VETIVER SYSTEM FOR ENVIRONMENTAL PROTECTION OF OPEN CUT BAUXITE MINING AT "LOS PIJIGUAOS" –VENEZUELA.

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ABSTRACT:

This paper presents the experience accumulated during three years of environmental recovery of a bauxite mine located in Los Pijiguaos, Bolivar State, Venezuela; through the application of the Vetiver Systems (VS). It describes the different phases of analysis, design and installation of provisional barriers such as sandy bags, stone rows or wooden fence before planting vetiver to protect vetiver tillers, especially in very high slope areas.

In this context, the company has incorporated the VS into its general policy to mitigate the impact of mining activities on the local community with the aim of providing social assistance, and economical development to the people of the region.

The operation of BAUXILUM mining must meet all the following environmental and social objectives:

- To re-establish the native forest affected by open cut bauxite mining
- To build sedimentation lagoons
- To protect the mining infrastructures
- To provide assistance to their neighboring communities.

Vetiver system has been used in this project, for stabilization of various gradient slopes, on the soil-concrete interface to protect infrastructures on the mine site, stabilization of gullies and border drains, reinforcement of lagoon dikes, bio-filter in gullies and around lagoons.

For erosion control a total of 26.300m of vetiver barriers have been planted, from 2003 to June 2006. Now CVG BAUXILUM is planning to plant another 7.400m of Vetiver barriers. This activity is carried out during the rainy season from June to October.

The experience is documented with photos, which show the graphic transition from the natural state of the land, during the process of vetiver barrier planting and after the Vetiver barriers fully established. It is also presented a study on the aluminum absorption of Vetiver leaves, with their corresponding charts and graphs.

Based on the above results, during the past three years, CVG Bauxilum has successfully adopted the Vetiver System for land rehabilitation and environmental protection to restore this open cut bauxite mining site of Venezuela, to a desirable environmentally friendly level.

1. - INTRODUCTION:

1.1 Problematic and location:

In the Amazonian region of Venezuela, the company CVG BAUXILUM, C.A. operates a bauxite sky open mine located in Los Pijiguaos, Bolivar State, (6°31´05”N, 66°44' 52”W). During the extraction process the land remain unprotected and under the action of the strong rains that fall in the zone, which originates important processes of hydric erosion and generates a volume of sediments that contaminates the water ways. On the other hand, this type of mining requires of works of services that entails to the construction of roads with its slopes, roadside ditches, etc, that it leaves to the bauxite exposed to the erosion and the drag of sediments. The ground absence in those intervened area makes difficult the establishment of the plants or gramineous commonly used to cover them.

1.2 Environmental policies

For the sake of the environment protection, the company applies like a systematized process, the removal of the existing flora in the spaces projected for the extraction of the bauxite and gathers it together the vegetal layer for its later use. Once concluded the exploitation phase of the mineral, the recovery of the material area is made placing the previously reserved material through the use of machineries that distributes it, simultaneously that makes deep scarification in the ground. Later proceeds the seed of species adaptable to the ecology of the zone.

Among those programs of environmental protection, also the company constructs annually lagoons to catch dragged sediments, by means of the excavation and formation of earth docks (bauxite); in spite of it rains that fall, sometimes exceed the glass of the lagoon and drag with themselves sediments in suspension. Of the same way, those great volumes of water combined with the speed of overflow by the existing unevennesses in the topography of the area cause the deterioration of the drainages when concentrates, originating furrows that finally becomes great gullies. In order to complement its policy of environmental recovery, the company has incorporated the Vetiver Systems Technology (VS) from year 2.003.

2. - THE BAUXITE OF THE PIJIGUAOS:

2.1 Characteristics

The deposit is recognized like a group of horizons located in the top of aluminical laterites, with a thickness average from 10 to 12 m. These horizons can contain a second level of bauxitic mineralization towards the average part, but it is of little thickness.

