Based
Units	ADMt/day	ADMt/month	ADMt	%
Six Months Production	2,250	67,500	405,000	81.0
Design Production	2,857	85,710	499,975	100.0

The inconsistency of these data contributed on production persists even if pulp out of specification is included into the mentioned tonnage. Usually, pulp ‘out of specification’ are the pulp not reaching the suitable ‘white’ (brightness) level, pulp not bleached at all, or within the latter, lots with a different degree of cooking or delignification, including abnormal quantities of small shives. The inconsistency of the production data and the lack of credibility are not exclusively caused by the differences mentioned above, but the irregular operation of the mill, usual in all start-up period should also be considered. Figure 4 shows this irregular running very clearly. With a few hours of effluent flow retention between the process and the effluent treatment, the total or partial halts in the fibre line are more than obvious.

In the following sections other inconsistencies and also serious omissions and mistakes will be mentioned, but the low credibility about production and effluent volume are crucial. They indicate the contrast between what is produced and what is wasted in the process. The actual level of the given information and the intentionality along the report are also seen.

3.2 About liquid effluents

Table 3.1 presented by EcoMetrix, shown in Figure 5, summarises most of quality parameters on the final effluent. In order to give the reader a clearer vision of the information presented by EcoMetrix and to show exactly what is being calculated, Tables 2 to 8 includes an exact copy of Figure 5, but grouped by pollutants. Moreover, the procedure seeks to emphasise the importance of each group of compounds on the total pollution load.

The calculated discharge values for a semester (in tonne) are included in the adjacent columns when applicable. In spite of the lack of confidence mentioned before, regarding the average effluent flow presented by Ecometrix for the semester, the value used to calculate discharge was 13,374,720 m^3 and not a larger one.

3.2.1 Some physical parameters

Table 2, which also includes part of EcoMetrix Table A-4, shows the great difference in conductivity between the effluent and river water: a semester average of 2644 μS/cm versus 103 μS/cm maximum. This value shows the great quantity of salts (electrolytes), which are present in the final effluent. The following sections will show these salts, which are and where they come from these compounds that raises so high the conductivity value of the effluent.

Figure 5 Botnia effluent quality. First six-months of operation

Summary of Effluent Quality during the First Six-Months of Operation

Parameters	Units	Effluent Quality (10 November 2007 to 10 May 2008)				
		n	Minimum	Maximum	Average	95th Percentile
Physical Indicators						
Temperature	°C	183	22.3	30.9	28.4	30.1
pH	-	183	6.9	7.9	7.4	7.6
Conductivity	µS/cm	183	180	4,336	2,644	3,669
Color	n.c.	181	300	1,750	650	1,400
Chemical oxygen demand	mg/L	181	90	490	224	354
Biochemical oxygen demand	mg/L	179	2.8	44.0	12.0	29.7
Suspended solids	mg/L	181	4	264	24	61
Nutrients						
Ammonia	mg/L	29	0.01	1.00	0.12	0.59
Nitrate	mg/L	28	0.01	4.60	1.15	3.55
Total nitgrogen	mg/L	26	1.32	7.57	3.42	6.91
Total phosphorus	mg/L	69	0.28	1.34	0.58	0.99
Metals						
Arsenic	mg/L	6	<0.01	<0.20	<0.14	-
Cadmium	mg/L	6	<0.01	<0.05	<0.04	-
Chrome	mg/L	6	<0.10	<0.20	<0.13	-
Copper	mg/L	6	<0.03	<0.50	<0.34	-
Iron	mg/L	6	<0.10	0.70	<0.40	-
Mercury	mg/L	6	<0.001	<0.005	<0.002	-
Sodium	mg/L	6	290	800	507	743
Nickel	mg/L	6	<0.05	<0.05	<0.05	-
Lead	mg/L	6	<0.01	<0.05	<0.04	-
Sulphur	mg/L	5	<0.10	<0.10	<0.10	-
Zinc	mg/L	6	<0.05	<0.30	<0.13	-
Other						
AOX	mg/L	20	0.02	1.72	1.08	1.69
Chlorophenols	µg/L	21	0.05	3.7	1.1	3.4
Phenols	µg/L	26	<1	91	19	45
Chlorate	mg/L	25	<0.10	109	18	86
Resin acids, total	mg/L	5	0.02	0.02	0.02	0.02
Detergents (LAS)	µg/L	5	14	31	18	15
Esteroles, total	µg/L	5	<1000	<1000	<1000	-
Fats	mg/L	5	<10	<10	<10	-
Cyanide	µg/L	6	<5	<5	<5	-
Fecal coliforms	ufc/100 ml	21	<18	4,900	292	230
2,3,7,8-TCDD	pg/L	3	<1	<1	<1	<1
2,3,7,8-TCDF (as TEQ)	pg/L	3	<1	<1	<1	<1

Source: From EcoMetrix Jul 2008, Table 3.1.

Table 2 Botnia effluents. Physical indicators

Parameters	Units	Effluent Quality (10 November 2007 to 10 May 2008)				
		n	Minimum	Maximum	Average	95th Percentile
Physical Indicators						
Temperature	°C	183	22.3	30.9	28.4	30.1
pH	-	183	6.9	7.9	7.4	7.6
Conductivity	µS/cm	183	180	4,336	2,644	3,669
Temperature	°C		18.0	30.0		
pH	-		7.2	8.9		
Conductivity	µS/cm		73.0	103.0 (1)		

Notes: Parameters, units and values are the exact copy of Table 3.1 of EcoMetrix report (shown in Figure 5).

(1) From the same report, Table A-4: Water Quality Observations by Botnia at Four Rio Uruguay Locations in 2005/2006 (not shown here).

3.2.2 Nutrients

Nutrients are used in the mill basically to maintain the microflora in the secondary treatment, even though ammonia and urea are also used in some chemical processes. In spite of the low concentrations found in the effluent, there are more than 70 tonne discharged into the river in a semester (Table 3), a factor that, without a doubt, will enhance the marked eutrophication currently exhibited by the Uruguay River.

