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Achievement of Tertiary Treatment and 99% + Reuse of Mill Solid Waste

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We are quite sure that everybody knows that the world is becoming smaller and smaller. We are also sure that green management is here to stay. Green and yellow are the colors of my country - yellow for the sunshine we have all the year to grow our green forests. Brazil is a huge country with a huge number of people who work hard and believe in the future. This is the place where Riocell is located. There is a river we call Guaiba River; it's more or less like a lake. The mill is located here, and just across the river we have a huge city, with about 1.5 million inhabitants. They are all paying attention to us, watching what we are doing in the mill. By the way, it's a wonderful area and we like it very much. Also, you can see where the mill is located. This is the Guaiba River and the city is about 3 to 5 miles away. It's Porto Alegre, capital of Rio Grande do Sul, South of Brazil. At Riocell we make both paper and dissolving grade pulps. We also make some small amounts of paper -- about 10% of our production. We are an exporting-oriented mill. Both dissolving and paper grades are domestic and exported products. This is another view of the company. By the way, we are both a wastewater treatment plant and a pulp mill. It's a nice facility here and we are going to talk about this later, after some more information about the company.

We decided to have a policy to become completely transparent to the surrounding community. This is quite important. It's a kind of management will, to be open with the community, to be transparent. You must tell them what you are doing and you must communicate with them, so we are what we call, "an open book". We are not alone in the environment. We are in a society and we have a lot of problems to solve every day -- and some problems are still demanding to be solved. Our families are part of this society. This wonderful family is my family and they live in the same surroundings where the company is located, so it's important to keep them happy. We use eucalyptus as source of raw material. This important raw material comes from planted forests. We plant all the wood we consume and this is used in all Brazilian pulp manufacturing companies. You always hear that the Brazilians are destroying the rain forest to make pulp, and it's a mistake,

an error. Our pulp in Brazil is made using planted forests and it always must be done in a sustainable way, combining natural forests together with plantations. You'll see here in the slide, that it's not important to have a huge forest. It's important to have small forests blended together with other sources of activities like cattle growing or rice plantations -- and so on. Thusly the people, the community, don't feel that you are planting too many eucalyptus or planted forests. They become integrated with you. You see here that these lower level forests are native, natural, the eucalyptus grows faster than the natural vegetation. It's important to have a very uniform raw material. This is a cloned forest, 2 1/2 years old. It's about 12 meters high. This is the wood with seven years of age that is used in the pulp manufacturing. In our case, it's debarked by some mechanical devices in the forest and we use all this bark as a fertilizer for the forest. As you can see here, it's a very fantastic humus for the forest. We also keep all the branches and leaves to give some nutrients to the next generation of trees. This is all because eucalyptus is a fantastic species that can sprout and create a new forest from its stumps. Also, the forest must be integrated with the community, so we allow the local farmers to grow cattle, to grow beans, and so on, right in our forests. In our forests we have about 2000 heads of cattle being farmed -- and not a single one belongs to Riocell. It's a social benefit, a social integration with the community. This other mill was Riocell 20 years ago and believe it or not, we were proud at that time of having such a progressive mill. It's a completely different mill. We had to convert ourselves, with a lot of money, R & D, and efforts from people were placed to "exchange" the mill for another one. You see, 15 years ago, when I started to work at Riocell, I took this picture. It was filled with fumes -- fume gases from the recovery boiler. This point here was the sun, so it was very difficult to convert the old mill to the today mill, but we got it. The population gives more than 80% of full acceptance to Riocell. This is quite impressive, because not a single president in most countries receives more than 80% of the public's votes. This is the way of democracy. The first point was to reduce the odor/smell, so we reduced sulfidity. Since 1992 we have reduced sulfidity to about the 5% level. And we reduced this sulfidity from 20% to about 5% using AQ. We have a charge of 0.05% AQ based on wood. Because of this, total TRS emissions were reduced. We have now, adding all sources, about 15 grams of TRS/ton of pulp, this is about 25-30 lb TRS/ton of pulp; that's a very good figure. However, we still have some smell and we have to improve even more. The second step was to improve the quality of the effluent; and this is the raw effluent. Riocell

uses about 40 m^3/ton of pulp. Forty m^3/ton of pulp is similar to the figures that have been shown by other speakers in this session.

Lets follow our waste water treatment: we have the primary clarifiers, heat exchangers, to reduce temperature; we have an aeration pond; then an activated sludge reactor; it's our UNOX system; it's a closed system made by Union Carbide/Degremont; then the required secondary clarifiers, and finally the tertiary step. This last treatment is done using alum for color removal, since color after the secondary step is still the same as the raw effluent. To reduce the color we were obliged to use the alum and clarification. We also have an emergency pond that enables us to keep the effluent in case of any problem with any of the equipment during the process. The activated sludge reactor is very compact and very efficient. After that we also have a neutralization stage. You see here, because of the alum, the pH is low, about 5.0, so you may see some corrosion. I'm sorry about the corrosion, but nothing is perfect.

We are concerned about a new trend that is coming into the country. The government has decided to tax the natural resources and, surely within a few years, we'll all not only have to pay to use the water but, we'll have to pay to throw it back the into the river. Thus, we must develop the total effluent free mill. Should we change technology or should we use end-of-pipe measures? We are working on both cases, and I'm going to have some results for you. We know the results up to the tertiary level, so we decided to continue to a quintenary treatment. It has proven to be very efficient.

