BIOSSOLIDS PRODUCTION WITH SOLID WASTERS GENERATED IN CENIBRA`S HARDWOOD KRAFT PULP MILL

[1]CARVALHO, Sebastião T., Celulose Nipo-Brasileira S/A, Belo Oriente, Brasil
[2]GUERRA, Marcos Antonio de S. L., Celulose Nipo-Brasileira S/A, Belo Oriente, Brasil
[3]LANDIM, Alexandre B., Celulose Nipo-Brasileira S/A, Belo Oriente, Brasil
[4]ALMEIDA, Antônio R., Celulose Nipo-Brasileira S/A, Belo Oriente, Brasil
[5]ANICIO, Deilson L. V., Celulose Nipo-Brasileira S/A, Belo Oriente, Brasil
[6]PIMENTA, Leonardo M., Celulose Nipo-Brasileira S/A, Belo Oriente, Brasil
[7]FELIX, Rinaldo C., Celulose Nipo-Brasileira S/A, Belo Oriente, Brasil
[8]VITORINO, Marcela D., Celulose Nipo-Brasileira S/A, Belo Oriente, Brasil

ABSTRACT

With objective uses of the fibrous residue, woody and biological sludge of the effluent treatment Station (ETS) generated in the industrial process, developed the study of the compound to assess the characteristics of the compost (biossolids) produced with its residue. The composting is the biological process of the conversion of raw organic material into the humid and stabilized substance use the mixture of rich material in carbon (fibrous and woody) with others rich in nitrogen (biological sludge). The carbon material supplies the organic material to the compost process and the nitrogenous materials supply protein, nucleic acid and amino acids apart from contributing to the growth and the cell operation of the organisms involved in the process. The wasted used for the compost pile preparation were: eucalyptus bark, grounded eucalyptus bark, the ash from the boiler biomass, biological sludg and urea. The study lasted 320 days and had measured the preparation of eight compost piles with different composition and size. The piles had biological sludge as the source of nitrogen in its composition and the woody and fibrous residues the source of carbon that presented satisfactory results in relation to the temperature, pH and relative C/N, during the period of composting, and the pile which didn't have any sources of nitrogen, the relative C/N was above that recommended, and disrupted the process of the compound. Notice that there isn't the necessary of adding urea the source of nitrogen because the biological sludge presented similar characteristics apart from being economically viable. The dioxin analysis in compost piles presented excellent results because it's were below the permitted limits of the U.S. Environmental Protection Agency (EPA/1989) and World Health Organization (WHO/1997) laws, since Brazil doesn't have the law regarding this condition yet, alone it gives evidence of the success of the environmental production 100% ECF. The reverse-utilization of the humidified compost ingredients goes to the forest area becoming of fundamental importance to the company, first in function of recycling and second because it returns nutrients back to the soil in the form of minerals.

KEY WORDS
Compost, biological sludg, dioxins

1- INTRODUCTION

The pulp and paper industry is a productive activity browing faster Brazil. Among the ten industries of great benefit to our country, that produces more than eight hundred tons a day, several have duplicated this production recently, and others, should make it in the next years (Fassa et al., (1996)).

In view of that ,Haccket (1999), these industries have been, collectively, more and more monitored by the responsible environmental organs, so that alternatives for the disposition of the residues can be generated in the factory in such a way that won't bring adverse consequences to the environment.

According to Budziak, (2004) was found an alternative some years ago for the pulp and paper industry to treat these rejects, it was to incinerate into the open sky or storage in inadequate places. This way, it happened, the volume of emitted highly poisonous organic matter, provoking damage to the environment, mainly in streams, rivers and springs.

It is in this context, several investigations are in the ongoing to seek uses for these residues, that allow their use and to decrease the environmental impact. Among the highly praised solutions, the biossolids production is positioned as an interesting alternative, given its low cost and its simplicity in technological terms, still allowing obtaining natural fertilizers, whose application will allow it to return to the field the only nutrients for the plants.