The bauxite of Los Pijiguaos is gibsitic, of pisolitic texture, spongy and cellular, typically quartzy. In the table the chemical composition can be observed, in dry base, of this bauxite:

Total alumina	Al_2O_3t	49.46%
Total silica	SiO_2t	9.33%
Silica quartz	SiO_2q	7.59%
Combined silica	SiO_2c	1.74%
Loss by ignition	PPI	26.74%
Iron oxide (hematic)	Fe_2O_3	12.58%
Titanium oxide	TiO_3	1.21%
Humidity		11.00%

(Lisena, M. 2.003)

2.2 Reserves and production

The bauxite deposit of Los Pijiguaos has an extension of 16 km2 and is located in the Páez hill, at the Norwest end of Cedeño municipality of the Bolivar State. This mountain range comprises of the precambric shield of Guayana. The probable reserves are located in the North part of the plateau. The maximum dimensions at the tops in forms of plateaus are of 11 km. in direction N-S and 5.5 km. in direction E-W. (Lisena, M. op. cit.)

It is considered that the terraces of aluminic lateritics have 5.000.000.000 of tons associated like possible reserve (Alusuisse, 1.980, mentioned by Lisena).

The operation carried out during year 2.005 reached to the number of 5.200.000 Metric Tons. and the goal for this year is of 6.300.000 Metric Tons.

3. - ECOLOGY, CLIMATOLOGY OF THE ZONA

3.1 General description

According to Lisena, the zone forms from the bioclimatic point of view, an ecotone between the tropical dry forest and the premountain humid forest, the first present on the low parts and the second in the highest parts of the relief.

The annual average temperature varies between 27.5° C in the right margin of the Orinoco River (45 meters over sea level.) until 24° C in the summit of the plateau where the operation of bauxite is made (650, m.o.s.l, average).

The annual precipitation average varies between 2.400 mm and 2.900 mm, appearing a dry station between November and March. In the months of June to October (both inclusively) it rains 84% of the days, whereas in May and November rains arrive at 50%. The total of rains in the year reaches to the 192 days.

3.2 Grounds

The grounds are oxisoles of extreme chemical poverty, variable physical conditions, according to the physiographic position and, in general, of a high erodability. They are old grounds with extreme degree of meteorization and very low reserve of bases. pH is located between 4 and 5.

4. - WHAT IS THE VETIVER?

Vetiver (*Vetiveria zizanioides)* it is a perennial gramineous that has a massive radicular system, deep (2 to 3 m of growth in a year); strong, its tensile strength is of 75 MPa, equivalent to 1/6 of the soft steel (Hengchaovanich, D. 1.996), it hitches the ground. Its foliage is erect, tall, abundant and also strong; being able, when are established barriers with him, to bear flood water sheets of to 80 Cms and to reduce its speed almost to zero; (RLAV, 1.999) at the same time that retains sediments.

Is an asexual plant that is to say, its seeds are not fertile, and therefore there is not risk that become weeds. Once its established tolerates extreme conditions of: droughts; floods; burns (reborn in a week); temperatures (-14º C to 46º C); altitudes (0 m to 2800 m.o.s.l); pH (3 to 12.5); adapts to soils with presence of aluminum, arsenic, cadmium, copper, chromium, plumb, manganese, mercury, nickel, selenium and zinc; sodium soils, salines, alkaline, (Troung, P. 1999). Its presence in the country went back to a hundred years ago (Mirabal, C T) in which was utilized in some southern regions of the country for to made the roof of dwellings, (Decanio, E. 2.004.)

5. - WHAT IS THE VS?