After the flocculation and clarification, we still have some very, very fine particles that could be easily removed by sand filtration. I've learned today this has already been done in Russia. Afterward we decided to use reverse osmosis, as it is very efficient. Unfortunately, reverse osmosis also gives some effluent. It's not able to completely close the water cycle: about 30% of total flow became a concentrated effluent. Our idea is to bring it back again into the system and to follow the treatment from the beginning. The only major problem we have is with chlorides, because of accumulation during the process. One place to remove them is the recovery boiler fly ash.

Our projections for the total effluent free process, named "clean rio", is to bear investment costs of about US$160/admt. year. It's about 8% of total capital costs in a new greenfield mill. Operational costs for this are about $10 per admt; handling costs for solid residues about $4 per admt. We are still at the tertiary stage, but have developed the technology to go farther. It's not difficult to go farther -- it only requires a sand filter as a first new step. We can also use a sandwich made of sand and activated carbon with amazing results. Reverse osmosis, in the next stage, is a process using well-known technology.

Now you see the results. We now have our chlorides at about 18 kg per ton. Our AOX today is about 0.12 lbs per 1000 lbs. COD is 4 kg per ton; BOD 0.3 kg per ton... All very low. Color is about 20 kg per ton. Continuing the treatment using filtration with sand and reverse osmosis, we can further reduce the chlorides from 25 to 1.5 kg per ton. This is 94% removal. The AOX from 0.5 in the raw effluent to 0.002, almost nothing. COD can be reduced from 55 to 0.25. This is 99.5% reduction. BOD is very good, but we can reach 0.1 kg per ton. Color goes to nothing, zero.

Today's figures: The pulp has 20 ppm AOX; raw effluent is 0.5 to 0.8 kg per ton, depending on the grade we are making. We have ECF and standard pulp with 75% substitution ratio. We also have dissolving grade, so there is some flexibility in these figures. The treated effluent has AOX in the range of 0.1 to 0.15, average 0.12 kg per ton. Dioxin, we are talking here about total toxic equivalent, all dioxins and furans together, the raw effluent is about 3 ppq, the treated effluent is 0.3 to 0.7 ppq. I emphasize -- we are talking about all dioxins together. Be sure about this, because many times, people refer to dioxin, being only 2, 3, 7, 8 TCDD. This is not the case here. The sludge is from 1 to 6 ppt of total toxic equivalent. In ppq level, we have not detectable 2, 3, 7, 8 TCDD and 2, 3, 7, 8 TCDF in treated effluent. In the sludge, the 2, 3, 7, 8 TCDD is not detectable, but we have about 20 ppt of 2, 3, 7, 8 TCDF, that multiplied by factor 0.1 gives you 2 ppt on the total toxic equivalent.

Now, the next step was to get rid of another problem we had. Being so close to a huge city, as you can imagine, it's difficult to handle and to dispose of solid residues. The objective was to

reduce the solid residues to nothing. Monthly we generate about 12,000 tons of solid residues. Today our rate of recycling is 99.7%. We decided to do this and we've received a lot of help. It also took a lot of effort because we were developing new products for new markets. These products could face some restrictions from the community side, mainly because the sources from which they were made were mill residues. Education, R & D and determination were placed to achieve what we are doing now. The total amount of solid residues in one year is about 160,000 tons. I'm considering the weight as-is, not on a dry solid basis. Take sludge, for example. It has 80% of moisture and we weigh it all. Thus, *total* weight is being considered. Fifty percent of these products go to agriculture. We have developed ways to use as fertilizers. Forty percent go to other industries in the surroundings and 10% go to recover degraded areas due to mining. We have coal mining in the areas surrounding the mill, so we are giving back the ash from the same coal-fired boiler to the mine's holes. Later, the area is covered with our organic fertilizers so that the mining surroundings have a really nice landscaped look, changing a previously ugly face. Our installations are very simple and this is fundamental because to work with residues, the cost may become very high if you go to very sophisticated reactors or very sophisticated plants. So, forget about sophisticated factories. Go for simple things. They are as simple as this: Farmers are simple persons; they like to be practical and objective. We may use these products in our eucalyptus nursery and plantations or sell to local farmers. We decided to have a partnership with a famous Brazilian ecologist, the former Minister of Environment in Brazil, Mr. Jose Utzenberger. He has his company and we have our company, so we decided to work together. I think this sets a good example that we can work together with ecologists and environmentalists. They are nice fellows; they have their ideas, we have our ideas; we can combine them and work for a better future.