The composting is a bio-oxidative process controlled that, in appropriate conditions of humidity, it produces the degradation of heterogeneous residues for use by varied microbial flora. During the composting process, the aerobic microorganisms degrade leaves from the organic fraction to carbon dioxide, water and mineral salts while other part go through a humidification process, resulting in a stable composition that possesses the appropriate characteristics for the use as an organic fertilizer. The properties of the final composition depend on the humidification degree reached during the process that, usually, it doesn't terminate completely in the composting unit. It follows a maturation phase then to room temperature, during the time in its applied soil, after the application of the fertilizer (Duffle-hall et al., (2002); Budziak et al., (2004)).

According to Budziak et al., (2004) and Vagstad et al., (2001) the pulp and paper industries possess essential materials for the compost process as source of carbon and nitrogen. The pulp and paper industries generate several types of residues as: woody residues as the bark of Eucalyptus, the residual ash from biomass in the burning auxiliary boilers ; the mass of this biological sludg obtained in the stages of effluent treatment, and secondary treatment systems, that it is rich in nitrogen and it possesses high values of organic matter.

In spite of the composting being an efficient treatment process and with great fertilization results in the plantings, possibilities of contamination exist due to certain chemical structures, the problem is explained is of a complex nature of the mixtures of dioxins and furans. To outline this problem, the concept of Poisonous Factors of Equivalence was developed (Toxic Equivalence Factors) or TEF's, that represent the relative toxicity composed of the group of the dioxins and furans in relation to 2,3,7,8 TCDD (Tetra-clorodibenzene-p-dioxin), whose value of TEF is same to the unit. The values of TEF for a composition and its concentration can be used to calculate the Equivalent Poisonous (Toxic Equivalent) or TEQ, and this value is the same of the product of TEF for the concentration of the substance measured in the sample (Hackett, (1999)).

In the last analysis, the formation of these compositions necessarily needs a source of chlorine, a source of organic matter and a thermal atmosphere or chemical reagent, as well as the prevalence of such potential conditions to render the formation of these composed. The main sources of formation of dioxins and furans are related to conditions of incomplete combustion, but in the case of the pulp industry, these precursors are related to the process of bleaching the pulp where elementary chlorine is used. The large industries are adhering new technologies as, for instance the pre-delignification with O_2 adoption and the substitution of Cl_2 for ClO_2 in the bleaching plant (Fisher and Gillespie, (1998); USEPA, (2000B) phase Mounteer, (2004)).

2 - MATERIALS AND METHODS

Materials

The materials used in the experiment were: biological sludg, dirty Eucalyptus bark and triturated biomass wasted from boilers, urea, and ash from the precipitator eletrostatic (Biomass Boilers). The materials were mixed in relation to the inicial C/N ratio distributed in piles with different compositions.

Table 1: Results of the analyses of the residues before the making of the piles.

		Wood yard wastes	***Bark of Eucalyptus***	***Biological sludg***	***Ash from eletrostatic precipitator***	***Triturated biomass***
PH				7,15	12,55	
Humidity 110ºC		20 – 30	40 – 48	92,97	23,90	42
Total Organic Materials		70	90 – 97	86,61	19,46	96
C Total			52	48,12	10,81	53
N Total			0,30	6,08	0,11	
P	%		0,03	1,63	0,53	
K			0,40	0,56	4,17	
Na		Inorganics Materials 30%		1,27	0,63	
Ca			1,13	1,54	15,66	1,59
Mg			0,12	0,28	2,37	0,13
S				0,06	0,23	
Zn				58,4	59,8	
Cu	mg/dm^3			23,8	35,4	
Fe				7132	20453	

Compositions of the compost piles

Eight piles were prepared with the objective of testing different compositions. The nitrogen in the form of biological sludge and urea, were included in some piles to reduce the C/N ratio and to accelerate the decomposition process. The compositions of the piles were of the following sequence:

Pile 1 - Wood yard wastes with Biological sludge;
Pile 2 - Bark of Eucalyptus with Biological sludge - mixing every 10 days;
Pile 3 - Bark of Eucalyptus with Biological sludge - monthly mixing;
Pile 4 - Bark of Eucalyptus with Biological sludge;
Pile 5 - Bark of Eucalyptus;
Pile 6 - Bark of Eucalyptus with Biological sludge and ash from eletrostatic precipitator (EP)
Pile 7 - Bark of Eucalyptus with Biological sludge and urea;
Pile 8 - Triturated biomass wasted from boilers with Biological sludge.