Table 3 Botnia effluents. Nutrients

Parameters	Units	Effluent Quality (10 November 2007 to 10 May 2008) n	Minimum	Maximum	Average	95th Percentile	Discharges in the semester Mt
Nutrients							
Ammonia	mg/L	29	0.01	1.00	0.12	0.59	***1.6***
Nitrate	mg/L	28	0.01	4.60	1.15	3.55	***15.4***
Total nitgrogen	mg/L	26	1.32	7.57	3.42	6.91	***45.7***
Total phosphorus	mg/L	69	0.28	1.34	0.58	0.99	***7.8***
Nutrients, Total							***70.5***

Note: Parameters, units and concentration values are the exact copy of Table 3.1 of EcoMetrix report. (shown in Figure 5).

3.2.3 Organic load and dissolved oxygen demand

The oxygen demand measured in the effluent (Chemical Oxygen Demand, COD, and Biochemical Oxygen Demand five days, BOD_5,) is an appraisal of the amount of dissolved oxygen that the microflora will consume when pollutants reach the river. The total pollution load per tonne is vital – not the concentration in the water of the river (Table 4). If this load is excessive for the receptor, even when total anoxia would not be reached, it may cause severe damage to river biota. An increase in the temperature of water, a serious decrease in the river flow or a change in its flow regime, constitute critical impact factors, which can amplify their power in the presence of other pollutants, like nutrients that favour algae growth, which in turn consume oxygen and produce powerful toxins.

Table 4 Botnia effluents. Organic load

Parameters	Units	Effluent Quality (10 November 2007 to 10 May 2008) n	Minimum	Maximum	Average	95th Percentile	Discharges in the semester Mt
Chemical oxygen demand	mg/L	181	90	490	224	354	***2,996***
Biochemical oxygen demand	mg/L	179	2.8	44.0	12.0	29.7	***161***
COD/BOD5 Ratio					***18.7***		

Note: Parameters, units and concentration values are the exact copy of Table 3.1 of EcoMetrix report (shown in Figure 5).

Both COD and BOD_5 are indicators of the 'organic load' or 'total dissolved organic', which in the case of this effluent type is constituted basically by cellulose waste (hexosan), C5-sugars (pentosan) and lignin (phenyl propane), present as both monomers and chains of a few monomers. Some of them may be present as chlorinated-organic compounds, organic sulphur compounds or metal-organic compounds (Na-organic). The ratio COD/Organic Load is based on the simple total combustion reaction $C_xH_yO_z + n_1 O_2 > n_2 CO_2 + n_3 H_2O$. In the case of phenyl propane, the ratio is typically 3.4, but both for hexosan and pentosan it is barely higher than 1.

It is impossible to know beforehand, without a complete analysis of the final effluent (which EcoMetrix does not report), the real composition of dissolved organic matter. Most researchers use the ratio COD/TOC, where TOC is Total Organic Carbon. Some authors found this ratio to be as low as 0.92 and 0.85 (Shackford et al., 2006; Costa and Colodette, 2007), even 0.58 (Costa and Colodette, 2007). Other values were found to be as high as 2.6, but the same author also showed values of 1.4 (Yousefian, 2000). A representative value seems to be 2.0–2.4 (Cerqueira, 2006), though low values are related to bleaching effluents, the highest ones are related to the total effluent. It all depends on the balance in the effluent between sugars (hexosans and pentosans) and lignin waste, and how they respond to aerobic treatment.

Taking into account the variability and uncertainty on TOC and the ratio lignin/sugars, adopting COD as Organic Load seems simply unavoidable

Furthermore, seen from another point of view, which is the value that best represents the Organic Load in the Uruguay River, COD or BOD_5? Undoubtedly, *COD plus* BOD_5, considering that each determination represents a different group of biodegradable compounds in the final effluent.

The high ratio of $COD/BOD_5 = 18.7$ in Table 4 indicates that Botnia's secondary treatment is especially efficient in BOD_5 reduction, but possibly not so good in COD reduction. The other option, the presence of an exceptionally large fraction of bio-refractory (recalcitrant) organic matter in the final effluent does not match previous experiences, where COD/BOD_5 ratios are not higher than 3–6. In some cases, the intensive use in bleaching of chelating agents generates peaks of 10–13 (Furley et al., 2001; Meuller et al., 2003; FadiniI et al., 2004; Pokhrel and Viraraghavan, 2004; Alarcón et al., 2005).

In brief, a plain reading of Table 4 indicates 3000 tonne of organic load discharged into the river in the semester, which is a result of concern, threatening very low values of dissolved oxygen in the Uruguay River during summer.

3.2.4 Arsenic and heavy metals

There is a short list of atoms and their ions, considered to be the most persistent, bioaccumulative and highly hazardous pollutants in nature, namely lead (Pb), mercury (Hg), cadmium (Cd), chromium or chrome (Cr), copper (Cu), nickel (Ni) and zinc (Zn), usually known as 'heavy metals'. It is very common to include arsenic (As), a non-metal element with similar dangerous properties within the same category (E.U. European Commission, 2002; FOREGS, 2008). In any case, 'heavy metals' is *'a meaningless term...'* without *'...authoritative definition'* according to the International Union of Pure and Applied Chemistry (IUPAC) (Duffus, 2002; Hodson, 2004). Anyway, 'heavy metals' is used here only because of the lack of a current definition for the entire group (Table 5).

Table 5 Botnia effluents. Arsenic and heavy metals

Parameters	Units	Effluent Quality (10 November 2007 to 10 May 2008)					Discharges in the semester Mt
		n	Minimum	Maximum	Average	95th Percentile	
Metals							
Arsenic	mg/L	6	<0.01	<0.20	<0.14	-	1.40
Cadmium	mg/L	6	<0.01	<0.05	<0.04	-	0.40
Chrome	mg/L	6	<0.10	<0.20	<0.13	-	1.30
Copper	mg/L	6	<0.03	<0.50	<0.34	-	3.41
Mercury	mg/L	6	<0.001	<0.005	<0.002	-	0.02
Nickel	mg/L	6	<0.05	<0.05	<0.05	-	0.50
Lead	mg/L	6	<0.01	<0.05	<0.04	-	0.40
Zinc	mg/L	6	<0.05	<0.30	<0.13	-	1.30
Arsenic and Heavy Metals. Total.							**8.75**

Notes: Parameters, units and concentration values are the exact copy of Table 3.1 of EcoMetrix report (shown in Figure 5).