The organic sludge is totally converted to organic fertilizer. We have three types of products. The first is blended together with ash to give a kind of soil, it's called "humus soil". The second product is sold as-is, it's only composted sludge which we sell in bulk form, larger volumes. The last is a kind of syrup, called humoflor. I'll show you later, but to make it you take the composted sludge and you blend it with water, make a syrup and apply it together with the water of irrigation over the leaves. This humic material is loved, especially in gardening. You can imagine all these materials, all these residues. You go to the supermarkets and flower shops and you'll find they

like this material. I feel proud and very happy because my residues are becoming useful products. They are being sold and people are accepting them. As I mentioned earlier, we can also sell in bulk. I'm director of the company, but if I want these products, I have to buy them. They are not free, because it's a business. I have to go stand in the line and wait my turn because they are in such demand that it takes some days to get these products. They often are sold out. This is the syrup I mentioned, the organic fertilizer blended with water and used in the water of irrigation. Also, we have another great fertilizer, which is created when the organic sludge is decomposed by earthworms. This is the most expensive of the three, made especially to be sold in small amounts. You might use a teaspoon in your indoor gardening at home. It's well worth the money -- the regular sludge takes two years to ferment. It's a kind of anaerobic fermentation. Afterward, it goes off to be dried and an aerobic fermentation happens. It's a simple thing, as I told you before. If you ask consultants (sorry, consultants or engineering companies) for solutions, they often come up with things that will cost you several million of dollars, and the actual technology can be very simple. We used a very simple drying bed and it just uses sunshine. After drying and fermenting it's screened and placed inside plastic bags or sold as is. We produced lots of research; both chemically speaking and in terms of ecotoxicology. We have tested all these products in terms of Ames test, microtox, daphnia, ceriodaphnia, fish, and a lot more. We conducted a five-year program of R & D evaluations before starting to sell the products on the market. We want to be sure we are doing the best thing., and you need to be sure about it. We must be somewhat conservative, we have to work on the safe side because these products are used to grow food.

All of the sawdust from the chipping and screening of the wood is sold as fuel to small factories in the surrounding areas. From these factories we get back the ash because they are helpful to our fertilizers. We blend the ash obtained from burning the sawdust, together with the organic humus. Some bark also comes to us along with the logs because it is not completely removed and when the logs are washed, the bark pieces are released. They also go for composting. Fly ash from the coal-fired boiler is 100% used by the cement industry and the bottom ash from this boiler goes to recover degraded areas. We have also developed technology to make construction materials. But, these materials still cost more than clay bricks, so we have more to do on this product.

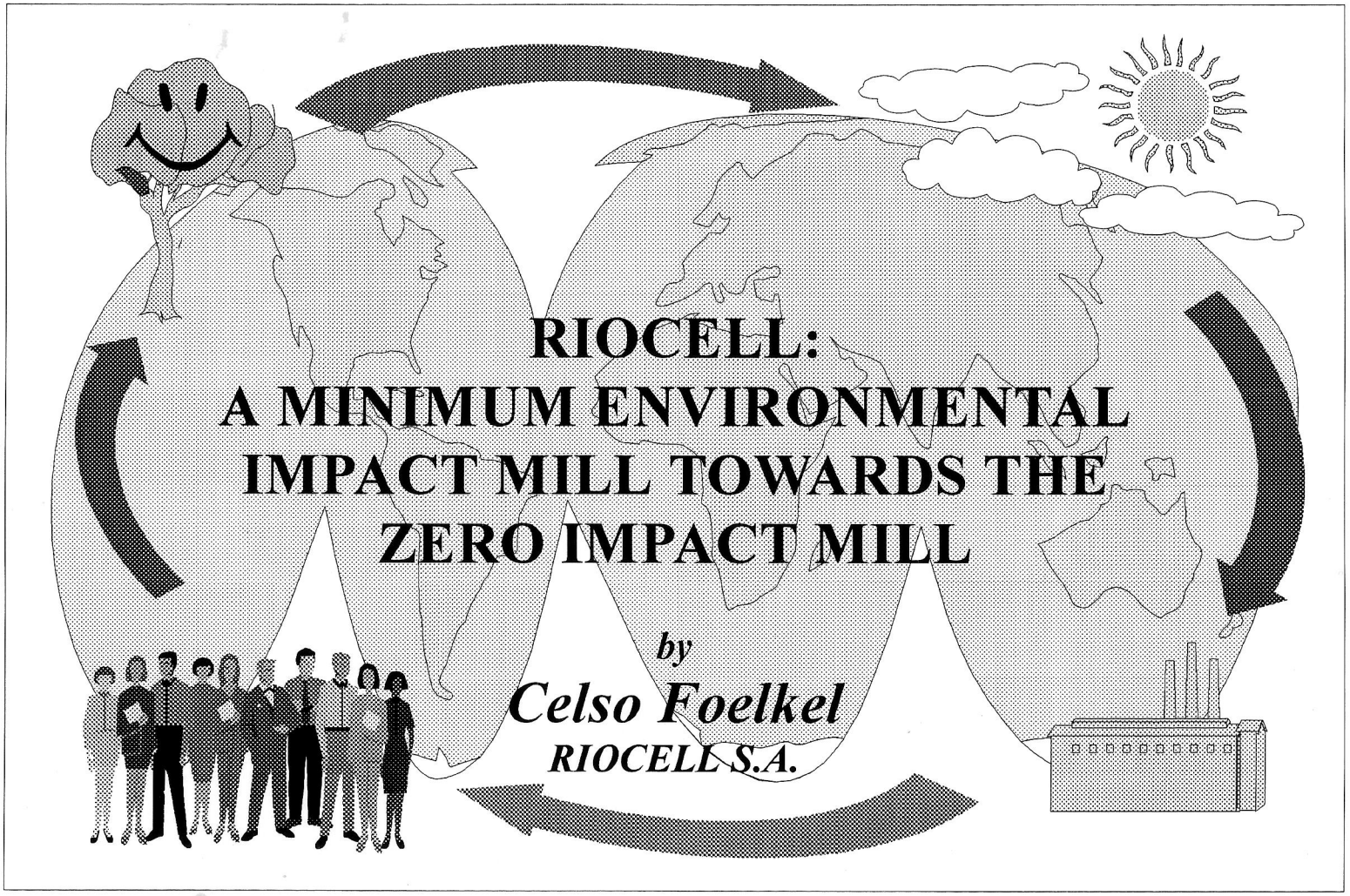
2

Dregs, grits and lime mud from causticising are sold for soil pH correction. They are in high demand.