The Vetiver Systems Technology (VS) is originated by the Bioengineering, a conjunction of several disciplines of the biology and the agronomic and civil engineering, which interact for the design, installation and maintenance of alive barriers, using vetiver as base plant for the erosion control, stabilization of slopes, filtered of sediments, recovery of basins, control of flows and of floods, served water processing and biorepairer of contaminated soils. The international experience on protection of infrastructures dates from 1.908 in Malaysia, (RLAV. op. cit.), as well as in other applications of the Bioengineering is extensive and is abundantly registered through the different regional vetiver networks, and very particularly, by the world network http://www.vetiver.org/

6. - ENVIRONMENTAL RECOVERY IN THE MINE OF LOS PIJIGUAOS:

6.1 Generalities:

The existence of large areas of unprotected soils originates severe problems of water erosion, with its known consequences. The dragging of the bauxite removed by the rains arrives to the streams and rivers of the region, contaminating them. We will emphasize here some symbolic areas that have been protected with VS, as well as the way in which the execution of the works has been undertaken:

6.2 Methodology:

6.2.1 Design:

After doing an evaluation from the sites to recover, soil samples are taken for its analysis; there are observed factors like: ways of water presence in the area of the zone to treat, stability of the soil, slopes of the land and which will be the use of the barrier; with all this information is determined the Vertical Interval (VI) to apply, which generally is located between 0.80 m and 1.00 m. Subsequently proceeds to design the barriers (fig. 1)

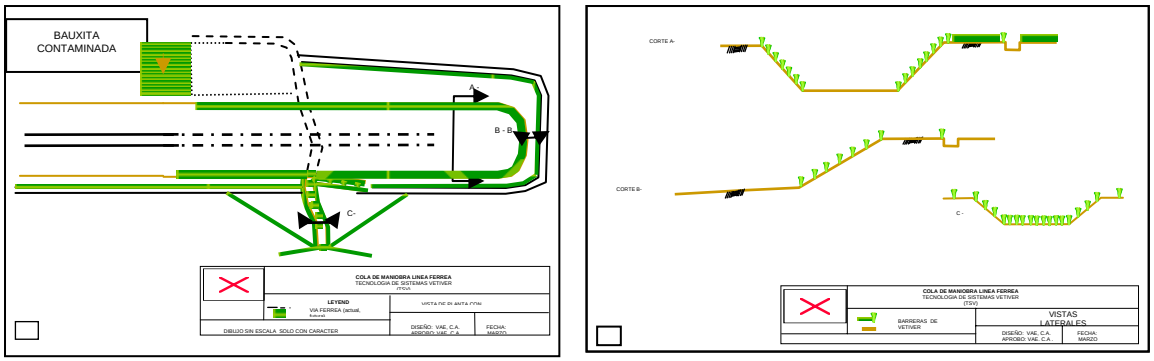

Fig 1: Design drawings

6.2.2 Execution:

The works in field begin with the layout of the contour lines. Sometimes, when the land is very irregular, a previous conformation is done; then ditches of 20 x 20 Cms approx. are opened all along of the layout, a NP formulated fertilizer (generally DAP) with high phosphorus content is applied in the ground, next it is covered with an earth layer and it is placed a layer of organic fertilizer above; if the ground is dry the channel is irrigated and it proceeds to seed the vetiver plants at the rate of 7 or 8 by meter. The amounts of fertilizer to apply in each case are determined with the results of the ground analysis.

6.3 Work Areas:

The works are performed in areas of the mine where heavy machineries permanently pass. The mine is located in a jungle zone. The slopes of lands are variable in each area to protect and go from 5° (roadside ditches) to 80° (gullies).

When the slope is very inclined works are done applying techniques similar to rappel, that is to say, moored from above with a rope tied to a deeply buried trunk, tying this one to a second support.

6.4 Security:

Besides an obligatory chat about industrial security dictated by CVG Bauxilum; before initiating each work an induction is given to our personnel over the risks of the works and the security measures that one must adopt permanently, so much in the road as in the work site. Strict fulfillment norms are given to each worker. The inexpert workers are trained in the application of the VS. Also is induced to them the necessity of protect environment, particularly the fauna of the region.