To obtain the total discharge of the semester, the average is multiplied by 0.75.

EcoMetrix shows these compounds under the simple heading of 'Metals' (Figure 5) mixed with sodium, atomic sulphur and iron (EcoMetrix, 2008). As if this were not enough to mask and minimise the resulting magnitude of this group, the report hides vital information giving the concentration values simply as '< x mg/l' (less than x milligrams per litre). All techniques and regulations in force demand values to be reported in tenth or hundredth of µg/l, ng/l or even pg/l, i.e. units thousand or billion lower than those reported.

It is almost incredible that Botnia or any other fairly respectable laboratory expresses the results as EcoMetrix does (Figure 5). The criterion of the International Analytical Method uses the *'less than... a given upper limit'* when this limit is the lowest end the technique or equipment may measure, which is not applicable here in any case.

Table 5 shows the original list, only with arsenic and heavy metals. Due to the truncated information at a very high level, applying a common factor of 0.75 on every average value for calculation of the semester discharge is considered a conservative measure. Therefore, it results that the mill discharged almost 9 tonnes of those hazardous compounds into the river.

3.2.5 AOX, phenols and chlorophenol

The compounds belonging to the group of Absorbable Organic Halides (AOX), phenols and chlorophenols are also persistent and bioaccumulative. Most of them are generated during the bleaching process. Maximum concentrations are extremely low, which may relate to an efficient operation of the mill, or to a low consumption of bleaching chemicals as previously discussed (out of specification pulp, Section 3.1). It is clear that a six-month average is not appropriate to compare the 14.7 tonne resulting discharge (Table 6) with quantities in similar mills. However, the AOX value is relatively very low. The Botnia AOX semester average was 0.036 kg/ADMt (from Table 1 and Table 6), opposed to the Veracel (Brazil) AOX 2006 annual average of 0.1 kg/ADMt (Veracel, 2006).

Table 6 Botnia bleaching effluents

Parameters	Units	Effluent Quality (10 November 2007 to 10 May 2008)					Discharges in the semester Mt
		n	Minimum	Maximum	Average	95th Percentile	
AOX	mg/L	20	0.02	1.72	1.08	1.69	***14.40***
Chlorophenols	µg/L	21	0.05	3.7	1.1	3.4	***0.01***
Phenols	µg/L	26	<1	91	19	45	***0.25***
AOX, Phenols and Chlorophenols. Total.							***14.66***

Note: Parameters, units and concentration values are the exact copy of Table 3.1 of EcoMetrix report (shown in Figure 5).

3.2.6 Dioxins and furans

The family of compounds known as Dioxins and Furans (D&F) are the smallest group in quantity, but the most hazardous and presenting the highest risk among persistent bioaccumulative compounds (as recognised throughout the international scientific community).

Firstly, they receive by EcoMetrix exactly the same treatment as heavy metals. The 'untidiness' of reporting only 'less than 1 pg/l' is recurrent here, as if it were the detection limit of the current technology. Otherwise, D&F are reported worldwide in tenths or hundredths of pg. Consequently, the criterion applied here for calculation is multiplying for a common factor of 0.75 as in the case of heavy metals.

Secondly, the report shows only 3 (three) dioxins measurements and 3 (three) of furans *over the semester!* It goes without saying that all important international regulations demand a minimum of one monthly sample for mills in full operation. It is unacceptable to control the start-up of a mega-mill with less than two or three monthly tests or a minimum of a dozen in the period.

Thirdly, the dioxins group in the report is only represented with the concentration of the most toxic congener, 2,3,7,8-TCDD. US EPA rules and other regulations require that 7 (seven) congeners (those of higher known toxicity) should be analysed and reported in toxicity equivalent units (Toxic Equivalent Quotient (TEQ), toxicity-weighted masses of mixtures of several congeners) (U.S. EPA, 2006). At least there is a second congener almost as toxic as 2,3,7,8-TCDD and three congeners with a toxicity level around 10%. The same reference states that at least 10 (ten) congeners must be determined in the furan family. What is the certainty of EcoMetrix having evaluated these 10 furan congeners?

It must be highlighted that 2,3,7,8-TCDD low concentration does not imply at all that the rest of the congeners is at a similarly low level. Otherwise, it is very possible that having analysed the 10 congeners and calculated the corresponding TEQ, the values of dioxins exceed the values disclosed by EcoMetrix. Reports related to projects similar to Botnia estimated values, in the final effluent, higher than 2 pg TEQ/l of dioxins (Beca AMEC, 2006; Gunns Bell Bay, 2006), for a production equivalent to that EcoMetrix reveals in the semester.

In any case, the 20 millions of ng TEQ of dioxins and furans disclosed (Table 7) are very high values taking into account the production bleaching levels suggested by the AOX already mentioned.

Table 7 Botnia effluents. Dioxins and furans

Parameters	Units	Effluent Quality (10 November 2007 to 10 May 2008) n	Minimum	Maximum	Average	95th Percentile	Discharges in the semester ng TEQ
2,3,7,8-TCDD	pg/L	3	<1	<1	<1	<1	10,000,000
2,3,7,8-TCDF (as TEQ)	pg/L	3	<1	<1	<1	<1	10,000,000
Dioxins and Furans. Total.							**20,000,000**

Note: Parameters, units and concentration values are the exact copy of Table 3.1 of EcoMetrix report (shown in Figure 5).

To obtain the total discharge of the semester, the average is multiplied by 0.75.