Dregs has 50% of activated carbon, so it holds the nutrients. It is especially designed for fruit tree plantations. Lime mud is not a true residue. Sometimes, when you have problems at the lime kiln, you have to remove some lime mud. At the same time it is a product that is very widely used by farmers. We sell both either in bulk form or in small plastic bags for garden use.

We also recycle the garbage from our residential area and also from our offices, restaurants, everything. The important is to separate according to the sources, to the nature. If you blend all of these, you are wasting money and time. The secret is to separate according to the type. So what we have, finally is this: A 100% recycling rate for bark; 100% for sludge; 100% for dregs and grits; 100% for lime mud; 100% for fly ash; 100% for bottom ash; 100% for sawdust and 85% for garbage. The remaining 15% of the garbage is plastics, wood, metals, stones and other things that are difficult to recycle. I want to show you the people who work on this, they love what they do. Renata is an agronomist who grows vegetables close to eucalyptus trees, proving that it's possible to grow vegetables together with trees. José is a great fellow and one important thing he does -- and I admire him for this -- is that he teaches children how to grow vegetables using organic agriculture. In a country with poor people like Brazil, it's important to children to learn how to grow food.

My final statements today is: be responsible and somewhat conservative, but don't get scared to try new things. Usually companies become scared about doing things related to environment. They feel that new regulations are going to come along, or some new restrictions are coming. However, it's impossible to restrict all things. Can it mean that what is not restricted, therefore is allowed? If you think and feel you may work, do it. Your ideas could help to improve the world.