Table 2: Treatment scheadule.

	Bark of Eucalyptus	***Triturated biomass***	**Wood yard wastes**	***Biological sludg (9,5%)***	***Ash from eletrostatic precipitator***	***Urea***	***Total (Kg)***
	Kg						
Pile 1			*23.040*	*9.000*			**32.040**
Pile 2	*13.500*			*9.000*			**22.500**
Pile 3	*13.500*			*9.000*			**22.500**
Pile 4	*13.500*			*9.000*			**22.500**
Pile 5	*13.500*						**13.500**
Pile 6	*13.500*			*9.000*	*800*		**23.300**
Pile 7	*13.500*			*9.000*		*100*	**22.600**
Pile 8		*12.630*		*9.000*			**21.630**

Size and construction of the piles

The piles were built in a triangular way and with approximate size of 3m of high by 4m wide, and materials were mixed schedule proportion one the piles with hydraulic digger aid.

Monitoring

The temperature was measured daily at three points of the piles (base, center and top), with the objective of evaluating the need of the remixing.

Monthly compost samples were collected in each composition pile for humidity monitoring, PH, organic material, carbon and nitrogen analysis.

Remixing

During the period of the composting, remixing was done in 10 days except for the pile number 3 that was remixed monthly, such procedures allow the promotion of aeration and to reduce the temperature of the same ones, since the temperature decomposition of the materials can reach up to 70ºC.

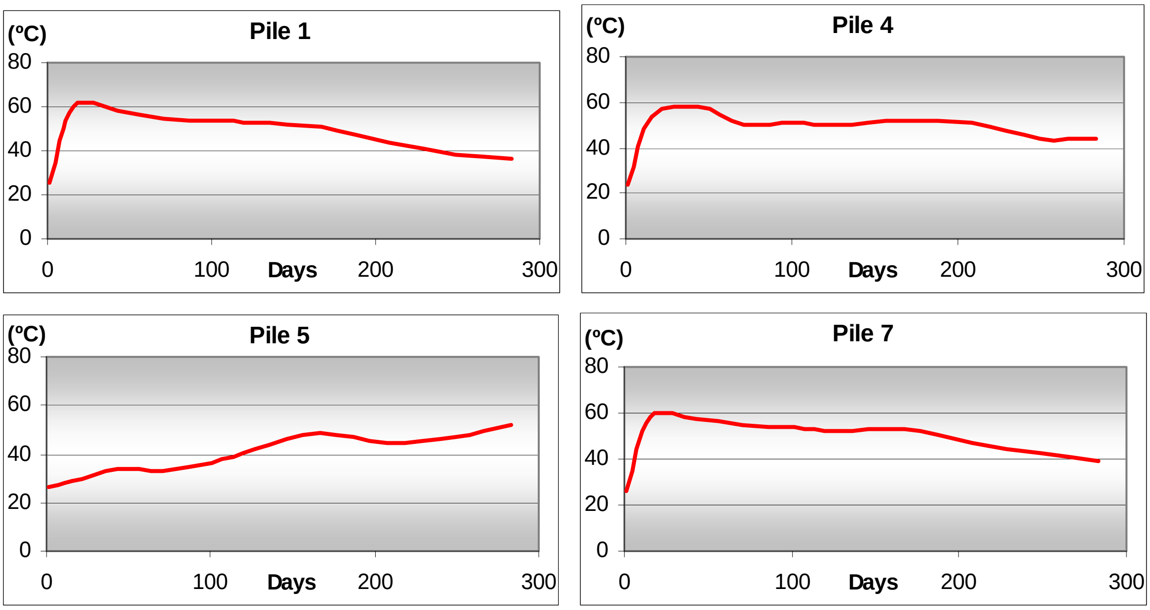
Picture 1: Remixing and aeration of the compost piles
Source: Cenibra S/A