3.2.7 Other critical compounds

'Critical compounds' are defined in this text as those pollutants scientifically proved to be of a high risk, either for river biota or human health, and those which – in direct reference to Kraft effluents – Environment Canada simply calls 'toxic' (CEPA, 1991). All compounds already reviewed here are among them, as well as the group of five compounds reported by Botnia (Table 8). Chlorates are waste from chloride dioxide (ClO_2) manufacturing mills, in this case a waste from Kemira chemical island. Sterols or phytosterols, the same as resinic acid, are originated in the same wood that has been processed. Undoubtedly, the great tonnage discharged in chlorates and sterols is a strong and alarming warning for its known medium and long-term effects on biota.

Table 8 Botnia effluents. Other critical contaminants

Parameters	Units	Effluent Quality (10 November 2007 to 10 May 2008) n	Minimum	Maximum	Average	95th Percentile	Discharges in the semester Mt
Other							
Chlorate	mg/L	25	<0.10	109	18	86	240.74
Resin acids, total	mg/L	5	0.02	0.02	0.02	0.02	0.27
Detergents (LAS)	µg/L	5	14	31	18	15	0.24
Esteroles, total	µg/L	5	<1000	<1000	<1000	-	10.03 *
Cyanide	µg/L	6	<5	<5	<5	-	0.05 *
Other Critical Contaminants. Total.							**251.33**

Note: Parameters, units and concentration values are the exact copy of Table 3.1 of EcoMetrix report (shown in Figure 5).

*To obtain the total discharge of the semester, the average is multiplied by 0.75.

3.2.8 Summary of emissions publicly stated

Table 9 summarises the total quantity of persistent accumulative contaminants, detailed in Tables 5, 6 and 8. Table 10 shows the total value of critical contaminants publicly disclosed by Botnia in the EcoMetrix report. A total of 3300 tonne of toxics was discharged straight into the river: an overwhelming though not unexpected quantity, in view of the Veracel performance (Veracel, 2006).

Table 9 Botnia effluents. Summary of persistent bioaccumulative compounds

AOX, Phenols and Chlorophenols	**14.7 Mt**
Arsenic and Heavy Metals	**8.8 Mt**
Persistent Bioaccumulative Compounds. Total.	**23.5 Mt**

Table 10 Botnia effluents. Summary of discharges

Persistent Bioaccumulative Compounds	**23.5 Mt**
Organic Load (COD)	**2,996.0 Mt**
Nutrients	**70.5 Mt**
Other Critical Contaminants	**251.3 Mt**
Efluents. Critical Contaminants. Total.	**3,341.3 Mt**

3.2.9 What has not been included in the pollution load

Table 10 does not show the following parameters informed by EcoMetrix: faecal coliforms, fats, atomic sulphur (S), total suspended solids (TSS, 321 tonne) and soluble sodium (Na^+), resulting in 6780 tonne. They are not only products to worry about, but they are also clearly omitted among critical contaminants, at least while they remain limited to these levels. The case of sodium is special. Even though the figure seems to be very high, actually Botnia has declared to consume fairly more sodium in different compounds (EcoMetrix, 2007) such as sodium hydroxide, sodium chlorate, sodium chloride and sodium sulphate.

According to the report, sodium associated with chlorate present in effluents would not exceed 50–70 tonne of sodium, as expressed in Table 10. The question remaining unanswered in the report is how much sodium corresponds to sodium sulphate (sodium and sulphur make up), even when in principle it is a lower fraction of total Na^+.

3.2.10 What EcoMetrix has completely omitted about the effluents

As to effluents, EcoMetrix has absolutely omitted any reference to inorganic sulphides, $S^{-2}/HS^{-}/SH_{2,}$ present in one or another form according to pH. Consider that to sustain the white liquor sulphidity between 37% and 40%, approximately 15–20 tonne/day of sodium sulphate or equivalent compound had to enter the recovery boiler (Análisis, 2007). This means that about 1500–2000 tonne of SNa_2 were lost via chimneys or effluents. Since as it is discussed in emission into the atmosphere, Botnia apparently has not released via chimneys more than 200–300 tonne among SNa_2, Total Reduced Sulphur (TRS) and particulate matter, it should be inferred that it discharged into the river a minimum of *1,000 tonne of inorganic sulphide* not disclosed in any part of the report, and which must be included, without a doubt, together with other critical contaminants in Table 10. Sulphides ion (S^{-2}) and hydrosulphide ion (HS^{-}) are well-known and highly stable toxics for living organisms (chronic and acute toxicity according to species and concentration). If pH decreases to less than 4.8, by accident or negligence even in relatively reduced areas, the quantity of hydrogen sulphide gas produced can immediately kill every human being nearby. The pH cannot drop below 5 by natural causes in the Uruguay River, but the menace of a disaster is highly probable, considering the important river traffic of chemical supplies for Botnia, 365 days a year.

3.2.11 Summary of the total estimate of contaminants discharged into the river

The Grand Total of Critical Contaminants discharged into the River cannot be less than 4300 tonne, considering what is calculated in Table 10 and sulphides mentioned in the Section 3.2.10, above reported.

In addition, 321 tonne of TSS and a minimum of 4000 tonne of dissolved sodium (Na^+) not related to other inorganic salts have to be taken into account but not added to none of the tables, even though they cannot be considered critical contaminants.

3.3 Emissions into the atmosphere

3.3.1 Summary of emissions disclosed

The only useful data on atmospheric emissions disclosed are those shown in Figure 5.3 by EcoMetrix (not shown here). This figure shows the monthly average of pollution load in kg/ADMt only for five compounds: SO_2, NOx, TRS, Total Particulate Matter (*Dust*) and CO. Table 11 includes the six-month average calculated for these compounds and total tonnage of emissions, which results from multiplying 405,000 ADMt of production by the average of the semester. No other type of calculation starting from monthly values is done due to the inconsistencies in the data on production mentioned in Section 3.1 (Fundamental Data). The figures in Table 11 give as a result 978 tonne of emissions into the atmosphere.

