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Title: Letter to the Editor: Botnia Fray Bentos and the environment of Uruguay River basin. The reports of EcoMetrix-World Bank

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Keywords: Kraft process; ECF-TCF bleaching; environment; pollution load; bioaccumulative compounds; Botnia Fray Bentos; standard; regulations; environmental pollution; Uruguay River; environmental health.

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Letter to the Editor: Botnia Fray Bentos and the environment of Uruguay River basin. The reports of EcoMetrix-World Bank

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Biographical notes: Elías Jorge Matta is a Chemical Engineer, and a specialist on pulp and paper science and technology. He is a Senior Professor at the ITC (FIQ, UNL) and a Professional at the INTEC, UNL-CONICET. Between 1976 and 1983, he was Technical Manager at Villa Ocampo Mill, Head of the Division of Process Engineering, Quality Control and Development at Papel Prensa Mill, and Head of the Research and Development Department at Papel del Tucumán Mill. He is a Counsellor to the Argentinean Chancery for the Argentine-Uruguayan Bilateral Commission (Cellulosic Projects, Uruguay River), and a member of the Argentinean Delegation before the International Court of Justice (The Hague, Netherlands, June 2006).

1 Introduction

In December 2008, the author submitted the article 'The pollution load caused by ECF Kraft Mills, Botnia-Uruguay: first six months of operation' (Matta, 2009) to be published in the *International Journal of Environment and Health*. The article was published in 2009.

Among the several aspects developed in the paper, the critical analysis based on the EcoMetrix report dated July 2008 (EcoMetrix, 2008) is highlighted here, named by the same consultant '*Botnia S.A. Orion Pulp Mill, Uruguay. Independent Performance Monitoring, as required by the International Finance Corporation (World Bank)*'. In the article mentioned above, the following points are expressed:

1 Data referred to effluent quality and Botnia chimney emissions are highlighted. Along with production and effluent volume, it allowed the estimation of the pollution load discharged in the lower Uruguay River catchment area by Botnia during the period.

2 The pollution load thus determined must be considered only as a 'floor' or 'the minimum lowest level', considering the serious mistakes made by Botnia-EcoMetrix when presenting the information. Even worse, there are numerous and important omissions, in particular those related to persistent accumulative compounds.

3 The 'minimum lowest level' determined, constituted only by compounds which proved to be toxic, was higher than 5300 tonne after only 180 days of operation and 405,000 tonne of pulp produced. The pollution load is so large and disproportionate regarding the receptor environment that forces the mill to be definitively considered 'non-environmentally sustainable'.

4 In spite of the indisputable evidence contributed by the data presented by the same consultant, EcoMetrix keeps repeating in various paragraphs that the mill is in compliance with what was predicted by previous studies and 'the mill is performing to the high environmental standards predicted in the EIA and CIS, and in compliance with Uruguayan and IFC standards'. This statement is technically unjustifiable and raised serious ethic questions.

5 The 'state of the environment' is always a major concern. However, it is not possible to give an answer to this question with the type of tests that Botnia and DINAMA have been using (the so-called 'environmental monitoring'). There are well-defined protocols, tested in many ecosystems worldwide, to assess the state of the environment. None of them was followed, nor informed by EcoMetrix. Therefore, the report contributes with nothing to determine the true 'state of the environment'.

On 10 March 2009, the International Finance Corporation (World Bank) disclosed a new report by EcoMetrix consultant, in which Botnia emissions throughout the year 2008 are mentioned (EcoMetrix, 2009a). Regrettably, Botnia and the consultant make the same mistakes again and fall into the omissions of July 2008, and introduce new and conflictive factors that hinder the understanding of information by the non-expert. Unsustained criteria and statements also appear repeatedly. In any case, EcoMetrix no longer says that the plant meets the 'high standard of the World Bank'.

On the following lines there is an attempt to disclose the real mill pollution load discharged in the lower Uruguay River catchment area. They also remark the insistence of Botnia-EcoMetrix in skimping on information and minimising their own results. Finally, the new report states once more the validity of the author's previous conclusions (Matta, 2007; Matta, 2008; Matta, 2009).