3 - RESULTS AND DISCUSSIONS

The main factors that governed the test of the compost will be commented on in the following:

Temperature

Second Pereira Neto (2004), in the composting process the temperature is the factor more indicative of the biological balance, what reflects the efficiency of the process. The modern compost process is associated to the thermophile development of temperatures, controlled in the strip from 50 to 65ºC, what guarantees a series of advantages as: development of a diversified microbial population, an increase in the amount of decomposition of the organic matter, like as the most important the elimination of pathogenic microorganisms, seeds of weeds, eggs of parasites and larvae of insects.

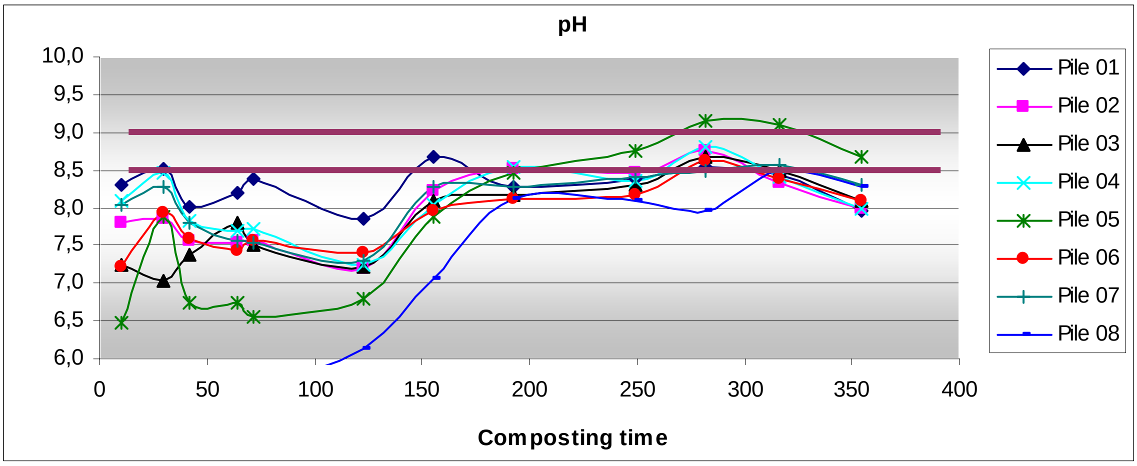


Graph 1: Composting time vs.Temperature of the piles

As they recommended by Kiehl (1985) and Pereira Neto (2004), the piles in the test showed temperatures in the strip as recommended, being not above 65ºC in application of the mechanism of used during aeration, in the beginning of the compost an elevation of temperature was observed and it declined over time trending until it stabilized. Just the temperature of pile 5, where there was no addition of nitrogen, the temperature rose gradually over the time.

The high temperature as it was already commented on in the beginning, it interrupts the whole microbial activity in the process, and the disposition of an organic residue in the pile without the due aeration worries, it will propagate an anaerobic atmosphere with serious risks of spontaneous combustion.