Table 11 Botnia. Summary of emissions into the atmosphere

Compound	Semester Average Kg/ADMt [1]	Total Discharges in the semester, Mt
SO2	0.487	197
NOx	1.825	739
TRS	0.019	8
PM (Dust)	0.062	25
CO	0.023	9
Emissions into the Atmosphere. Total.		978

Note: [1] Data calculated from Figure 5.3 of EcoMetrix report (not shown here).

3.3.2 Dioxins and furans by combustion: a main omission

EcoMetrix *does not report emissions of D&F into the atmosphere* in spite of the vast existing bibliography on the generation and emission of D&F by combustion (Uloth and van Heek, 2002). Estimations made for Botnia and other projects point out that the quantities of D&F by combustion are important and could be higher than those of liquid effluents. In the case of Botnia, there is an aggravating factor: the whole biomass generated by secondary treatment is being burnt at the recovery boiler. Considering the level of AOX reported it is obvious that such biomass contains an important quantity of organochlorinated compounds, and there is a possibility for these compounds to generate an additional increase in the level of D&F emissions. Tasmania new regulations recommend *'…the firing of fuels having minimum contamination with dioxins, furans and their precursors to minimise dioxins and furans in the flue gases'* (RPDC, 2004).

Furthermore, not less than 25 tonne of particulate matter were discharged (Table 11) over the period (mostly PM_{10} and $PM_{2.5}$) according to the report. However, the quantity of D&F in those 25 tonne is not reported. It should be noticed that D&F together with several heavy metals and other contaminants usually accompany these particles in significant quantities.

According to previous calculations (Matta, 2007), the minimum quantity of D&F by combustion discharged by Botnia over the semester is 10 million ng TEQ, a figure which will be subsequently added to the critical pollutants total quantity.

The treatment of the issue of D&F given by EcoMetrix and Botnia well deserves what was said in the first Hatfield report: *'The reference to dioxins/furans in mill discharges appears to be handled in a rather cavalier manner. These compounds are of significant concern to the general public…Setting the issue aside by concluding that dioxins/furans will be at 'undetectable levels' is unacceptable…without scientific support…'* (Hatfield, 2006). The same report also requests not omitting measurements in effluents and gases, at least until it is conclusively confirmed that the D&F emission levels are effectively 'undetectable'. The Hatfield report of March 2006 was commissioned by the IFC to review the Cumulative Impact Study (CIS) (Malcom Pirnie, 2005), a previous evaluation of the impact of Botnia and Ence mills working together in the same ecosystem. The CIS was seriously questioned by Argentina and also by the Ombudsman of the IFC (CAO, 2006).

3.3.3 Kemira chemical island

The gaseous emissions from the four important chemical plants of Kemira on Botnia's grounds (oxygen, hydrogen peroxide, chlorate and chlorine dioxide) have been completely ignored by EcoMetrix. This is a peculiar situation, since a previous report from the same consultant (EcoMetrix, 2007) highlighted Botnia's liability regarding such emissions. Continuous emissions from Kemira are surely not relevant, but they add up to the total values. Sporadic emissions (incidental or accidental ones) are surely very dangerous.

3.3.4 TRS and hydrogen sulphide

It is also unbelievable that the public is not informed, but reality is hidden behind the euphemism of 'TRS' that from the 8 tonne of odorous gases (Table 11) at least 6 correspond to hydrogen sulphide gas (H_2S) of both acute and chronic very high toxicity. H_2S sources in the mill are many, most of which are non-controlled sources like the blow tank (where the cooking vessel discharge) and the ponds of primary and secondary effluent treatment.

4 Grand total of critical emissions over the semester

The grand total of critical emissions of Botnia in its first six months, whether publicly disclosed or not, is reached by adding partial totals from Table 10 plus 1000 tonne of sodium sulphide (Na_2S) discharged into the river and gases from Table 11. Besides, D&F in Table 7 must be added to 5 million ng TEQ, omitted in effluents since 6 out of 7 congeners of dioxins were not measured plus 10 million ng TEQ of D&F by combustion. All this is summarised in Table 12.

Table 12 Botnia. Summary of stated and some not stated critical contaminants

Nutrients	**70.5 Mt**
Persistent Bioaccumulative Compounds	**23.5 Mt**
Organic Load (COD)	**2,996.0 Mt**
Critical Gases	**953.0 Mt**
Particulate Matter	**25.0 Mt**
Other Critical Contaminants	**1,251.0 Mt**
Critical Contaminants. Grand Total.	**5,319.0 Mt**
Dioxins and Furans to Effluents	**25,000,000 ng TEQ**
Dioxins and Furans to Atmosphere	**10,000,000 ng TEQ**
Dioxins and Furans. Grand Total.	**35,000,000 ng TEQ**

The final figures are adjusted and conservative, taking into account the information provided by EcoMetrix report. On reaching the end of the review, focus must be placed on the initial words: data from production and the volume of accumulated effluents over the semester are crucial. If there is actually a significant error (in excess or defect) in the final figures, the main liability lies on the weakness of these two values.

5 The pollution load of Botnia and other mega-mills

When an ECF Kraft mega-mill is intended to be set up anywhere in the world, two images are attempted to be imposed on the public by the Environmental Impact Reports and the advertising campaigns. Firstly, that contamination is almost exclusively due to bleaching. Secondly, that such project has ‘nothing to do’ with the old Kraft mills bleaching with elemental chlorine [Cl_2 (g)], responsible for serious and global contamination. Unfortunately, both images are wrong.

The contaminants managed by a Kraft mill in 1970/80 were almost the same as a modern mill, with only a few exceptions. Botnia, a mega-design based on 2004/05 ECF IPPC BAT technology discharges – with a few exceptions – practically *the same type of hazardous compounds and the same pollution load (tonne of contaminants/year) as an 'old' mill designed in 1970/80 which bleached with elemental chlorine of 500,000 or 600,000 ADMt/year.* Data from EcoMetrix report under review here corroborates these statements.