When the toil is on very pronounced slopes, the worker who is in the wall is attended by another who permanently watches to the one that is making the work, as well as to the tools and the surroundings. This policy has been reflected in the nonexistence of incidents (type of accident of small level) during the three years that we have toiling in that mine.

6.5 Application of VS Bioengineering and commentaries:

6.5.1 Lagoons of sedimentation: (years 2.003 to 2.005)

They are constructed by excavation in, or near to, drainages. Its intention is to diminish the sediments transport towards the natural ways of water (streams, rivers); they are located in lands of little slope. The slopes that rise are very erodables, therefore furrows are formed and occasionally both faces come together causing the dike weakening and originating its rupture when the lagoon is overtopped.

With the sowed of vetiver plants (photo 1) the phenomenon of erosion in the slopes has been controlled; achieving besides to reinforce the structure of the dike, thanks to the net of roots which moor the ground. The barriers formed by their leaves offer an additional over elevation, due to they behave like a porous wall (photo 2) that allows the lagoon to release water through its crest, when rains of great dimensions fall; simultaneously they captures the sediments suspended in the waters that pass through them.

It has been observed that the barriers located in the inner face of the lagoons frequently are flooded during 2 months, without any vetiver affectation by this reason.

photo 1

photo 2

6.5.2 Soil-concrete Interface (year 2.003)

One of the problems that commonly appears in engineering is the erosion of the transition areas between the concrete and the ground; very particularly in the zones by which the rainwater drains (photo 3). The VS was applied in curbstones of a hard pending road of 1.200 m that leads to “the adduction”. Although the road was in its first year, in some sites the curbstone presented deep furrows; even though as prevention a poor concrete mantle had been applied, the action of waters continued eroding and the damage in the referred zone persisted before the sowing.

Initially in the greater inclination areas there were difficulties with a lot of plants, which were dragged by the currents during rains; the problem was solved placing provisional barriers with sand bags, able to turn aside the water towards the road.

Vetiver grew fast and strong throughout 1.050 mts; in the 150 mts remaining, located in areas with shade presence, the development of the plants was slow and dispersed; nevertheless they also stopped the erosion.

photo 3

photo 4

6.5.3 Slope “The Adduction” (Year 2,003)

It is formed by a slope to three ramps, two natural – one longitudinal and other cross-sectional, while the third, also cross-sectional, is of cut; this last one with an inclination of 60º.

During the previous evaluation in April 2.003 (summer), the road to the adduction was recently constructed so the conformation of the slope was homogenous. In October 2.003, when the sowing began (final of rains) furrows of important size had formed in the three slopes and began to appear some gullies (photo 5). The land was manually conformed. It was necessary to work moored, like in rappel (photo 6). Subsequent to sowing, the growth of the plants was relatively fast.

photo 5

photo 6

The slope is stable and the barriers are strongly developed (photos 7 and 8). Additionally the presence of pioneering vegetal species for the recovery of the original forest has been observed in it.

photo 7

photo 8

6.5.4 Gully "Chorro de agua" (water spurt) (year 2.003)

This was a gully of 95 meters in length, (photo 9) formed by vertical walls with unevennesses up to -5,00 m, that reached up to 15,90 m wide. It had been repaired in diverse occasions but also continue failing; later a torrent flood of concrete was constructed to lead waters, nevertheless, the visual contamination and the risk that which waters looked for their previous course continued.

photo 9

For the application of the VS a machine conformation of the land was made, previous to the sowing of vetiver (photo 10). Seed was made at the end of the cycle of rains and it limited the formation of the barriers in its totality. Although irrigation workings were not made, and the summer in the region is strong; the plants of vetiver stayed in a latency state until the rains restart, five months later. In the 2.004 took place a reseed in some failed points; in that occasion all the plants grew vigorous (foto11).

photo 10

photo 11

Here is important to refer that a year after the vetiver sowing, one pipe bordering that gathers an important volume of water collapse; nevertheless, this event partially affected a single barrier. At the present time it is in frank recovery by natural form.