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

2 EcoMetrix report, March 2009

2.1 Basic data

The document shows that over the period, Botnia produced 935,000 ADt of pulp (Air Dried tonnes, 10% water content). On the other hand, EcoMetrix Table 3.4 (not shown here) (EcoMetrix, 2009a) proves that the annual average effluent load measured was 28 m^3/ADt. From what is stated above, it can be deduced that the total effluent load during 2008 was 26,180,000 m^3.

2.2 Summary of effluents and gas emissions

Tables 1 and 2 exhibit the concentration values corresponding to the different compounds measured in the effluents, as shown by EcoMetrix 2009. For the sake of comparison, these tables also include values belonging to July 2008. Notice that pH and conductivity averages increased along 2008. Since the four first months of 2008 are included in the First Six Months, it is evident that the average of the last eight months resulted even higher than that of the whole year.

Table 3 repeats values from Table 1. Only annual averages of toxic compounds during 2008 arranged by kind of compounds are included. In those cases where it was necessary, the average value was corrected – as in first six months of Operation Evaluation (Matta, 2008; Matta, 2009) – multiplying by 0.75 in order to obtain the annual average discharge in tonnes. Table 4 includes emissions into the atmosphere. Table 5 shows a comparative summary of discharges (in tonnes) according to the last two reports issued by the World Bank consultant.

Contrarily to what is stated by Botnia and EcoMetrix, the figures presented in the report clearly show that during 2008 Botnia released about 2300 tonne into the atmosphere and discharged more than 6200 tonne in the Uruguay River, adding up to a total of 8500 tonne of toxic compounds. This figure includes 52 tonne of persistent bioaccumulative compounds and 108 tonne of nutrients (nitrogen and phosphorus). The report also presents about 22 million of toxicity units (ng) of dioxins and furans.

As it was already mentioned in the introduction and it will be explained in the following sections, this pollution load must be considered a 'minimum low level' and it is only a fraction of the total emissions of the mill.

Table 1 EcoMetrix summary of effluents quality (July 2008 vs. March 2009)

Botnia Fray Bentos - Summary of Effluent Quality
(from EcoMetrix Table 3.1, July 2008 and March 2009)

Parameters	Units	First Six-Months of Operation			2008 Monitoring Year		
		Minimum	Maximum	Average	Minimum	Maximum	Average
Physical Indicators							
Temperature	°C	22.3	30.9	28.4	15.7	30.9	27.3
pH	-	6.9	7.9	7.4	7.6	8.4	8.0
Conductivity	µS/cm	180	4,336	2,644	260	5,935	3,042
Color	n.c.	300	1,750	650	200	1,750	605
Chemical oxygen demand	mg/L	90	490	224	90	445	213
Biochemical oxygen demand	mg/L	2.8	44.0	12.0	2	39.3	9.0
Suspended solids	mg/L	4	264	24	4	264	18
Nutrients							
Ammonia	mg/L	0.01	1.00	0.12	0.01	2.74	0.15
Nitrate	mg/L	0.01	4.60	1.15	0.01	10.40	0.79
Total nitgrogen	mg/L	1.32	7.57	3.42	0.88	10.10	2.58
Total phosphorus	mg/L	0.28	1.34	0.58	0.08	2.00	0.59
Metals							
Arsenic	mg/L	<0.01	<0.20	<0.14	<0.01	<0.2	<0.2
Cadmium	mg/L	<0.01	<0.05	<0.04	<0.01	<0.05	<0.0
Chrome	mg/L	<0.10	<0.20	<0.13	<0.1	<0.2	<0.1
Copper	mg/L	<0.03	<0.50	<0.34	<0.03	<0.5	<0.5
Iron	mg/L	<0.10	0.70	<0.40	<0.10	0.7	<0.5
Mercury	mg/L	<0.001	<0.005	<0.002	<0.001	<0.006	<0.003
Sodium	mg/L	290	800	507	290	1000	633
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.5	<0.1
Lead	mg/L	<0.01	<0.05	<0.04	<0.01	<0.3	<0.1
Sulphur	mg/L	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1
Zinc	mg/L	<0.05	<0.30	<0.13	<0.05	<0.3	<0.1
Other							
AOX	mg/L	0.02	1.72	1.08	0.48	2.58	1.12
Chlorophenols	µg/L	0.05	3.7	1.1	<0.05	3.7	0.3
Phenols	µg/L	<1	91	19	<1	91	15
Chlorate	mg/L	<0.10	109	18	<0.01	37	1
Resin acids, total	mg/L	0.02	0.02	0.02	0.02	0.13	0.06
Detergents (LAS)	µg/L	14	31	18	<14	58	34
Esteroles, total	µg/L	<1000	<1000	<1000	<1000	<1000	<1000
Fats	mg/L	<10	<10	<10	<10	<10	<10
Cyanide	µg/L	<5	<5	<5	<5	<5	<5
Fecal coliforms	ufc/100 ml	<18	4,900	292	<18	3,500	316
2,3,7,8-TCDD	pg/L	<1	<1	<1	<1	<1	<1
2,3,7,8-TCDF [1]	pg/L	<1	<1	<1	<0.1	0.2	<0.1