5.1 The incidence of bleaching on pollution

The same data from EcoMetrix report contribute again most of the arguments. Table 13 (top) shows the group of those critical contaminants, which would be present due to Botnia's emissions, even when pulp was not bleached at all. Contaminants from bleaching are obtained by subtraction from the total in Table 12 (Table 13, bottom).

Table 13 The pollution load of Kraft Mills. With and without bleaching

Arsenic and Heavy Metals	9 Mt
COD (33% of Total)	1,000 Mt
Nutrients (33% of Total)	23 Mt
Sterols, Resin Acids, Detergents	10 Mt
Sodium Sulphide (not reported by EcoMetrix)	1,000 Mt
Particulate Matter and Gases	980 Mt
Critical Contaminants from Kraft Process (No Bleaching)	3,022 Mt
A minimum of 10 millions ng TEQ of Dioxins and Furans must be added to Kraft Process (from combustion).	
Critical Contaminants Due to Bleaching (1)	2,297 Mt

Note: (1)They include bleaching effluents, production of chemicals required in bleaching and nutrients necessary in effluent secondary treatment because of bleaching.

It is obvious that, at least in *quantity*, the contaminants related to bleaching do not exceed 43% of the total. If the *toxicity* factor is also considered in each fraction it is possible that ECF bleaching balances or exceeds by a few points, the contribution of the remaining areas of the mill.

Arsenic and heavy metals result from the processed wood itself, and they are found in traces in the different chemical supplies used in the mill. Phytosterols and resinic acid also come from wood. They are all released mainly at cooking. Sodium sulphide (Na_2S) and its ions also represent losses from the area of cooking, brown stock washing (by overflow and carry-over), evaporation system and its condensates. Without bleaching there is no AOX in the effluents to be treated and the total organic load to reduce is lower. The quantity of chemical products discharged to secondary treatment is also lower. As a consequence, COD without bleaching was estimated in one-third of what was reported by EcoMetrix very conservatively. Therefore, fewer nutrients are required to sustain the microflora of the secondary treatment.

Practically all the emissions into the atmosphere do not depend on the existence or absence of bleaching, including D&F by combustion, in particular in cases like Botnia, where there is no recycling (no evaporation nor burning) of an important part of the effluents of bleaching.

At this point, it is convenient to explain that if a Total Chlorine Free (TCF) bleaching replaces the Elemental Chlorine Free (ECF) bleaching of Botnia mill, the changes in Critical Contaminants Due to Bleaching (Table 13) will reduce from roughly 2300 tonne to a minimum of 1500 tonne, which is only 35–40% of improvement in bleaching load.

It must be considered that the TCF organic load (COD) and the consumption of nutrients is similar to ECF. The clear differences are the absence of AOX, chlorine-organics and the toxicity of the bleaching effluent.

5.2 How to compare 1970/2005 mills

Having demonstrated that almost 50% of the pollutant load has no relation with bleaching, it is absolutely simple to show how to compare mills of such a different technology.

To begin with, two factors previously mentioned should be considered independently. One is the *quantity* of contaminants and the other is the *toxicity* of emissions (acute as well as chronic). The final figure is the sum of the product of the quantity and toxicity of each contaminant and a relative weight factor.

Omitting bleaching and secondary treatment for the time being, there is no difference at all in the type of contaminants managed or generated by a modern Kraft mill and an old one. The contrast is marked by the quantities discharged. Modern mills have a better control of black liquor losses, throughout the fibre line, especially in blow gases and brown stock washing; and they have substantially improved combustion gas emissions due to the advances in technology and operating methods. From an environmental point of view, there are negative aspects regarding the recent use of combustion and digestion additives (urea, anthraquinone), and some chemicals used for cleaning and maintenance. Another factor is the tendency to increase white liquor sulphidity from 28% to 30% in the ‘70s to an average of 38–40% in 2008.

We are not sure of how much additive is used by Botnia, but certainly the mill will raise the sulphidity as much as possible. In any case, 20–22% of improvement is the maximum advantage, which a modern mill can state for the Kraft process.

Unmistakably, the greatest environmental achievement of the last two decades in industry has been in the sector of pulp bleaching. The passage of elemental chlorine to chorine dioxide has played an important though not exclusive part. Delignification extended with oxygen, the use of pressurised peroxide and other technological improvements have severely reduced the quantity as well as the toxicity of bleaching contaminants. Such reduction of all organochlorinated compounds (AOX, chlorophenols, D&F) and their reduced toxicity, based on a 95% reduction of the most toxic congeners of D&F and a smaller number of chlorine as a substitute in the organic matter. The result is a global improvement of the area of about 80–85% compared with old mills. As a negative environmental aspect, modern mills have concentrated almost all production of chemicals aimed at bleaching in satellite mills located within their own premises. Currently there are not less than 12 high risk supplies and half a dozen contaminants that did not exist in older mills, incorporated only to sustain the new bleaching lines. Not all of them are shown in Figure 5 (EcoMetrix Table 3.1).

The secondary treatment of effluents has certainly improved in modern mills. As a result of technology, advances in the reduction of AOX, BOD and COD by means of activated aerobic sludges constitute remarkable progress. Globally speaking, levels of 39–48% have been reached.

An entire mill designed in 2005–2006 can proudly exhibit improvements of 90–99%, even 100%, when compared with the old 1970–80 mills. Enhanced performance is absolutely unlikely.

As stated at the beginning of Section 5, *the pollution load is similar or equivalent in a modern factory that produces 1 million ADMt/year compared with a mill (designed in 1970–80, elemental chlorine), which produces 0.5 million ADMt/year.*

5.3 Mega-mills: a dramatic fact

As it was presented in the Introduction, at the limit of their environmental possibilities and seeking better energetic and economic conditions, the leading companies of the sector in the developed countries planned early the setting up of new mills in selected tropical and subtropical areas.

Lacking all sense of shame or prudence, instead of setting up ECF Kraft mills with low or very low pollution load, companies are setting up mills of 1.0, 1.3 or 1.5 million ADMt/year. Which, without any doubt, are mills equivalent to 'Elemental Chlorine 1970/80', 500,000 or 700,000 ADMt/year, as seen before.