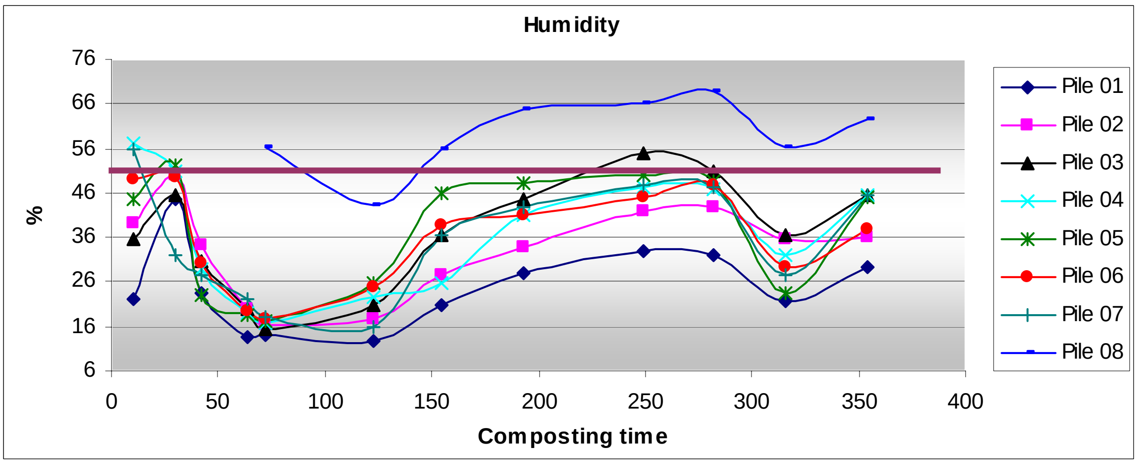
pH



Graph 2: Composting time vs. PH.

According to Kiehl (1985), in the first days of composting process the composition can become more acid yet, due to the formation of small amounts of acids minerals, that soon disappear, and they give way to the organic acids, these, as they go on forming is neutralized reacting with the liberated bases of the organic matter. At the end of the composting, the piles possessed a neutral tendency.

Humidity



Graph 3: Composting time vs. Humidity.

In humidity terms, this stayed around 20 to 50% during the composting process, but Kiehl (1985) recommends for a great humidity during the composting around 55%, which was the maximum limits and desirable minimum, same to 60 and 40%. The pile 8 presented the highest humidity value, and pile 1 had during whole the decomposition process the lowest percentage of humidity. That fact influenced the composting process, could have affected the attained maximum temperature and also the time of decomposition.

The way the biological sludge was applied to the compost piles, for aerating or through close weighing, the piles later were mixed with the digger didn't have any influence in the humidity percentage, because: the humidity in both cases was practically identical.

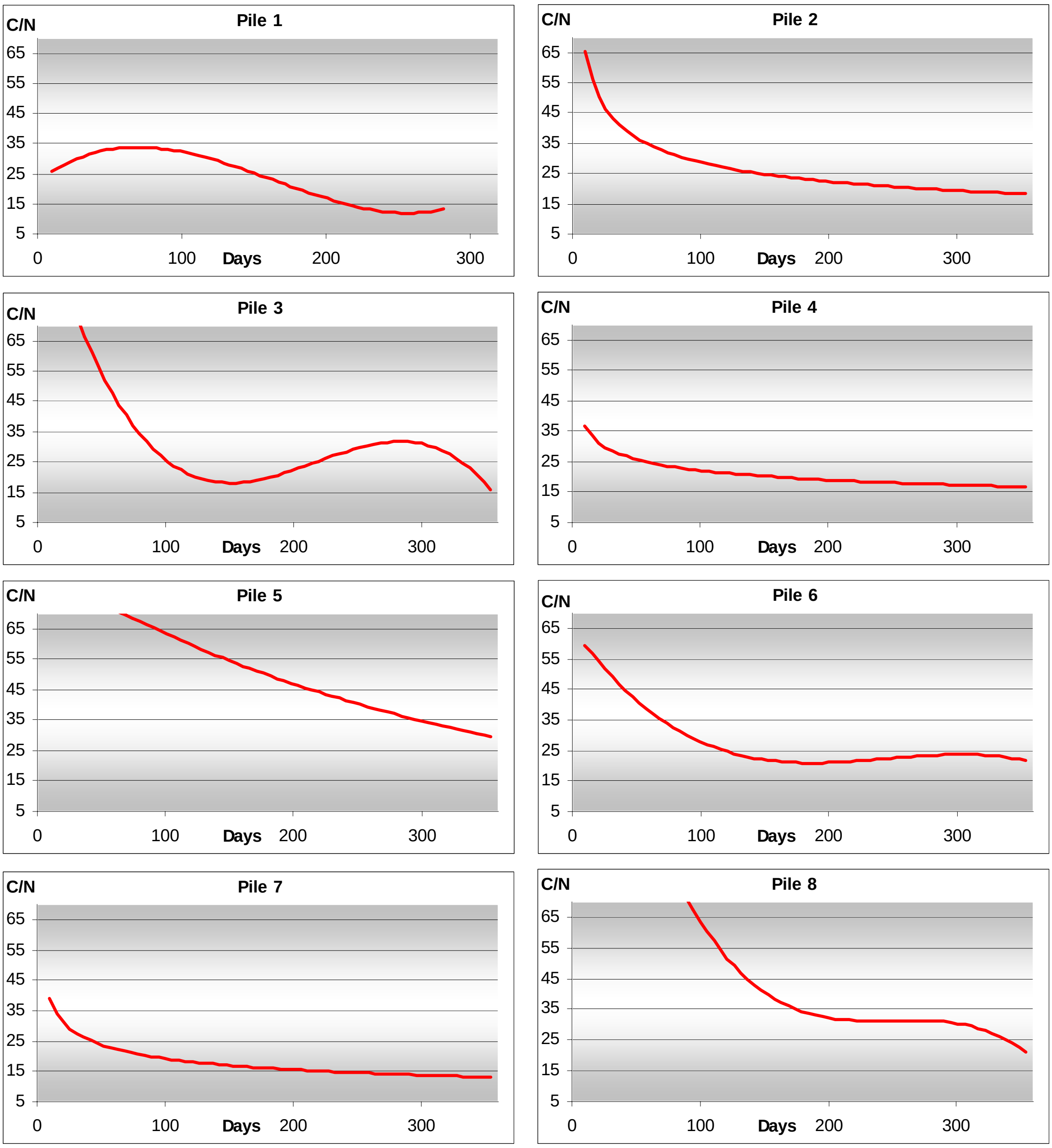
It was decided no water addition during the test, because this option would increase the production cost considerably.