[1] ***Furans Values: July 2008, as WHO/EPA TEQ. March 2009, as NATO I-TEQ***

Table 2 EcoMetrix Furans calculation (July 2008 vs. March 2009)

Botnia Fray Bentos - Summary of Effluent Quality
(from EcoMetrix Table 3.1, July 2008 and March 2009) [1]

Parameters	Units	Effluent Quality (10 November 2007 to 10 May 2008)				
		n	Minimum	Maximum	Average	95th Percentile
2,3,7,8-TCDF (as TEQ)	pg/L	3	<1	<1	<1	<1

Parameters	Units	Effluent Quality (2008 Monitoring Year)				
		n	Minimum	Maximum	Average	95th Percentile
2,3,7,8-TCDF (as I-TEQ)	pg/L	6	<0.1	0.2	<0.1	-

[1] ***Furans Values: July 2008, as WHO/EPA TEQ. March 2009, as NATO I-TEQ***

Table 3 Toxics in effluents discharge from EcoMetrix March 2009

Botnia Fray Bentos - 2008 Annual Effluent Quality and Discharges from EcoMetrix March 2009						
Year 2008 Production	ADt					935,000
Effluent Volume	m3/ADt		28.00	m3		26,180,000
Parameters *[1]*	**Units**	**Value**	**Corrected Value**	**Units**	**Discharge**	**Cumulative**
Arsenic and "Heavy Metals"						
Arsenic	mg/l	0.200	0.150	t	3.93	
Cadmium	mg/l	0.010	0.008	t	0.20	
Chrome	mg/l	0.100	0.075	t	1.96	
Copper	mg/l	0.500	0.375	t	9.82	
Mercury	mg/l	0.003	0.002	t	0.06	
Nickel	mg/l	0.100	0.075	t	1.96	
Lead	mg/l	0.100	0.075	t	1.96	
Zinc	mg/l	0.100	0.075	t	1.96	22
AOX and Phenols						
AOX	mg/l	1.120	1.12	t	29.32	
Chlorophenols	µg/l	0.300	0.30	t	0.01	
Phenols	µg/l	15.000	15.00	t	0.39	30
Total Oxygen Demand						
Chemical oxygen demand	mg/l	213.000	213.00	t	5,576.34	
Biochemical oxygen demand	mg/l	9.000	9.00	t	235.62	5,812
Nutrients						
Ammonia	mg/l	0.15	0.15	t	3.93	
Nitrate	mg/l	0.79	0.79	t	20.68	
Total nitrogen	mg/l	2.58	2.58	t	67.54	
Total phosphorus	mg/l	0.59	0.59	t	15.45	108
Others Toxic Compounds						
Chlorate	mg/l	1	1.00	t	26.18	
Sterols	mg/l	1	0.75	t	19.64	
Fats		10	7.5		196.35	
Cyanide	µg/l	5	3.75	t	0.10	
Resin acids	mg/l	0.06	0.06	t	1.57	
Detergents	µg/l	34	34.00	t	0.89	245
Toxic Emissions with the Effluents, from de EcoMetrix Report				t		6,216
Dioxins and Furans from de EcoMetrix Report						
2,3,7,8-TCDD	pg/l	1.000	0.750	ng	19,635,000	
2,3,7,8-TCDF (as I-TEQ)	pg/l	0.100	0.075	ng I-TEQ	1,963,500	21,598,500

[1] Average from EcoMetrix March 2009, Table 3.1 (Shown in Table 1). All corrected values were multiplied by 0.75.