It is worse due to serious aggravating factors. In the '70s and even not long ago, Kraft mills were installed under historical and careful engineering norms: by the sea so as not to contaminate freshwater sources; hundreds of kilometres far from any settlement of importance; at distances not less than 150–200 km from similar or equally polluting mills in order not to interfere mutually and not to enhance contamination in the area. On the contrary, Botnia and Ence were on the brink of setting up at less than 6 km apart, on a freshwater river which does not flow into the sea but into another river; at 25 km from a city in Argentina having a population of 90,000 inhabitants and in a highly active economic area, almost fully devoted to the production of food for local consumption and exports. All this was being done with the consent and the insistence of the World Bank and the Commissioners of the European Union (Helsingin Sanomat, 2006; Mercopress, 2007).

In the case of Botnia today, it is also very clear that the 5000 tonne of toxics discharged to produce 405,000 ADMt of pulp are as hazardous as the 2500 tonne, which an old mill would discharge to produce 200,000 ADMt.

EcoMetrix makes a new mistake when stating that, '…the performance measures account for the short-term variability expected during this initial start-up phase…' (Page ES.ii), and 'Air emissions are expected to improve as the production of the mill increases to full capacity…' (Page ES.iv) (EcoMetrix, 2008). It is certainly possible that the ratio kg/ADMt of contaminants/pulp produced improves due to adjustments in some sectors over the following year. However, the mill will simultaneously increase its production at its best convenience. Therefore, at full production, the pollution load cannot be expected to improve more than 5–10%. About this point, the emissions evolution of Veracel in 2004–2006 is very illustrative (Veracel, 2006).

Considering the vital role played by the pollution load on the irreversible damage caused by hundreds of new or old Kraft mills all over the world (see Section 2.1 and 2.4), there was never a doubt about the harm that Botnia would generate or better, is already generating in the lower Uruguay River catchment area. *This first international report on the mill emissions is merely corroborating prior concerns.*

It has been publicly stated previously and it is hereby reinforced that the sum of pulp mills in all Argentina, over the years, never reached an emission equivalent to 500,000 tonne 1970/80 Elemental Chlorine plant. This statement is not judgmental of the current environmental practices in this country, or of its industry. It does neither contemplate specific and temporary situations. Nevertheless if a wise halt is not to come to, this is what will happen in a few years with the 'ultramodern' 2005–2008 designs.

6 The state of the environment

The 'state of the environment' has always occupied a privileged position in the speeches and promises made by Botnia and the Government of Uruguay. To the best of our knowledge, this is just a front to avoid mentioning what is truly important, i.e. how much contaminant is actually discharged by the mill, how big the pollution load is and how they will affect the environment in the long term.

Of course, being able to measure the quality (or deterioration) level of the ecosystem is extremely relevant. The point is that this is not possible with the type of test which has been announced and used, a supposedly 'environmental monitoring' limited to measuring the same variables which are controlled (or should be controlled) in the mill emissions.

There are serious physico-chemical and technological limitations to the measurement of many contaminants after they leave the effluent emissary or the chimneys. The first limitation is a dilution level can exceed 1200, which places the equipment on the limit of the measuring range. Also, there are problems of total or partial insolubility in water, contaminants deposition from water into particles and flocs in suspension, which irremediably do deposit – sometimes very fast – on the bottom sediment the river. Additional problems are dispersion by wind, particle deposition, gas washout by rainfall, dewfall or plume condensation.

What should really be measured in the ecosystem, especially in living organisms and bottom sediment is the total of accumulated contaminants, particularly the value of persistent cumulative compounds. Also, a follow up of the health and number of populations (plankton, crustaceans, bivalves and fish) should be done, though it is never easy. Surely, all this work will not yield any trend of concern (except by isolated values) after only 180 or 365 days after the mill start-up.

Unfortunately, EcoMetrix report does not contribute to determining the actual pollution load and it does not either provide any relevant information regarding the true state of the environmental conditions.

7 Conclusions

- EcoMetrix report undoubtedly shows that Botnia contaminates in a high degree. It also shows that during the first 180 days of operation the mill has discharged into the Uruguay River and into the surrounding atmosphere more than 5000 tonne of hazardous substances. Not less than 48 tonne are particulate matter and persistent bioccumulative contaminants. Among the latter, a minimum of 35 millions of toxic units (ng TEQ) of D&F has to be considered.
- Intentionally or unintentionally, Botnia, EcoMetrix and the World Bank have skimped on information to the public, thus hindering the awareness of the whole dimension of the contaminants generated and discharged, especially those which are persistent and bioaccumulative.
- The impacts of these contaminants go beyond the frontiers. The Uruguay River is not a drain but a living ecological system to be shared even with the existence of political borders. On the other hand, emissions into the atmosphere will deposit onto inhabited and economically active areas of the Argentinian as well as of the Uruguayan territory.
- EcoMetrix has not reported on any relevant parameter illustrating 'the conditions of the environment' after these first 180 days. Any related definition is therefore, hasty and capricious.
- The current site of Botnia has no other justification than maximising the economic benefits of the project, without any consideration to the long-term effects on the environment.
- Botnia Fray Bentos does not guarantee at all that it will operate without harming the environment. The data analysed show that damage will be severe and evident much faster than what is desirable and foreseen.
- Determining pollutants concentration in freshwater and air at ground level can only give us a slight idea of the total emissions from the mill, even carrying out large-scale research, assisted by computer models. Data on effluent and chimney emissions from Botnia in EcoMetrix report are, though partial, the best information available to date on pollution load over the area.
- The international scientific expertise on Kraft mills has demonstrated that similar pollution load on greater ecosystems or with better defences than the lower basin of the Uruguay River, has caused a serious and irreversible damage to the flora, fauna and health of the inhabitants of the catchments area in a few years.