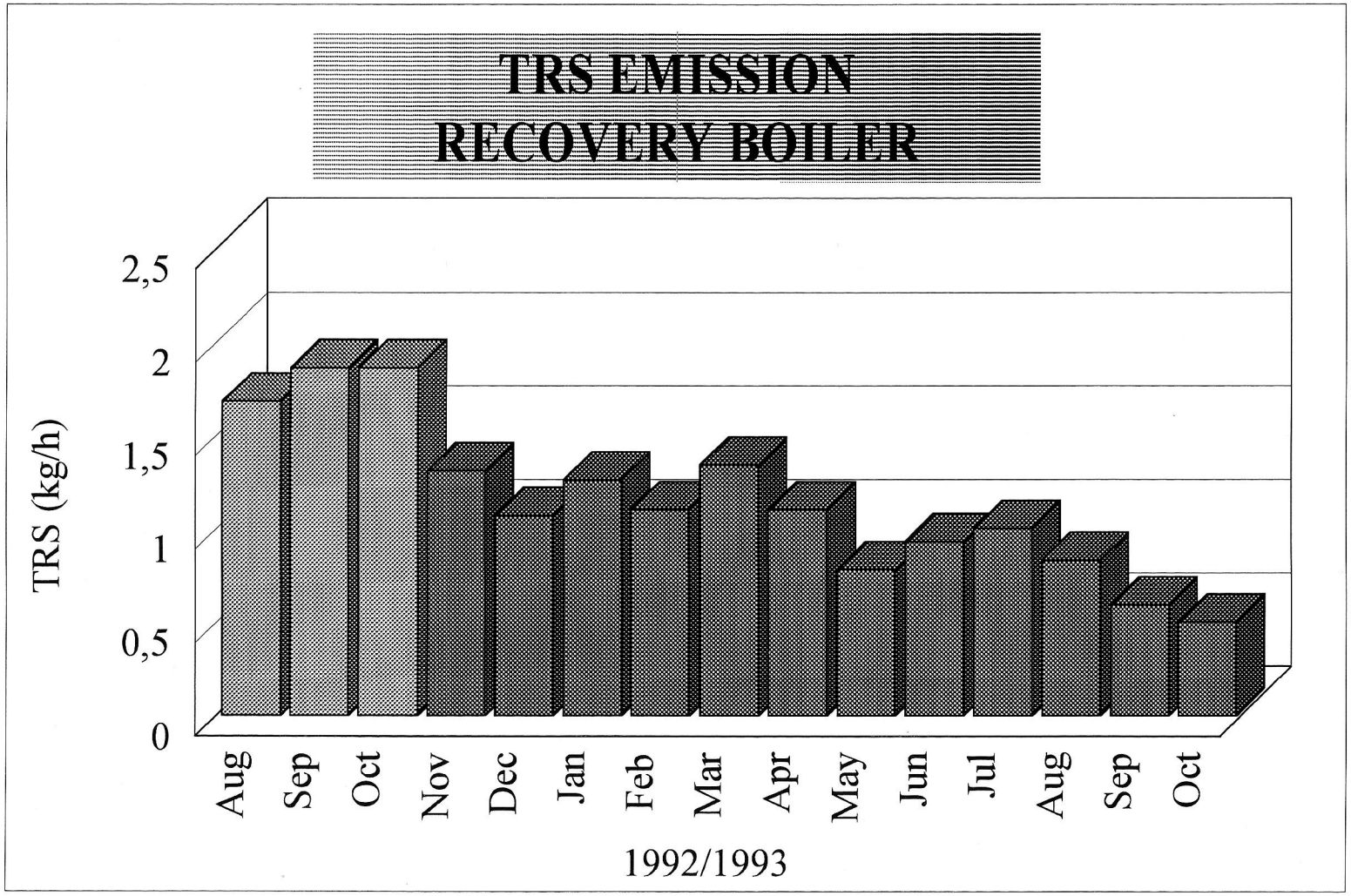


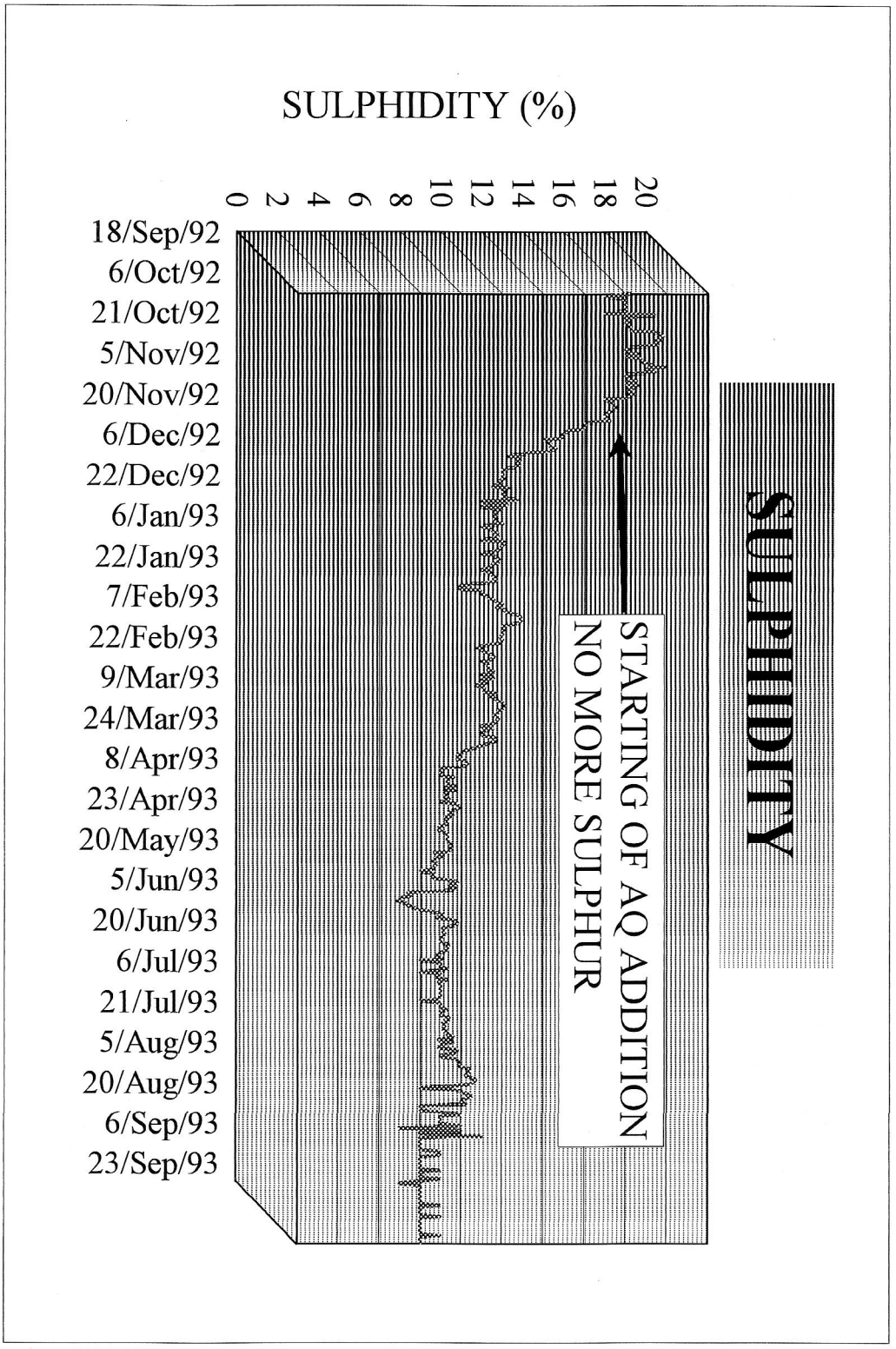
RIOCELL: A MINIMUM ENVIRONMENTAL IMPACT MILL TOWARDS THE ZERO IMPACT MILL

by

Celso Foelkel

RIOCELL S.A.


