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September 1988  
ENGLISH

CUENCA COMPOST PLANT  
SI/ECU/88/801

Republic of Ecuador

Expert Report \*

Based on the work of Mr. E.G. Hughes  
Expert in composting municipal solid waste

Prepared for the Government of Ecuador  
by the United Nations Industrial Development Organization  
acting as executing agency for the United Nations Development Programme

Backstopping Officer: R.O. Williams, Chemical Industries Branch

United Nations Industrial Development Organization  
VIENNA

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ACKNOWLEDGEMENT

I would like to express my gratitude to the Director of CREA, Senor Daniel Toral and the staff at CREA for the unfailing assistance and co-operation that I received during this part of the project.

In particular, I would like to thank my friend and colleague, Director of Technological Investigations at CREA, Dr Virgilio Espinoza, for his constant enthusiasm and interest.

I thank Senors Angel Penafiel, Angel Lituma and Paulo Morales for their skill at the drawing board.

I thank Edison Ramos of CENDES for his interest and Malena Castro for her linguistic ability.

Anne Braghetta of the US Peace Corps gets a special thanks for her invaluable aid.

Dr Peter Kruck and Nicole Steyer of the UNDP get my unreserved thanks for their total support and interest.

ABSTRACT

This part of Project SI/ECU/88/801/11-01 was the first part of the follow up to the feasibility study as to the advisability of establishing a full scale municipal solid waste composting plant at Cuenca, Ecuador, in conjunction with the Centro de Reconversion Economica del Azuay, Cañar Y Morona, Santiago (CREA) and the municipal authority of Cuenca.

The requirements were to finalise the engineering drawings, establish the plant specification, prepare a tender document to enable contracts to be negotiated and to suggest a training programme for the personnel to be involved in the project.

This project was undertaken from 25th July 1988 and continued until the end of August 1988.

**RECOMMENDATIONS**

RECOMMENDATIONS

1. In view of the fact that some of the components of the proposed plant cannot be manufactured in Ecuador due to the unavailability of certain highly specialised steel and the unavailability of machine tools of the great size required, it will be necessary to import these components.

Due to the contractual arguments that could result through this combination of local civil construction and the mixture of local and imported mechanical equipment, it is recommended that a turnkey contract be entered into with the main contractor totally responsible for all aspects of the project. All this work should be guaranteed by the respective bid, construction, throughput, operation and performance guarantee bonds.

2. The main contractor should have previous experience in the construction of such a plant and the financial strength of the contractor should be such as to enable him to obtain all the necessary bonds from sound, reputable financial institutions.
3. The offers received should be evaluated by a competent person, familiar with composting plants of this type, prior to any contract being awarded.
4. The Director of Technological Investigations of CREA should be sent on a study tour of two weeks at the composting plant outside Barcelona, Spain and a further two weeks split between the plants at El Salem, Cairo; Abu Rawqsh, Giza and Abbis, Alexandria, all in Egypt, to enable him to receive the knowledge that is vital to the continued success of this project.

**ENGINEERING DRAWINGS**



**ENGINEERING DRAWINGS.**

Fully dimensioned engineering drawings were produced as follows:-

1. Topographical site layout including plant layout with all the utilities.
2. Main building layout showing ventilation.
3. Plate feeder conveyor.
4. Alternative, less complicated feed conveyor.
5. Picking belt with magnetic extraction of ferrous materials.
6. Elevating feed conveyor.
7. Compost conveyor.
8. Reject conveyor with magnetic extraction of ferrous material.
9. Final screening and cleaning plant,
10. Single line electrical distribution layout.
11. Plan view of plant layout.
12. Section through complete plant.

**SPECIFICATIONS**

**SPECIFICATIONS**

Specifications were prepared for the following:-

1. Fabricated steel equipment.
2. Mechanical beam scales.
3. Plate feed conveyor and alternative feed conveyor.
4. Picking belt with magnetic extraction.
5. Metal baling press.
6. Paper and textile baling press.
7. Homogenising drum.
8. Compost belt.
9. Reject with magnetic extraction.
10. Mobile plant.
11. Screening and finishing plant.
12. Electrical equipment including central control panels and motors etc.
13. Laboratory.
14. Civil work.