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Glossary of Terms and Abbreviations

AOX (*Adsorbable organic halogens*): A measure of the total amount of halogens (chlorine, bromine or iodine) bound to dissolved or suspended organic matter in a wastewater sample.

ADMt (*Air dried metric tons*): Pulp with 10% water content by weight.

BAT (*Best Available Techniques*): See also IIPC, BREF.

BREF: Document reference for a particular industrial sector. See also IPPC.

BOD, BOD_5 (*Biochemical Oxygen Demand*): Amount of dissolved oxygen in water required by microorganisms to degrade organic and inorganic contaminants. BOD_5 is the BOD measured over a five-day period.

Black liquor: Aqueous spent liquor generated in the Kraft cooking process. Rich in SNa_2, CO_3Na_2 and organic matter dissolved from the wood.

Bleaching: Chemical treatment of pulp fibres for the purpose of increasing pulp brightness (white level).

Blow gases: Gas and steam generated during the decompression of cooking vessel and the discharge of brown pulp.

Brown Stock: The mixture of brown pulp and black liquor.

Cellulose (*cellulosic pulp or pulp*): A suspension of plant fibres in water. The resulting material of processing the wood, avoiding serious damages to fibres.

COD (*Chemical Oxygen Demand*): Amount of oxidisable compounds, mostly organic ones.

Common Prefix: (p), pico, 10^{-12}; (n), nano, 10^{-9}; (μ), micro, 10^{-6}; (m), milli, 10^{-3}; (K), kilo, 10^{+3}; (M), mega, 10^{+6}.

Cooking (*pulping*): Treating wood with chemicals, under pressure and extreme heat, to produce pulp for making paper and paperboard.

Delignification: A pulping (cooking) process to remove lignin from wood.

Digester: Pressurised vessel in which wood chips are cooked.

DINAMA: Dirección Nacional de Medio Ambiente. Uruguay's Environmental Agency.

D&F: Dioxins and Furans compounds (see TEQ)

Elemental Chlorine: Chlorine gas (Cl_2 g).

ECF (*Elemental Chlorine-free*): Bleaching processes that uses chlorine dioxide (ClO_2) instead of elemental chlorine.

EIPPCB: European Integrated Pollution Prevention and Control Bureau.

EPA: United States Environmental Protection Agency.

Eucalyptus: Hardwood, Technically, a dicotyledonous tree, originally from Australia.

Fibre Line: The sectors of the mill that produce the pulp: cooking, washing, bleaching and dry lap and bale former.

Greenfield Mill: Mill or production facility built on undeveloped site.
See http://www.paperonweb.com/dict11.htm

IPPC (*Integrated Pollution Prevention and Control*): A European Union normative (known as the IPPC Directive 1996). The IPPC provide common basic standards for each industrial sector, the so-called Document Reference or BREF, which includes some regulations to design the plants (BAT, Best Available Techniques) and limits to emissions.

Lap (*Dry lap*): A thick sheet of pulp with 80–90% of moisture usually cut and baled to transport the pulp out of the mill.

LATU: Laboratorio Tecnológico del Uruguay. One of the official Uruguay's laboratories.

Kraft mill: Mill that produces Kraft pulp.

Kraft process: Chemical alkaline process with several steps: delignification (with a mix of Na_2S and NaOH); pulp washing (to separate pulp from black liquor); chemical recovery of the inorganic compounds. The key operation here is the combustion of the black liquor in the Recovery Boiler.

Mt. Metric ton (*M t*): Tonne. Mass unit.

NAFTA: North American Free Trade Agreement (1994).

PM (*Particulate Matter*): PM_{10} is the fraction of particles with dimensions less than 10 microns. $PM_{2.5}$ is the fraction less than 2.5 microns. Both fractions are known by physicians as 'inhalable particulate matter' or 'thoracic particles', and associated with cardiovascular disease.

Pollution Load: The amount of stress placed upon an ecosystem by pollution, physical or chemical, released into it by man-made or natural means (European Environment Agency, http://glossary.eea.europa.eu/EEAGlossary/P/pollution_load)

Pulpwood: Wood ready to be used at the pulp mill (logs or chips).

Secondary treatment: Systems to reduce mostly BOD and COD (and also AOX) of the effluent with the aid of aerobic or anaerobic microorganisms.

Sulhpidity: The way to express the content of SNa_2 in the cooking liquor. Ratio $SNa_2/(SNa_2+NaOH)$.

TCF (*Totally Chlorine-Free*): Bleaching process that uses zero chlorine compounds. As a substitute, ozone, oxygen and hydrogen peroxide are the main chemicals.

TRS (*Total Reduced Sulphur compounds*): Mix of compounds that causes the odour associated with Kraft pulp mills: hydrogen sulphide (main component), dimethyl sulphide, dimethyl disulphide and methyl mercaptan.

TSS (*Total suspended solids*): Amount of solids in the effluent. They can eventually settle after a relative short interval.

TEQ (*Toxic Equivalence Quotient*): EPA TEQs are calculated values that allow us to compare the toxicity of different combinations of dioxins and dioxin-like compounds. The two most toxic compounds are the comparison point. In order to calculate a TEQ, a toxic equivalent factor (TEF) is assigned to each member of the dioxin and dioxin-like compounds category. The TEF is the ratio of the toxicity of one of the compounds in this category to the toxicity of the two most toxic compounds in the category, which are each assigned a TEF of 1: 2,3,7,8-tetrachlorodibenzo-p-dioxin (commonly referred to as dioxin) and 1,2,3,7,8-pentachlorodibenzo-*p*-dioxin. TEFs that have been established through international agreements currently range from 1 to 0.0001. For example, consider the following 60 g mixture: 10 g of A, with a TEF = 1; 20 g of B, with a TEF = 0.5; 30 g of C, with a TEF of 0.2. The TEQ of this mixture would be: (10 g x 1) + (20 g x 0.5) + (30 g x 0.2) = 26 g TEQ.

Available online at: //www.epa.gov/tri/lawsandregs/teq/teqprule.html (accessed on November 2008).

UNEP: United Nations Environment Programme.