TRS EMISSION
RECOVERY BOILER
TRS (kg/h)
2,5
2
1,5
1
0,5
0
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
1992/1993


SULPHIDITY (%)
0
2
4
6
8
10
12
14
16
18
20
18/Sep/92
6/Oct/92
21/Oct/92
5/Nov/92
20/Nov/92
6/Dec/92
22/Dec/92
6/Jan/93
22/Jan/93
7/Feb/93
22/Feb/93
9/Mar/93
24/Mar/93
8/Apr/93
23/Apr/93
20/May/93
5/Jun/93
20/Jun/93
6/Jul/93
21/Jul/93
5/Aug/93
20/Aug/93
6/Sep/93
23/Sep/93
STARTING OF AQ ADDITION
NO MORE SULPHUR
SULPHIDITY

TOTAL EFFLUENT FREE MILL

CHANGING TECHNOLOGY ?

OR

END-OF-PIPE MEASURES ?

OR

BOTH ?

TOTAL EFFLUENT FREE MILL

QUINTENARY TREATMENT

THE CLEAN-RIO PROCESS

PRIMARY STAGE:	SETTLING
SECONDARY STAGE:	ACTIVATED SLUDGE
TERTIARY STAGE:	FLOCCULATION / SETTLING
QUATERNARY STAGE:	SAND-BED FILTRATION
QUINTENARY STAGE:	REVERSE OSMOSIS

TOTAL EFFLUENT FREE MILL

THE CLEAN-RIO PROCESS

INVESTMENT COSTS:	**160 US$ / admt/year**
OPERATIONAL COSTS:	**10 US$ / admt**
HANDLING COSTS FOR SOLID RESIDUES:	**4 US$ / admt**

TOTAL EFFLUENT FREE MILL

QUINTENARY TREATMENT

STAGE	kg / admt				
	Cl	AOX	COD	BOD	COLOR
RAW EFFLUENT	25	0.50	55	15	120
SETTLING	22	0.35	26	8	100
ACTIVATED SLUDGE	22	0.28	15	0.9	180
FLOCCULATION / SETTLING	18	0.12	4	0.3	20
FILTRATION	18	0.10	2.3	0.25	13
REVERSE OSMOSIS	1.5	0.002	0.25	0.1	0
TOTAL EFFICIENCY, %	94	99.6	99.5	99.3	100