TENDER DOCUMENT  
AND  
METHOD OF PROCEDURE

TENDER DOCUMENT AND METHOD OF PROCEDURE

From the engineering drawings and the specification a complete technical tender document was prepared that only required CREA's standard conditions of contract to be added, prior to issue. The draft copy, in English, is attached. CREA are translating this document into Spanish.

This tender should be advertised in the Quito newspapers and preferably in one of the international construction journals.

Three months should be allowed from the advertisement being published to the contractors being required to submit their documentation.

This method will enable both local and international companies to be considered, thus ensuring that Ecuador will get the benefit of low, local prices for the local ~~parts~~ components plus the benefits of the experience of international companies in constructing such plants.

It is vital for the security of the project that one main contractor be appointed to have overall responsibility for the project even if some of the work is sub-contracted. This main contractor must provide the bid bond, construction and performance guarantees. Failure to adopt this procedure can result in CREA becoming involved in contractual disputes that could stop the project. For example, if contracts are entered into with different contractors for civil engineering construction and mechanical item supply it is possible that if, for example a machine foundation failed that each contractor would blame the other. If one main contractor is appointed then it is of no consequence to CREA who is to blame. It is the responsibility of the main contractor to put the matter right.

An evaluation of the offers received should be undertaken by a competent person, familiar with composting plants, prior to any contracts being awarded.

TRAINING  
REQUIREMENTS

### Training Requirements

Señor Daniel Toral, the Director of CREA, is to relinquish his post in November, in favour of a new appointee.

However, the Director of Technological Investigations for CREA is retaining his career post and staying in office. This gentleman, Dr Virgilio Espinoza, has been responsible for this project since its inception and will continue to be responsible for it. Ultimately he will have overall responsibility for its' operation and for the administration.

It is essential that the Director of Technological Investigations receives a training that will enable him to gain a full understanding of the difficulties that can be experienced during construction, the procedures required for the successful operation of the plant and a thorough knowledge of the administrative practices required.

For these reasons I consider it vital that the Director of Technical Investigations for CREA should visit overseas composting plants of a similar size and type to that due to be installed in Ecuador to gain this very necessary experience.

On his return to CREA he will be able to disseminate this knowledge among the other involved personnel.

I would recommend a two week visit to the composting plant outside Barcelona, Spain and a further two weeks split between the composting plants at El Salem, Cairo; Abu Rawash, Giza and Abbis, Alexandria, all in Egypt.

The proposed Plant Manager should visit the site during each stage of construction to familiarise himself with work that will ultimately become hidden, eg. water pipe, sewage pipe and electrical cable layouts.

The persons responsible for the future electrical and mechanical maintenance should visit at periodic intervals to view their areas of respective interests.

When the installation of the machinery commences, the Plant Manager, Electrical Engineer and Mechanical Engineer should be present on a full time basis.

When the commissioning starts all the maintenance personnel should be present full time.

One week prior to the start of operations all the personnel should be present to receive instructions.

The UNEDC appointed experts should be in post one month prior to the start of commissioning to check that the contractual obligations have been met and to undertake the training of the Ecuadorian personnel throughout the various stages. This will ensure that by the start of full operation all the personnel will be fully trained in their respective duties.



**Appendix A**  
**Draft tender document**

CUENCA

ECUADOR

TENDER FOR THE SUPPLY  
AND ERECTION OF A  
SOLID WASTE COMPOSTING PLANT

CLOSING DATE . . . . .

INTRODUCTION

Tenders are invited from suitably qualified Companies to erect a solid waste composting plant on a turn-key basis at VALLERA, CUENCA, ECUADOR as shown on the ~~accompanied~~ <sup>accompanying</sup> map. Tenderers are invited to submit fully detailed tenders including engineering design, site preparation, construction, erection, ~~running~~ <sup>commissioning and the</sup> training of engineers and operators on site.