Others gullies (years 2.003 and 2.004)

Others gullies have become stabilized, among them, the most relevant are:

- One of 15 mts of depth with an inclination of 80° (photo 12). Formed by the rupture of the dock of a sedimentation lagoon that was constructed near a depression, according to previously used criteria today discarded. It was required to seed by points, that is to say, it was not possible to open ditches due to the instability of the land (photo 13). During the phase of establishment of the plants three focused slidings happened, caused by the rains. These were reseeds in each occasion. At the moment the recovery is total.

photo 12

photo 13

- The other had a depression of approximately 40 m of depth and an inclination of 60° (photo 14). Of a similar origin to the previous one, it was modified by the action of works made in the lagoon that produced it. The overturning of the material formed a very unstable slope caused by filling without compacting; to it was added the filtration of the lagoon through the inferior part of the slope; all these elements were conjugated so a sliding happened after to have seeded. The works of repair were undertaken the following year. Today it is stable and also there is presence of other pioneering vegetal species.
  In the execution of both cases, the workers moor themselves using technical similar to rappel (photos 13 and 15).

photo 14

photo 15

6.5.5 Sliding in road by edge fault (year 2.004)

At km 4 of the road that leads to the mine happened a sliding that considerably deteriorated a stone wall that was in the area, leaving in addition without support a pipe section that leads potable water to the residential camping (photo 16). The security's department of Bauxilum declared an emergency in front of the possible rupture of this pipe which represented a double risk:

- This incident would close the access to the area of mines.
- To leave without potable water the residential camping.

Two options were considered to solve this situation; the first was to construct a tightened screen. The other however, was to build terraces with the accustomed soil-cement walls and to anchor them with barriers of vetiver. Last one was adopted and the project required only of a month for its execution (photo 17). The other proposed design was rejected as engineering solution by slow and expensive.
The mentioned works were made in March and was necessary to use irrigation during two months, until rains began. The following year a fire of vegetation happened in the zone, burning the barriers in its totality. Nevertheless, to the following week vetiver had turned green again, before that the surrounding vegetation showed recovery signs. The losses of vetiver were minimum.

photo 16

photo 17

6.5.6 Slope in road (year 2.004)

In km 10 from the route to the mine two slidings took place in slopes of cut with a high of 15 m and 25 m respectively, and an inclination of 75° (photo 18). The slopes are located in the East face of the mountain; across (at the West) a leafy vegetation exists; this situation restricts the incidence of light in the zone to few hours of the day.

During the inspection was determined the presence of small water courses that slipped in the zone. A cleaning was made in the superior part and the waters were canalized until other slopes. The plants were seeded opening individual hollows; we worked with techniques of rappel.

The growth and development of the plants were very poor due to the little incidence of solar light, to the point that at the date, two years later, the presence of them is hardly noticed. Nevertheless the slope stays stable; perhaps by the absence of the waters that were turned aside to another slope (photo 19).

photo 18

photo 19

6.5.7 Sediment filter: (years 2.003 to 2.005)

The naked ground roadside ditches, that lead great water volumes product of the rains or of the lagoons overtopping, they are susceptible to the formation of gullies, in spite of its continuous maintenance.

Due to the strong currents that moves through those drainages (photo 20), sometimes is required to install provisional barriers with sand bags, rocks or wood, previous to the vetiver sowing to avoid that the plants be dragged before they root in the ground. In other cases we have worked with barriers preformed in the nursery anchoring them with the use of steel treenails and mooring them strongly.

The establishment of barriers of vetiver as sediment filter not only has fulfilled that intention but also the process of erosion when filling up has reverted and to form terraces in the located areas above waters (photo 21).

photo 20

photo 21

7. - ALUMINUM ABSORPTION TESTS

In order to determine the levels of aluminum absorption on the vetiver plants of the environmental recovery area of the mine, tests were made to 15 ground samples taken in sites where barriers had been settled. As reference was taken a sample of the ground in plants seeded within the populated center (PTAR), with different characteristics from the one of the mine; with the results plants in B2S8a and in B1CCA were selected and the amount of aluminum in its leaves was analyzed.