ORGANIC SLUDGE

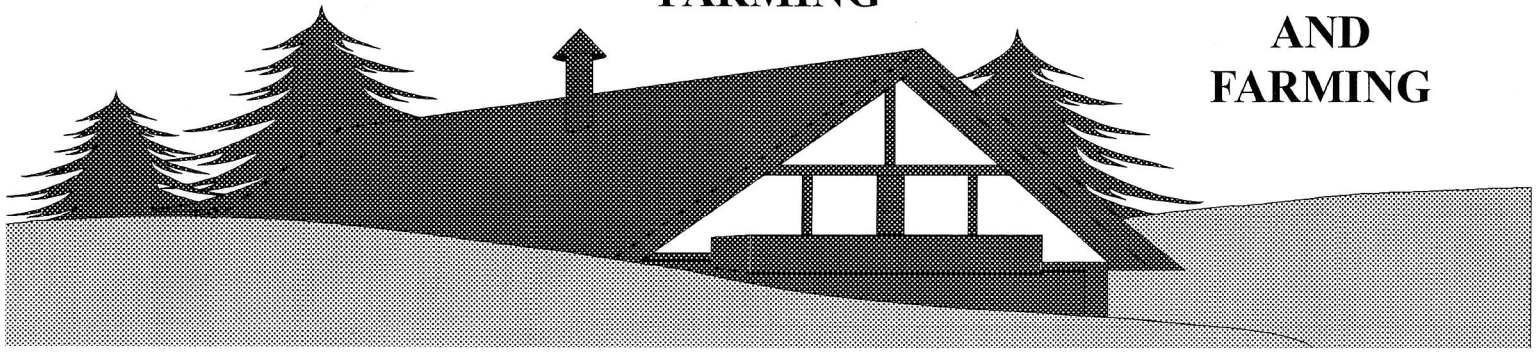
FROM WASTEWATER TREATMENT PLANT

ORGANIC FERTILIZER

`HUMOSOLO`
GARDENING

`HUMOATIVO`
FARMING

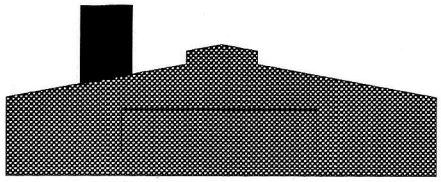
`HUMOFLOR`
GARDENING AND FARMING



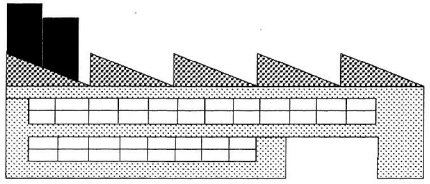
SAWDUST

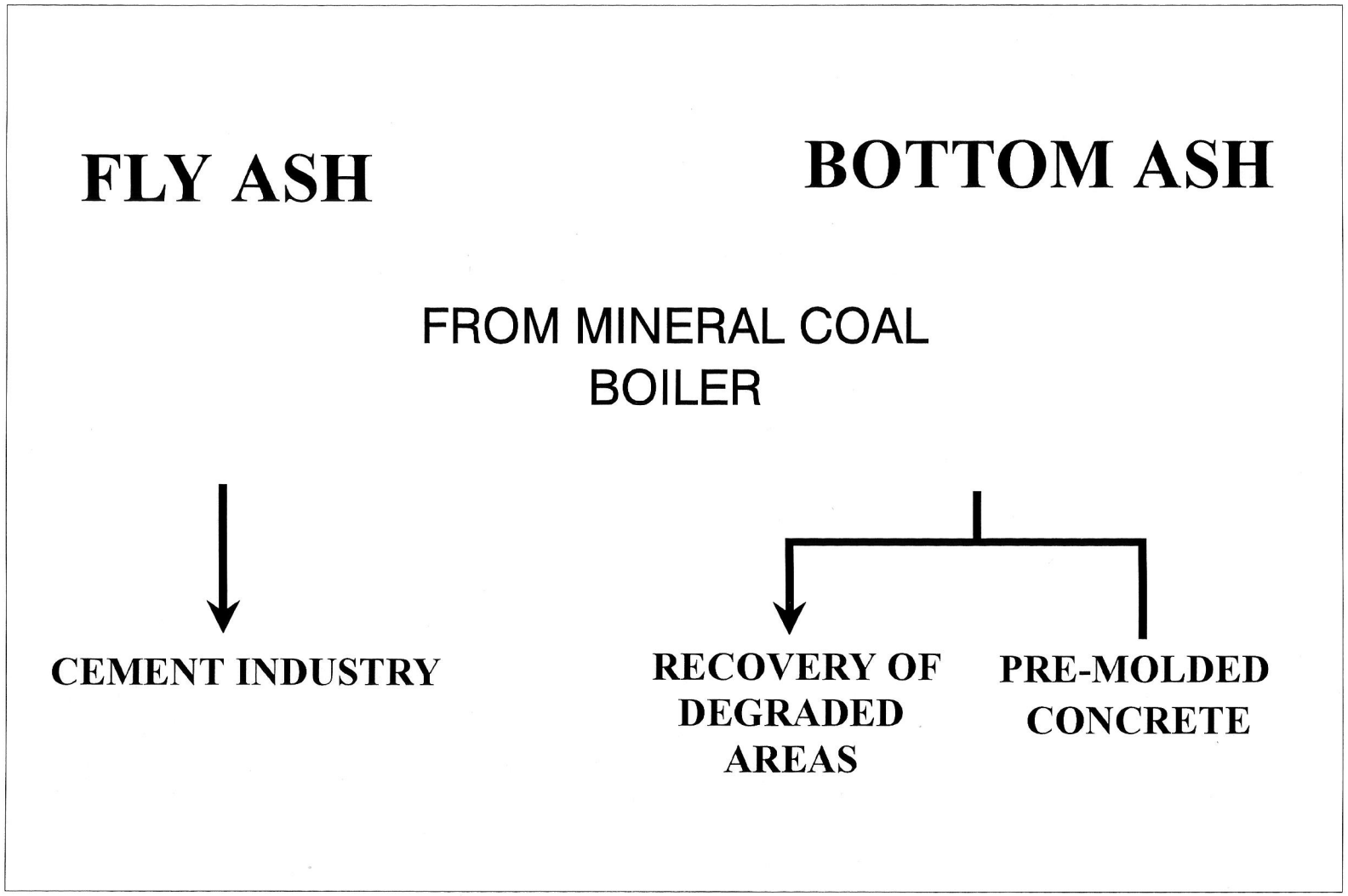
FROM CHIPPING AND SCREENING OPERATIONS

ENERGY GENERATION IN OTHER FACTORIES



BEDDING MATERIAL FOR CHICKEN



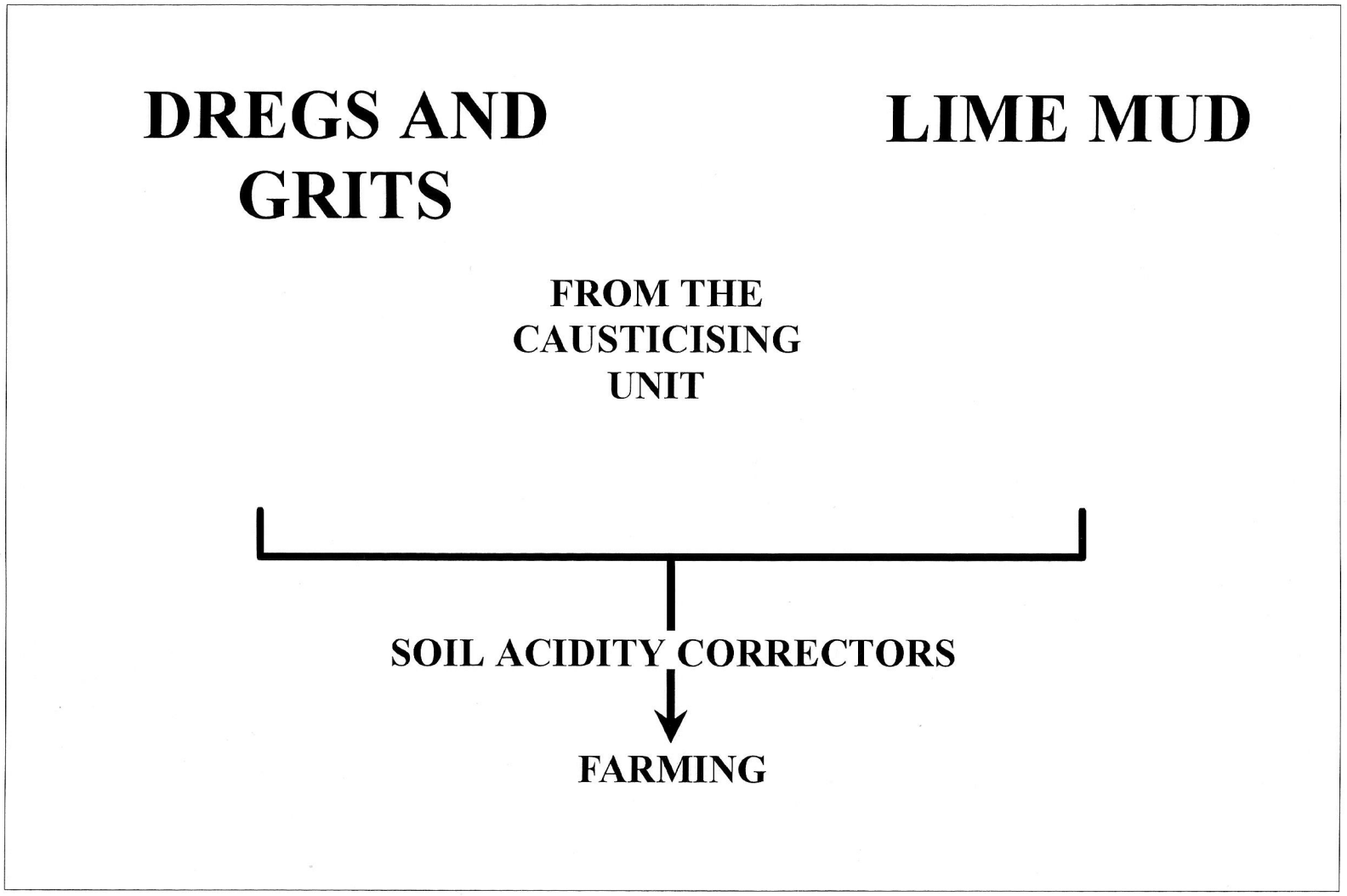

FLY ASH
BOTTOM ASH
FROM MINERAL COAL
BOILER
CEMENT INDUSTRY
RECOVERY OF
DEGRADED
AREAS
PRE-MOLDED
CONCRETE

GARBAGE

FROM RESIDENTIAL AREAS, ADMINISTRATION OFFICES, LABORATORIES, ETC.

SEPARATED ACCORDING TO ITS NATURE (e.g. PAPER, GLASS, PLASTIC, METAL, ETC)

RECYCLING CENTERS


DREGS AND GRITS
LIME MUD
FROM THE CAUSTICISING UNIT
SOIL ACIDITY CORRECTORS
FARMING

BARK

↓

FROM WASHING OPERATIONS

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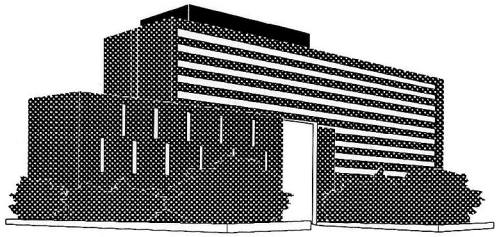