The capacity of the plant shall be 85 tons per day on a 8 hour basis, ~~emanating from a summer population of ..... and a winter population of .....~~ Daily input tonnages will vary i.e.

~~Winter~~ Monday

~~Tuesday~~

~~Wednesday~~

~~Thursday~~

~~Friday~~

~~Summer~~ Monday

~~Tuesday~~

~~Wednesday~~

~~Thursday~~

~~Friday~~

~~X~~

1. TENDER DOCUMENTS:

*2 Spanish + 1 English*

The tender documents must contain ~~3~~ (three) copies of at least the below mentioned documents:

Flow diagram indicating full description of the proposed plant.

Detailed drawings showing:

- a. General plant layout, scale 1:500 including possibilities for extension.
- b. Project drawings showing layout and sectional views of the treatment lines, scale 1:100.
- c. Project drawings showing layout and sectional views and fronts of all buildings, scale 1:100.

Specifications of all major processing equipment including but not limited to:

- Name of manufacturer,
- Place of Origin, and
- Technical specifications.

A list of spare parts proposed together with information about expected working life.

Mass balance for the proposed plant.

List of the personnel necessary to run the plant.

On-site training programme for key personnel.

Detailed time schedule for execution of the plant.

Daily consumption of electricity, water, fuel and oil for the plant.

Estimated/

~~7~~

Estimated yearly maintenance costs.

Tenderers qualifications and experience in the construction of similar plants, together with reference list of composting plants shall be given.

....

2. GENERAL CONDITIONS AND SPECIAL PROVISIONS:

This tender shall be in accordance with the following special provisions:

All contracts shall be issued by the .....

All quotations should be based on a Turn-key project including supply of the equipment necessary for the project and executing all the civil and erection work.

The contractor shall be responsible to receive all the imported equipment from the sea port and shall be responsible for transport to site.

The contractor shall be responsible to provide the site with power and water necessary for the erection, and shall bear all expenses during that period.

The contractor shall be responsible for the safety of the equipment and personnel in the plant during the period of erection and testing.

Bidders are requested to furnish bid guarantee amounting to one percent of the grand total bid price (foreign and local component) in favour of..... This bid guarantee should be valid for at least 3 (three) months from the date of bid opening.

Bid guarantee of unsuccessful bidders shall be released after being notified of the bid not being successful, but not later than 3 (three) months after date of bid opening.

The successful bidder will be released from the bid guarantee upon receipt of the performance guarantee amounting to 5 (five) percent of the grand total bid price.

A copy of the specifications, drawings, and catalogues should/

should be submitted with the offer.

The commodities to be imported shall be seaworthy packed and protected to prevent damage or deterioration during transport.

Quotations shall include all the shipping and insurance costs for all imported equipment.

Quotations should specify the amount of foreign component and the amount of local component for the complete project including all the items specified in this tender document.

Bidders shall state the terms of payment for both the foreign and local payments.

The contractors shall be responsible for the guarantee of the whole plant during one year starting from the date of provisional acceptance.

Final taking over of the plant shall be performed after one year from the date of provisional acceptance. *Providing the performance is in accordance with the contract and there are no outstanding jobs.*

The performance guarantee of the plant shall be released after the final taking over of the plant.

#### MANNING AND TRAINING OF PERSONNEL:

The tender must include a list of personnel for the manning of the plant.

Further the tenderer must indicate the various stages of delivery at which all individual groups must be engaged in order to acquire the best possible understanding of the operation of the plant.

The contractor shall carry out the necessary instruction and training/

training of key personnel for running, operation and maintenance of the plant.

The tenderer must include details of how these instructions and training shall take place.

TRAINING:

To train management and key personnel especially during the operation of the plant for a period of 3 (three) months starting from the provisional acceptance.

The tender shall include a detailed program for training.