Table 4 Toxics Discharges to Atmosphere from EcoMetrix March 2009

Botnia Fray Bentos - Emissions to Atmosphere, Year 2008				
Year 2008 Production			ADt	935,000
Parameters *[1]*	**Average**		**2008 Discharge**	
	Units	**Value**	**Units**	**Value**
Sulphur Dioxide (SO2)	Kg/ADt	0.25	t	233.8
Nitrogen Oxides, NOx (as NO2)	Kg/ADt	1.85	t	1,729.8
Total Reduced Sulphur, TRS	Kg/ADt	0.01	t	9.4
PM Total (TMP)	Kg/ADt	0.10	t	93.5
Carbon Monoxide (CO)	Kg/ADt	0.30	t	280.5
Total Emissions to Atmosphere			t	2,347

[1] From EcoMetrix March 2009, Chapter 5.2 and Figure 5.4

Table 5 Comparative total emissions from EcoMetrix (July 2008 vs. March 2009)

Botnia Fray Bentos. Comparative Emissions [1] : First Six Months vs. 2008		
Source	**EcoMetrix Jul08**	**EcoMetrix Mar08**
Period	**First Six Months**	**Year 2008**
Pulp Production, ADt	**405,000**	**935,000**
Total Effluent Volume, m3	**13,374,720**	**26,180,000**
Continuous Discharges to Uruguay River	**------ tonne -----**	
Arsenic and "Heavy Metals"	**9**	**22**
AOX, Chlorophenols and Phenols	**15**	**30**
Total Oxygen Demand	**3,156**	**5,812**
Nutrients	**70**	**108**
Others Toxic Compounds	**352**	**245**
Continuous Discharges to Atmosphere	**------ tonne -----**	
Sulphur Dioxide (SO2)	**199**	**234**
Nitrogen Oxides, NOx (as NO2)	**736**	**1,730**
Total Reduced Sulphur, TRS	**5**	**9**
PM Total (TMP)	**18**	**94**
Carbon Monoxide (CO)	**9**	**281**
Total Emissions	**4,570**	**8,563**
Persistent and Accumulative Compounds	**24**	**52**
Continuous Discharges to Uruguay River	**3,602**	**6,216**
Continuous Discharges to Atmosphere	**968**	**2,347**
Total Dioxins and Furans, ng	**20,062,000**	**21,600,000**

[1] According with EcoMetrix-World Bank

3 Botnia-EcoMetrix: new and old mistakes

In the new report (EcoMetrix, 2009a), as in that of the first six months (EcoMetrix, 2008), Botnia and EcoMetrix repeat mistakes and omissions, including the use of expressions or criteria technically unacceptable, mentioned in the former article (Matta, 2009). Other factors that will be further detailed were also introduced.

3.1. Most important repetitions

1 Arsenic and 'heavy metals' values are wrongly reported and therefore, under-reported (Tables 1 and 3), possibly 25–30% below. The report shows 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.

2 Only one dioxin congener in the effluent is reported, contrarily to World Health Organization (JECFA, 2001; Van den Berg et al., 2006) and EPA (U.S. EPA, 2006; U.S. EPA, 2007) recommendations requesting the measurement of the seven most

toxic congeners. The result may be 40 and even 70% below the real emission. The excuse of EcoMetrix to avoid full measure was: "This statement that dioxins and furans are not associated with modern mills is also true for the Orion mill (Botnia)". The comment may be considered a good marketing slogan but it does certainly not fall within the scope of science and technology. Omissions are impossible without demonstrating that their measurement is unnecessary. EcoMetrix mentions some background. However, there is not enough information about similar mills in operation nowadays (Veracel and Aracruz in Brazil, Hainan Jinhai en APP China).

3 All dioxin and furan emissions by combustion are omitted, which, according to previous calculations made by the author (Matta, 2007), are not less than 20–30 million toxicity units (ng TEQ), based on Botnia's information and Uloth and van Heek Dioxin and Furan Emission Factors (Uloth et al., 2002). EcoMetrix not even considered the recommendations of World Health Organization Regional Office for Europe (WHO, 2000b).