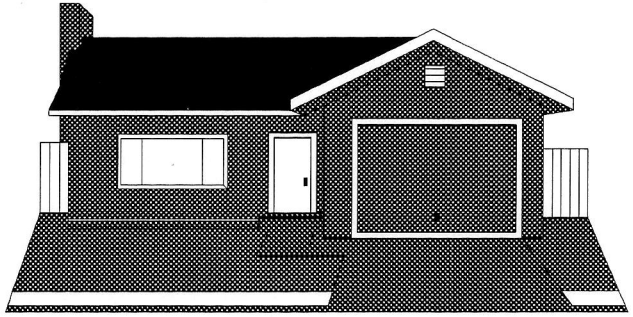
ORGANIC FERTILIZER

↓

FARMING





PRODUCTS / CONSUMERS

SOLID RESIDUES	AVERAGE MONTHLY PRODUCTION	RECYCLING RATE	CONSUMERS
EUCALYPTUS BARK	1000 ton.	100%	- Supermarkets - Farmers - Flower Shops
SAWDUST	1545 ton.	100%	- Factories - Farmers
DREGS AND GRITS	250 ton.	100%	- Farmers
LIME MUD	375 ton.	100%	- Farmers

PRODUCTS / CONSUMERS

SOLID RESIDUES	AVERAGE MONTHLY PRODUCTION	RECYCLING RATE	CONSUMERS
ORGANIC SLUDGE	5012 ton.	100%	- Supermarkets - Farmers - Flower Shops
FLY ASH	3655 ton.	100%	- Cement industries
BOTTOM ASH	1335 ton.	100%	- Pre-molded factories - Recuperation of degraded mining areas
GARBAGE	115 ton.	85%	- Recycling factories

PRODUCTS / CONSUMERS

TOTAL AMOUNT OF RESIDUES GENERATED BY RIOCELL IN ONE-YEAR BASIS	160.000 ton.	
AGRICULTURE END-USES	80.000	(50%)
INDUSTRY END-USES	64.000	(40%)
RECOVERY OF DEGRADED AREAS DUE TO MINING	16.000	(10%)
RECYCLING EFFICIENCY	99.7%	