LOCAL MANUFACTURING:

The bidder shall indicate the items of the specification that will be constructed/supplied in  ECUADOR

The design, construction and installation of all the equipment shall remain at the responsibility and guarantee of the tenderer.

REFUSE CHARACTERISTICS:

Information provided in this invitation to tender is given

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**CREA**

**CENTRO DE RECONVERSION ECONOMICA DEL AZUAY, CAÑAR Y MORONA SANTIAGO**

TELEFONO COMPUTADOR: 830-799  
DIRECTOR EJECUTIVO: 825-934  
TELEX 8810 CREACU ED  
CASILLA 4933  
CUENCA - ECUADOR

Average Composition of Rubbish in the City of Cuenca.

Organic Material	61 %
Paper and Cardboard	15 %
Metal and Drink containers	4 %
Glass	3 %
Textiles	2 %
Plastic and Rubber	7 %
Bone	1 %
Inert Material	7 %

~~Handwritten signature or mark~~





**CENTRO DE RECONVERSION ECONOMICA DEL AZUAY, CAÑAR Y MORONA SANTIAGO**

TELEFONO CONMUTADOR: 830-799  
DIRECTOR EJECUTIVO: 825-934  
TELEX 8610 CREACU ED  
CASILLA 4933  
CUENCA - ECUADOR

DATOS METEOROLOGICOS DEL VALLE

ALTITUDE	2.600 m.s.n.m.
ANNUAL PRECIPITATION	850 m.m.
AVERAGE TEMPERATURE	12.5º
RELATIVE HUMIDITY	76%
HOURS OF SUN	1729.7 Hours
CLOUDY	6/8
EVAPORATION	1259.4 m.m.
POTENTIAL TRANSPIRATION	918. m.m.

NOTA: THIS DATA IS THE AVERAGE OF ~~10~~<sup>16</sup> YEARS.

MOISTURE CONTENT:

The incoming refuse is estimated to contain 60-65% moisture by weight in winter and 50-55% by weight in summer.

DENSITY:

It is estimated to be 0.24 t/m<sup>3</sup> approx.

DATOS METEOROLOGICOS DEL VALLE

THE TECHNICAL PROCESS:

~~The plant is to be of the composting type of latest technology.~~

The following mentioned stages shall be considered as a guide:

The Technical Process

The plant is to be a moderate technology windrow composting plant provided with facilities for the hand sorting of recyclable materials.

The following stages are offered as a guide:-

Weighing the incoming trucks by using a mechanical beam scale

Unloading the vehicle in a receiving station where large non compostable materials can be removed.

Conveying the refuse to a picking belt for hand picking of recyclable and non compostable materials. **CRANES ARE NOT ACCEPTABLE FOR THIS DUTY.**

Removing of ferrous metals by a magnetic pulley



Mixing, homogenizing, pulverising and screening through a rotating drum. **HAMMER MILLS AND CRUSHERS ARE NOT ACCEPTABLE FOR THIS DUTY.**

Transport of the compostable material to a compost bay from where it is transported by a front end loader to the fermentation area.

Transport of the oversize drum rejects to a reject bay from where they will be transported to the tipping site by front end loader. **A magnetic pulley will remove ferrous material from the rejects.**

Constructing the windrows for aerobic fermentation in adequate areas.

Periodic turning of the windrows by front end loaders.

Transporting the fermented compost to the maturation area by front end loader.

The fermentation and maturation period shall be at least sixty days.

The maturation area shall be an open, roofed structure.

The mature compost shall be fine screened on an <sup>inclined</sup> flat bed oscillating screen and then passed over a stone separator to remove particles of glass, and stones and other inert materials.

2      FERMENTATION PROCESS:

After the mechanical process of producing a fine organic mix fermentable material, this should be followed by an aerobic fermentation <sup>and</sup> maturation period to transform the material into a high quality ~~compost~~ compost.

To ensure maturity it will be necessary to guarantee digestion of ~~at least forty~~ <sup>thirty</sup> percent of the original organic dry matter. This will be determined by comparison of content of organic matter in ~~the~~ the initial and final product (as loss by ignition).