4 Soluble sulphides in effluents are not reported at all. Sulphides ions (S^{-2}) and hydrosulphide ions (HS^{-}) are well known and highly stable toxics for living organisms. Since Botnia must replenish after losses of about 28–30 tonne of SO_4Na_2/day, considering chimney losses and other situations, the minimum quantity discharged in the river is about 4000 tonne of SNa_2 during 2008.

5 Like in July 2008, Botnia-EcoMetrix do not mention continuous and permanent discharge of several thousands of supplies poured into the river. The most serious effects of this action on the biota are not controlled by any measurement. Among the latter, chelating agents, anti-foaming agents, dispersant and biocides outstand because of the hazard they represent. Arguable measurements of acute toxicity and possible detection as part of COD and BOD do not represent adequately the pollution load of this important fraction of environmentally high-risk compounds.

3.2 New 'mistakes'

1 As it can be seen in Table 1, chlorate average concentration in effluents decreased from 18 to only 1 mg/l. This mistake is too noticeable, even accepting an extraordinary improvement over the last eight months of 2008. This means that discharges during the first six months in 'Other Toxic Compounds' (Table 5) are clearly higher than discharges during the whole year 2008 (325 tonne vs. 245 tonne).

2 Botnia-EcoMetrix changed the calculation method with which furans effluent discharge is expressed (Tables 1 and 2). In every previous report, including July 2008, the method recommended by World Health Organization (WHO, 2000a; Van den Berg et al., 2006) and EPA (U.S. EPA, 2007) was applied. This is the most modern method as referred to in the glossary of this article. Surprisingly, EcoMetrix March 2009 follows the protocol dated 1989 by the North Atlantic Treaty Organization (NATO). Furans discharges during the first six months are expressed in 'TEQ', whereas those of the whole 2008 appear in 'I-TEQ' (see Tables 2, 3 and 5). There is neither equivalency nor conversion factor between both methods due to the different values of the Toxic Equivalency Factor (TEF) (Brantner et al., 1992; Pegg et al., 2007; U.S. EPA, 2007). As a result, apparent concentration during the first six months is ten times higher than the complete year 2008 (Table 2). Dioxin and

furan apparent discharge with effluents (Table 5) is practically equal for both periods. There is no way to improve the emissions of furans during the period in more than 3–5%. This is nothing but an attempt to hide vital information from Botnia. And it could be considered a serious offence.

In the face of these mistakes and omissions, it could be stated without abandoning prudence and maintaining very conservative figures that the actual pollution load value generated by Botnia is much closer to the 15,000 tonne of toxic substances released into the river and the atmosphere. A total of 50 million toxicity units (ng TEQ) of dioxins and furans must be added.

4 EcoMetrix reports and environmental commitment

Why are there so many mistakes and omissions, inappropriate of a recognised technical group? What is the purpose of complicating data representation that any postgraduate student may design and show in a much simpler way?

Why do they insist on analysing 'the state of environment' with criteria and measurements unacceptable for any serious international regulation and discarded by scientific experience?

A plain and clear explanation should be given: the regulations that apply in Uruguay were tailor-made for the Mega-Kraft mill and the forestry-cellulosic project of Uruguayan government. It is the same used for EcoMetrix to judge the responsibility of Botnia regarding the 'state of the environment' It threatens a pristine region of the planet with regulations that do not respect any rule of science, and certainly do not control the physicochemical behaviour of the toxic substances on nature.

Today the whole world claims for a greater commitment with the environment, which is seen fragile and at risk, globally.

There are already many people affected by the continuous contamination generated by Botnia in the lower Uruguay River catchment area. Severe recent events caused by toxic gases in Fray Bentos (Uruguay), Gualeguaychú (Argentina) and the region along coastlines are other clear examples (Análisis, 2009; El País, 2009; InfoBae, 2009; MaximaOnline, 2009b; MaximaOnline, 2009c; Montevideo Portal, 2009). It is also undeniable the discharge of thousands of cubic metres of chemical supplies in 3–4 February 2009 at Botnia's dock (El Día, 2009a; El Día, 2009b; La Nación, 2009; MaximaOnline, 2009a). In addition, arsenic, heavy metals, dioxins and furans early detection in the river sediment just in front of Botnia climbed to 3–6 times higher proportions, in relation to the samples taken more than 50 km upstream, only ten months after the mill start-up (INTI, 2009).