The table Nº 1 gathers the values obtained in the samples of ground; whereas in the figure N° 2 the graphical comparison of these results settles down.

GROUND SAMPLES ANALYSIS

Origin of the Sample	Number of the Samples	Sample (ppm)	Soil pH analyzed	Aluminum content (ppm)	Iron content (ppm)
Village	0	300,000	6.23	****	****
B1S8	1	250	7.90	14.976	4.764
B2S8a	2	249.8	6.96	12.594	4.840
B2S8b	3	250.4	6.14	17.939	3.094
B2S8c	4	250	6.85	16.628	3.252
B2S3	5	249.4	6.06	16.920	3.109
B2S1	6	250	6.93	15.964	3.604
B1CCA	7	250.1	6.00	28.470	5.317
B1S4	8	250.3	5.59	16.735	3.963
B1S3a	9	250.3	6.11	16.440	2.968
B1S3b	10	249.8	6.28	16.773	4.543
B1S6	11	250	6.14	19.204	7.064
B1S4LS2	12	249.9	5.66	17.959	4.217
B1S4LS3	13	249.8	5.57	17.566	3.014
B1S4LS4	14	250.1	5.96	18.100	6.449
B3S2	15	250.3	6.00	16.410	5.549

Table N° 1

PRESENT IRON AND ALUMINUM IN THE GROUND

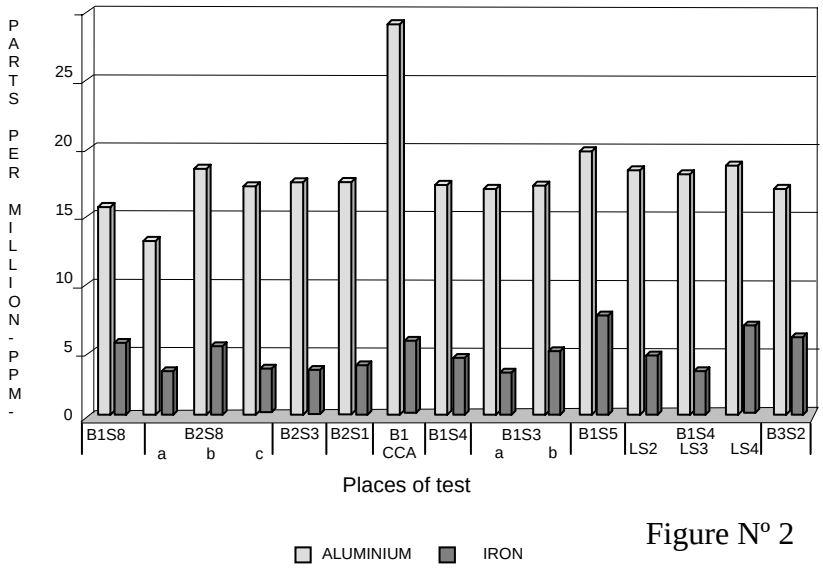

Figure Nº 2

On the other hand, the table N° 2 shows the aluminum levels contained in the leaves of the sampled plants, which are compared graphically in figure N° 3.