The fermentation/maturation process should be made ~~in two~~ in two stages. The first stage (fermentation) should take place under aerobic conditions for a ~~minimum~~ period of ~~3~~ <sup>about 4</sup> ~~(three)~~ <sup>to 5</sup> weeks. The second stage should incorporate the transfer of material from the fermentation area to a maturation area by bucket loader or equivalent, and allowance made for storage over a ~~three week~~ <sup>four week</sup> period.

Final treatment should be included to segregate by screening the larger inert content (e.g. glass, stones, plastic). This process should be designed to permit interchange of differing screen meshes for production of a range of compost grade.

*A storage area for screened compost shall allow sufficient space for holding 30 days production*  
It is possible that a bagging unit will be required and this items should have the capability of feeding 15/25 kg bags and be complete with all ancillary handling equipment. This item should be shown as an optional extra.

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GENERAL TECHNICAL REQUIREMENTS:

Design and Construction:

The tenderer shall take the full responsibility for design and construction of the complete plant on a turn-key basis. The delivery must include supply and erection of all machinery and equipment necessary for the operation of the plant including staircases, platforms etc. necessary for inspecting and adjusting all stationary machinery. All special tools necessary for the operation and maintenance of the plant must be supplied.

Machinery, steel structures and conveyors equipment are to be manufactured of good quality materials free from defects.

Painting and Surface Treatment:

The work comprises full surface treatment of steel parts as follows:

Grit blast to Swedish standard SIS 05590 sa2½ and paint 2 coats of epoxy zinc phosphate primer, each coat 50 micron. *For Ecuador standard: There is a or to*

Conveyors:

- Belt types are to be of a quality suitable for handling refuse and compost *and constructed to be fire retardant.*
- All belt conveyors must be provided with automatic safety protection devices.
- The conveyors must be provided with a belt adjusting device which must be simple and easily accessible.
- All supporting rollers must be constructed of steel tubes with sealed for life bearings.
- Drive pulleys are to be mounted in dust-proof bearings.
- Each belt must have an integral, efficient cleaning device to clean the belt in order to prevent accumulation of material.
- *cleaning The/* All pulleys are to be *helical* wound self cleaning types
- The drum feed, reject and compost conveyors shall be covered to prevent the material becoming wind-borne.

The tenderer is asked to submit the design, the capacity and dimensions of each conveyor, belt materials, angle of inclination, speed and technical data.

Components of the Plant:

- The Components of the plant must be executed so that they require a minimum of adjustment and maintenance.
- All bearings must be dust-proof.
- Necessary lubrication of running parts shall take place by central lubrication to the greatest possible extent.
- Easy access must be provided for inspection and adjustments.
- All necessary guards must be supplied.
- The construction must allow reasonably quick replacement of wearing parts.

Laboratory:

The plant should include a laboratory which contains all the necessary equipment required to determine the <sup>following</sup> components of the compost, ~~such as~~:

- ~~Phosphorous content.~~
- ~~Nitrogen content.~~
- Dry matter percentage.
- Ignition loss.
- pH value.
- Temperature <sup>during</sup> ~~in~~ fermentation.

Among others the following equipment should be supplied:-

- a. Laboratory work bench with a chemical resistant cover of length 8 meters.
- b. Ceramic sink with cold water and acid proof sewer connection.
- ~~c. Supply of 10 kg gas cylinder at least together with gas fittings and 5 taps for Bunsen burners or alike.~~
- ~~d. Sink cupboard with outlet to the open air.~~
- e. Lockable cupboards for instruments and chemicals.
- f./