The case has been filed at the International Court of Justice. Here, technical opinions may be decisive for Botnia continuity and the environment of the catchment area.

Even of a further importance is the fact that there is a huge and valid preoccupation in more than 150,000 people about their uncertain future, involving not only their quality of life (health, recreation) but also the economic conditions of the area they live in. People have the right to expect a prestigious consultant, summoned by a Multinational Bank to broadcast a reliable and enlightening report, an 'independent monitoring', to honour this responsibility.

Regrettably, EcoMetrix reports on Botnia do not rise to the occasion. The magnitude of the omissions is huge, as well as the quantity, the characteristics and the repetition of mistakes. The insistence on a discourse that is contrary to the figures and the experience of world is exaggerated. Testimonies are more than abundant. Who – as an independent expert – could accept that the flaws mentioned are fortuitous? Mustn't we have to consider these facts as a glaring problem of ethics in science and technology?

Perhaps it is time we reminded the involved institutions of what they say about themselves: **"**World Bank is a vital source of financial and technical assistance to developing countries… we provide low-interest loans, interest-free credits and grants… for a wide array of purposes that include investments in education, health… financial and private sector development, agriculture, and environmental and natural resource management" (World Bank, 2009). "…people should have the opportunity to escape poverty and improve their lives. Our values are excellence, commitment, integrity, and teamwork" (IFC, 2009). "Environmental Specialists providing the highest quality of professional consulting service to industry and government. The environment is the world in which we live and play. It requires care and consideration, which requires knowledge and experience. This is the role of EcoMetrix" (EcoMetrix, 2009b).

5 Conclusions

1 EcoMetrix-World Bank report, March 2009, confirms the excessive pollution load level to which Botnia subjects the lower Uruguay River catchment area, announced in advance by the same consultant report, July 2008. This pollution load, according to the background known, will cause serious and irreversible damages to the flora, fauna and health of the inhabitants of the basin within a few years.

2 Toxic emissions of around 8500 tonne for all year 2008 are deduced from the report figures. However, more realistic projections indicate continual emissions of 15,000 tonne of toxic substances released into the river and the atmosphere and 50 million toxicity units (ng TEQ) of dioxins and furans.

3 For a second time, EcoMetrix has not reported on any relevant parameter illustrating 'the conditions of the environment' in his 'Environmental Performance Review 2008 Monitoring Year'. Any related definition is therefore, hasty and capricious.

4 EcoMetrix reports are far from reaching the technical quality and clarity that would be expected from an international technical office. Omission, repetition and a confusing presentation of the vital technical information discredit their assertions and question the role as an 'independent consultant' of the World Bank.

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Glossary of Terms and Abbreviations

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

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.

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.

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

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.

Elemental Chlorine: Chlorine gas (Cl_2 g).

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

EcoMetrix: EcoMetrix Incorporated, Ontario, Canada.

EPA: United States Environmental Protection Agency.

IFC: International Finance Corporation, World Bank.

I-TEQ (*International Toxic Equivalence Quotient*): Recommended by a Committee of NATO in 1989 and widely used, even after the WHO-TEQ were imposed. Similar to TEQ calculation, the I-TEF has different values than WHO-TEF for dioxins and furans congener. Consequently, there is not conversion factor to switch from TEQ to I-TEQ or vice-versa.

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.

Kraft pulp: Cellulosic pulp ('cellulose') produced with the Kraft process.

NATO: North Atlantic Treaty Organizations.

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) (April 2009).

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

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.

TEF: Toxic equivalent or equivalency factor (see also TEQ, I-TEQ).

TEQ (*Toxic Equivalence Quotient*): EPA TEF and TEQ are identical to WHO TEF and TEQ. 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 × 1) + (20 g × 0.5) + (30 g × 0.2) = 26 g TEQ. From http://www.epa.gov/tri/lawsandregs/teq/teqprule.html (April 2009).

WHO (*World Health Organization*): WHO is the directing and coordinating authority for health within the United Nations system.