ALUMINUM ABSORPTION IN VETIVER PLANTS (LEAVES)

	Village (near to PTAS)	Gully Chorro de Agua. **(B1 CCA)**	Slope on way to the aduction **(B2S8)**
Time (months)	36	26	34
ppm	36	198	430

Table Nº 2

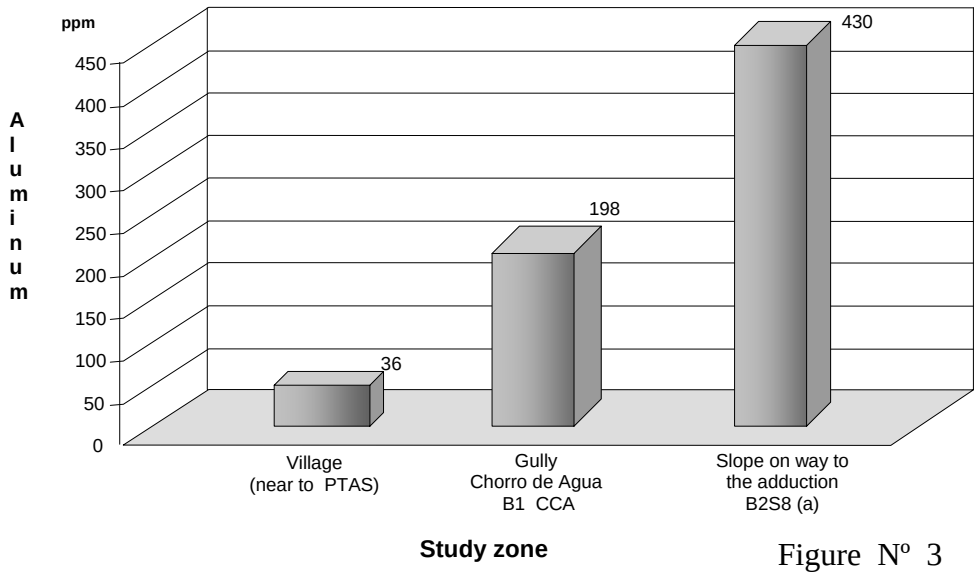

Figure Nº 3

From the result of the analysis made in samples of Vetiver plants (leaves); as well as in those of the ground of the planted area, the following concludes:

- From the samples obtained to determine the aluminum content present in the plant, were obtained the biggest results (values) in the plants established in the slope of the route to the adduction of the mine (B2S8a), presenting 430 ppm of accumulated aluminum 34 months after the sowing. Next, appear values of 198 ppm in the plants established in the gully of the stream "Chorro de Agua" (water spurt) (B1 CCA), with a time of sowing of 26 months. Both groups of plants established in the areas in recovery process.

  The lowest values of 36 ppm correspond with the species established in the proximities of Served Waters Treatment Plant (PTAR by its acronym in Spanish) that is located in the Populated Center; and therefore they are not associated neither to the process of operation of the bauxite mineral, nor to grounds derived from this type of mineral.
- Although the values of pH associated to grounds where the species of Vetiver settled down present values that reflect and indicate that its solubility does not have to reach a 10%. It is very probable that such values have been associated to low values of pH established at the beginning of the sowing process, through the application of great amount of organic material like amendment.

8. - SOCIAL ACTION:

Since year 2.004, CVG Bauxilum Los Pijiguaos and Vetiver Antierosión C.A. established an agreement to form craftsmen resident in the communities surrounding to the zone of influence of the project in the elaboration of handcrafts with Vetiver. 14 communities participate, mainly indigenous (photos 22 and 23). Between the objectives of this program, besides the teaching-learning process of an occupation and the benefits that it leads, it is the search of a technology transference that makes that the groups in formation replace the leaves of the moriche palm (*Mauritania flexuosa*), ancestrally used by different Venezuelan ethnic groups in the handcrafts preparation, by the Vetiver. The permanent exploitation of moriche has decreased significantly this palm, vital in the ecosystem of the zone.

The training program includes in addition to the formation like craftsman, techniques of commercialization of the elaborated pieces, and the development of the individual potentiality through the growth of the self-esteem. Parallelly courses have been dictated in the different schools of the zone to promote the potentialities of the Vetiver between the students and their family environment.