- ~~37~~
- d Rack for Chemicals etc.
  - e.s. Sufficient quantities of shelves, drawers (lockable to some extent) and cupboards shall be available.
  - f.r. Ignition loss furnace or another equipment at 600°C. The temperature shall be controlled by thermostat. The equipment shall have outlet to the open air.
  - g.s. An incubator with thermostatic control, temperature range 30°C - 150°C.
  - h.z. A precision <sup>scale</sup> ~~weight~~, digital read out, weight range: 0-1000 g, the smallest read out 1 mg. The ~~weight scale~~ shall be on a stone table.
  - i. x. Digital pH-meter including all necessary fittings: combined electrode, electrode holder, calibration liquids etc.
  - j. x. 12 digital portable thermometers, temperature range: 0-100°C <sup>each with</sup> including 2 interchangeable sensors with the lengths: ~~500~~, 600 and 1000 mm.
  - ~~r. 2 complete sets of kjeldahl destruction and distilling equipment for determination of the nitrogen content. All the necessary titration equipment shall be furnished too.~~
  - ~~n. Equipment for colorimetric determination of the phosphorous content in the compost (with a colour comparison disc).~~
  - ~~o. Equipment for determination of sodium chloride content in compost.~~

Furthermore, all the necessary laboratory equipment including <sup>but not</sup> limited to glass ware, ~~chemicals etc~~ and chemicals.

#### Workshop:

It shall be fully equipped for maintenance and repair of the machinery of the entire plant. The following equipment must be supplied:-

- a. Work bench with a parallel vice, length 5 m.
- b. Shelves and drawers for tools.
- c. Pillar drilling machine for max. 36 mm drills, with 4 spindle speeds, including drill chuck, complete set of drills 1-36 mm as well as machine vice.
- d. Electric grinder, bench type.
- e. /

- ~~2~~
- e. Anvil.
  - f. Welding plant with min. 30 m cable including 300 amp transformer and all necessary accessories.
  - g. Equipment for autogenous welding for plate thickness up to 15 mm and with cutting blow pipe set up to 50 mm plate thickness including reduction valves and tubes as well as welding equipment.
  - h. Air compressor.
  - i. Manual jacks.
  - j. Hand tools including but not limited to hand drills, electric grinders, wrenchers, tongs, hammers, pipe wrenches, etc., all of good quality.
  - k. A manual crane or travelling hoist block of at least 2 tons capacity should be installed in the workshop.

The above equipment shall not be used for erection purposes and must be delivered unused to the employer at completion of erection.

.....

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7. PERFORMANCE SPECIFICATION FOR MECHANICAL EQUIPMENT:

Processing Equipment:

The capacity of the plant shall be ...<sup>85</sup>... tonnes/day corresponding to .....<sup>8</sup>... working hours.

The plant shall be designed in such a way, that the following can be carried out:-

- Homogenization of the ~~refuse~~ <sup>solid waste</sup> including the addition of moisture.
- Separation of the organic rich materials.
- Fermentation of the organic rich materials.
- ~~Maturation and drying of the compost~~ <sup>under an open-cell</sup> Refining of compost. <sup>roofed structure.</sup>

The plant shall be constructed with a reception/storage area for the incoming refuse, which shall be large enough to hold one days input of refuse.

GENERAL DESCRIPTION OF PLANT PERFORMANCE:

The incoming vehicles unload the refuse in the reception area, and without the necessity for pre-sorting, except for obvious very large bulky items, ~~the refuse~~ <sup>the refuse</sup> should then be fed into a mixing and homogenizing drum, in which the moisture content can be increased if required. <sup>The loading of the drum shall not involve cranes.</sup>

The refuse must have sufficient residence time in order that the refuse is homogenized, to create the best possible conditions for the composting process.

The process must have a degree of flexibility and requires that the mixing/homogenizing drum can be operated for any required period without discharging, and unattended, to extend the residence time for a portion of the refuse treated, ~~if~~ <sup>if</sup> required.

The maximum amount of refuse that can be retained in this manner for extended residence time must be stated.