Ratio C/N

The necessary time for the bioestabilization depends on several factors and according to Kiehl (1985) a composed bioestabilized is not obtained before 30 to 60 days, or a humidified before 90 to 120 days.

The experiment had duration of 350 days, due to the study of the behavior ratio C/N along this period.

Kiehl (1985), it concludes that the final ratio C/N, of any material composted and humidified, should be from 8/1 to 12/1, however, materials with ratio C/N 18/1 or a little larger they are already bioestabilized, could be used as organic fertilizer without risk of causing damage to the plant.



Graph 4: Time of composting vs. Relation C/N of the treatments used

Table 3: Relation C/N during the composting period:

Piles	C/N					Bioestabilization
	10º days	50º days	150º days	200º days	250º days	
1	26/1	30/1	26/1	17/1	14/1	180º days
2	66/1	36/1	24/1	22/1	20/1	220º days
3	91/1	50/1	20/1	-	-	150º days
4	35/1	26/1	21/1	18/1	16/1	130º days
5	87/1	62/1	55/1	47/1	35/1	-
6	60/1	40/1	21/1	21/1	-	180º days
7	44/1	25/1	18/1	16/1	15/1	120º days
8	-	86/1	33/1	32/1	31/1	-

For the test a ratio was used based on C/N in the sludge generation and available woody material for the process. As the generation of natural bark during the period was considerably larger than the one of sludge (main source of nitrogen), the ratio of initial C/N was above its recommendation, being a fundamental factor for determining the time of composting.

The pile 1 constituted by wood yard wastes and biological sludge presented satisfactory results of temperature, PH and the ratio to C/N, but the humidity had a lower value than the other ones and was not recommended.

The piles 2, 3 and 4 were constituted of eucalyptus bark and biological sludge, being differentiated by the volume and time of mixing. In temperature terms, pile 4 having the larger base and shorter height presented graphic behavior as is recommended in Kiehl (1985), and losing temperature over time. The piles 2 and 3 had more difficulties in losing temperature. The PH was satisfactory in the three piles and the ratio C/N of the pile 2 and 4 finished the test with the ratio below 18/1. Pile 3 having a monthly mixing, presented difficulty in aeration had ratio of higher C/N. These three piles can be compared with the composting process in CENIBRA, mainly for the composition and operational patterns in area the composting.