This program is lead by Oswaldo Luque, Grace Rivero and Edgar Ceballos within a scheme of transference to CVG Bauxilum of part of the Project Vetiver carried out by Polar Foundation.

photo 22

photo 23

9. - CONCLUSIONS AND RECOMMENDATIONS:

The implementation of the VS in this bauxite mine has lead to tangible results and beneficial aim to the recovery of environment and to support the human development of the surroundings. Within it we can emphasize:

9.1 Direct results:

- It was reached to establish vetiver in a ground free of organic matter, with particular edaphologics characteristics that make difficult the propagation of other species.
- The erosion was controlled in: slopes, gullies, faults of edge, soil-concrete interface and roadside ditches located in a very erodable ground and highly rainfall zone.
- The barriers installed in the roadside ditches reverted the erosion process, catching sediments and forming terraces.
- It has protected indeed docks of lagoons against the erosion. The barriers have offered in addition an added value like sediment filters.
- As a result of both previous points, it has diminished the contributions of sediments to the natural water courses.
- The Vetiver causes the establishment of other native vegetal species between the barriers.
- The limitation of the Vetiver to grow under the shade was ratified.
- The aluminum content accumulated in the leaves of the plants is related to the high found aluminum concentrations in underlying grounds.

9.2 Indirect results:

- Since the results, CVG Bauxilum incorporated the Vetiver within their policy of environment recovery and improves of the social surroundings.
- The adjoining communities participating of the program are mitigating their socioeconomic problematic thanks to the formation like craftsmen and to the money that perceive by the sales of their products.
- The consumption of moriche (*Mauritania flexuosa*) in the zone in which the natives live is diminishing.
- CVG Bauxilum is evaluating the adaptation of vegetal species in red muds, for the biorepairing of an extensive area in its plant of alumina extraction in Puerto Ordaz. Among the selected species, vetiver is one of them.

9.3 Recommendations:

- It is recommended to give continuity to the execution of later tests that allow to determine the direct incidence of the aluminum content in ground (associate to bauxite mines) and its accumulation in the different structures from the organism (leaves, stems, roots) of the Vetiver specie.
- It is recommended to evaluate the contribution of vetiver in the diminution of the accumulation of bauxite in the natural water courses (streams and rivers)

10. - RECOGNITION:

I desire to show my gratefulness to BAUXILUM, C.A. by the welcome and great support, particularly to Eng. Wilfredo Aguilar and workers of the Engineering and Services Department that believed in this technology and in the company that I manage; also to the community of Los Pijiguaos, well called “land of encounters”. I desire to recognize to our workers very especially who have done possible to carry out this technology supporting, sometimes, conditions of work of high risk.

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12. - APPENDICE (Photografies)

photo 24

photo 25

photo 26

photo 27

photo 28

photo 29

photo 30

photo 31

photo 32

photo 33

13. - LEGEND:

Preparation and sowing of vetiver in a lagoon border, near to the deposit patio of bauxite (photos 24 and 25). Barriers provisionally installed, while vetiver consolidates (photo 26). Rain fell 2 weeks after seeding in the roadside ditch (photo 27). Sediments retained by barriers in formation (photo 28) and established (photo 29). Erosion in curbstones before the sowing (photo 30). Effect of the shade in the growth of the plants (foto31). Repairing damages caused by the rain in one gully during the establishment phase (photo 32). Our human equipment (photo 33)

Photographies credits N^{os} 22 and 23: Oswaldo Luque.

14. - Brief introduction to the First Author:

Rafael Luque Mirabal is an Electrical Technician specialized in High Voltage who worked during 30 years for the main electrical company of the country, supervising the civil and electromechanical works associated to the construction of transmission lines and sub-stations. During this lapse, he crosses all the country and keep worried about the environment deterioration observed in his frequent trips. After the retirement he dedicates to work in his farm and founds on year 2.001, along with his family, Vetiver Antierosión, C.A. Thence he directs and personally supervises the diverse works that the company makes in various regions of the country. He is self-taught in Bioengineering.