We took as reference pile 5 to study the behavior of the bark of Eucalyptus inserted into the yeard or in the composting areas without receiving biological sludge. The temperature continued increasing through time due to slow degradation of the microorganisms. Its ratio to C/N was always superior to 30/1.

The piles 6 and 7 presented a good correlation and recommended it for the process, opening options for the composting project in CENIBRA. In pile 6 ash was added and in pile 7 urea was used. This way, it became evident that the need for the introduction of urea isn't needed in the process; the option to use is biological sludge as source of free nitrogen with low cost, favoring the studied original proposal strongly. In a similar way, the introduction of residual ash becomes viable in the composting, without negative effects to the kinetics of the process.

Pile 8 composed of biomass and biological sludge had begun 30 days after the test start-up. The temperature stayed above 50ºC for the whole period. It presented the best result of organic matter and humidity of the test staying inside the recommended values. Its PH became more acid than the other ones, but it also met the values of the recommendation strip. The ratio to C/N was reduced over time concluding with 22/1 at the end of the tests, but it would tend to decrease still more. This pile represents a stage of important composting in relation to the stocks of the product in the area.

The tests of the composting was thoroughly satisfactory, the acquired results of this work will be of extreme importance for the dispersing of residues generated in the industrial process of CENIBRA.

4 - LIMITS OF REFERENCE FOR DIOXINS AND FURANS

Now the values of dioxins and furans is being widely discussed by environmentalists mainly when it is treated with your quantity of pulp mill, in function of the use of Cl_2 (active chlorine) in the called standard process, now this view is changing once most of your colleagues are substituting this precursory agent, for the processes ECF (Elemental Chlorine Free) and TCF (Total Chlorine Free) that uses ClO_2 H_2O_2 respectively. After 2002 Cenibra banished the use of the active chlorine in the bleaching process; this change allows the use of the biological sludge as source of nitrogen for composition production, eliminating the risk of contamination to the environment with chlorinated pollutants.

In this experiment the amount of dioxins and furans were analyzed, the results are demonstrated in the table below.

Table 4: Toxic Equivalent for the piles.

	Pile 1		Pile 2		Pile 3		Pile 4		Pile 5		Pile 6		Pile 7		Pile 8	
Nome do Composto	***EPA***	***WHO***	***EPA***	***WHO***	***EPA***	***WHO***	***EPA***	***WHO***	***EPA***	***WHO***	***EPA***	***WHO***	***EPA***	***WHO***	***EPA***	***WHO***
2378-TCDD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12378-PeCDD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
123478-HxCDD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
123678-HxCDD	ND	ND	0.018	0.018	ND	ND	ND	ND	ND	ND	ND	ND	0.031	0.031	ND	ND
123789-HxCDD	0.031	0.031	0.035	0.035	0.026	0.026	ND	ND	0.016	0.016	ND	ND	0.022	0.022	ND	ND
1234678-HpCDD	0.01	0.01	0.024	0.024	0.018	0.018	0.015	0.015	0.015	0.015	0.015	0.015	0.13	0.13	0.0049	0.0049
12346789-OCDD	0.0048	0.00048	0.013	0.0013	0.013	0.0013	0.0082	0.00082	0.01	0.001	0.0078	0.00078	0.13	0.013	0.0025	0.00025
2378-TCDF	ND	ND	0.067	0.067	0.027	0.027	0.023	0.023	ND	ND	ND	ND	0.033	0.033	ND	ND
12378-PeCDF	0.0038	0.0038	0.007	0.007	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
23478-PeCDF	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
123478-HxCDF	0.012	0.012	0.017	0.017	0.013	0.013	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
123678-HxCDF	0.006	0.006	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
123789-HxCDF	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
234678-HxCDF	0.0066	0.0066	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1234678-HpCDF	0.0032	0.0032	0.0022	0.0022	0.0026	0.0026	0.0024	0.0024	ND	ND	0.0023	0.0023	0.013	0.013	ND	ND
1234789-HpCDF	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12346789-OCDF	0.00036	0.000036	0.00052	0.000052	0.00066	0.000066	0.00047	0.000047	0.00045	0.000045	0.00041	0.000041	0.0035	0.00035	0.0004	0.00004
Grand Total TEQ ng / kg or pg / g	**0.07776**	**0.073116**	**0.18372**	**0.171552**	**0.10026**	**0.087966**	**0.04907**	**0.041267**	**0.04145**	**0.032045**	**0.02551**	**0.018121**	**0.3625**	**0.24235**	**0.0078**	**0.00519**

U.S. Environmental Protection Agency (EPA/89)
World Health Organization (WHO/97)
ND - No Detected

The obtained data evidence that the organic biossolids produced by CENIBRA brings together conditions being applied as fertilizer without any risk for the environment, in function of the detected values as they are well below the established limits in the the legislation (1 ng TEQ / kg) compared to the most extreme limit for 2378 TCDD.

5 - CONCLUSIONS

The composting test with their different piles and compositions was fundamental for obtaining of reference data to the needs of CENIBRA. The obtained results were considered satisfactory, and it will serve as a reference for implementation of the project

The test was very important for the understanding of the compost preparing piles with ratio C/N as established by the literature, this being a fundamental parameter for the process.

The control of the humidity is another factor that must be considered, because, the non observation of this parameter, will prolong the decomposition time and change the final quality of the product.

The composting at CENIBRA will use wasted woody, ash precipitation, and matter that won’t be applicable in other industries/processes.

The reutilization of the final product of the composting, destined to the forest area, is fundamental for the company, first for the recycling sense and second because it returns to the soil nutrients in the form of minerals and organic materials, closing the cycle of the CENIBRA bleached Kraft process.

The analysis of dioxins in the final product also evidences the environmental success of 100% ECF production, because all of the products and matters related meet lower than the permits limits for the EPA/89 and WHO/97 legislations, one of the most restrictive laws all over the world.

6 – BIBLIOGRAPHY

BAETA-HALL, Lina, SÀÁGUA, M Céu, BARTOLOMEU, M. Lourdes , ANSELMO, Ana M., ROSA, M.Fernanda Rosa. **A compostagem como processo de valorização dos resíduos produzidos na extracção de azeite em contínuo.** Lisboa, Biotecnologia Ambiental, 2002.

BUDZIAK, Cristiane R., MAIA, Claudia M. B. F., MANGRICH, Antonio S. **Transformações químicas da matéria orgânica durante a compostagem de resíduos da indústria madeireira.** Quimica Nova, Vol. 27, No. 3, 2004.

FASSA, Anaclaudia Gastal, FACCHINI, Luiz Augusto, AGNOL, Marinel Mór Dall'. **Trabalho e morbidade comum em indústria de celulose e papel: um perfil segundo setor.** Cad. Saúde Públ., Rio de Janeiro, 12(3):297-307, jul-set, 1996.

HACKETT, Graydon A.R., EASTON, Charles A., DUFF, Sheldon J.B. **Composting of pulp and paper mill fly ash with wastewater treatment sludge.** Bioresource Technology Nº 70, 1999.

KIEHL, Edmar José, **Fertilizantes Orgânicos.** São Paulo, Ed. Agronômica Ceres Ltda. 1985.

MOUNTEER, Ann H. **Características e riscos biológicos do lodo de estações de tratamento de efluentes da industria de celulose – revisão.** Relatório Técnico. Departamento de Engenharia Civil – UFV, fevereiro, 2004.

PEREIRA NETO, João Tinôco, **Compostagem: fundamentos e métodos**, 1º SICOM – Simpósio sobre Compostagem. Botucatu, SP, 2004.

VAGSTAD, N., BROCHE-DUE, A., LYNGSTAD, I., **Direct an residual effect of pulp end mill sludge on crop yield and soil mineral N.** Soil Use and Management, British Society of Soil Science, 2001.