The mixing/homgenizing drum must be so designed that reliability of operation must be demonstrated, and must be constructed in/



~~212~~

in such a manner as to provide a substantial operational life. Reference to this effect should be detailed with locations. *The reference must also include plants constructed in the last five years*

It must be shown that:

- The drum is <sup>internally</sup> protected against wear and <sup>is</sup> of substantial construction.
- The method of providing rotation is designed in such a way as to minimise breakdown, ~~and single motor drives must be avoided.~~
- The speed of rotation must not exceed 10 RPM.

After discharge from the mixing/homogenizing section of the drum, the organic rich material is to be converted aerobically to a stable compost. The matured compost shall be refined by screening to remove inorganic materials which remain.

#### PARTICULAR SPECIFICATION

##### Truck Scale

The truck scale shall be a mechanical beam scale. It shall have a capacity of 30 tonnes and the bridge size shall be at least 8 X 3 metres.

~~It shall be of pitless form and~~ the foundations <sup>should</sup> be reinforced concrete. ~~with approaching ramps.~~ The equipment will indicate and print or stamp out the vehicle weight on scale tickets. The offer shall include tickets for one year operation.

##### Plate Feeder.

Incoming wastes shall be discharged from the refuse truck onto the floor of the receiving building. They shall be transferred by front end loader onto a plate feeder. The plate feeder shall be 2. m wide and of variable speed. The mid point on the variable speed ~~gear box~~ shall be such that 10 tonnes per hour of <sup>wastes will</sup> ~~refuse~~ <sup>shall</sup> be delivered to the picking belt.

##### Picking belt

The picking belt shall be constructed of fire resistant materials. It shall be placed horizontally at a suitable level for efficient and easy hand picking from both sides of the belt. The belt shall be of variable speed between

30  
10 and 18 metres per minute. The effective <sup>size</sup> length of the belt shall be approximately 20 metres long and 1 metre wide. The conveyor shall be equipped with a tensioning device, scrapers top and bottom and side seals to prevent spillage. The rollers and return idlers shall be of steel tube with sealed for life bearings. The pulleys shall be self cleaning, *helical wound.*

Metal Baling Press

The metal baling press shall have sufficient capacity and pressure to bale the extracted metal to a size suitable for safe, easy handling without the need to use baling wire. The baling mechanism shall be hydraulically operated. *The cross section of the bale shall be approximately 30cm x 30cm*

The Paper and Textile Baling Press

The paper and textile baling press shall be electrically operated and the bales may be tied with wire or ribbon.

Magnetic Separator

The magnetic separator shall be of the permanent magnet rotating pulley type installed at the discharge end of the picking belt. *and reject belt.* They will discharge into a suitable hopper, ~~close to the metal baling press.~~ The pulleys shall be of sufficient magnetic power to ensure efficient extraction of the ferrous metal.

The Mixing, Homogenising, Pulverising and Screening Drum.

The purpose of the drum is to reduce the size of the refuse by pulverising, tearing, crushing and mixing the material to obtain a homogenous mixture that is suitable for fermentation in windrows.

The drum shall be of the closed rotating type that is driven by an electric motor and Vee belts via a gearbox that is capable of rotating in the reverse direction when the electric motor is stopped and the drum reverses its direction prior to coming to rest.

The drum should have a feed hopper at the stationary inlet end and the inlet end should be held in close contact with the drum by tensioning rollers to allow the minimum amount of spillage.

The drum should run on support rollers that can be adjusted to ensure the drum runs true. The support rollers should be of sufficient strength to take the weight of the drum and its contents through two live rings.

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Positioning rollers should be fitted to the inlet plate to ensure rotational accuracy and the inlet end plate should be supported on moveable spring loaded tensioning columns to protect the end plate and drum against any eccentricity that may have been built in or may occur due to temperature variations.

The longitudinal <sup>movement</sup> play shall be controlled to within stated limits by a locating roller situated on each side of the live ring nearest to the feed end.

The exit end of the drum shall incorporate an exit door with a variable opening. *The operation of the door shall not be manual.* Internally, the drum shall have wearplates at the inlet and exit end and a system of wear <sup>surfaces</sup> bars to prevent the refuse coming in contact with the metal of which the drum is constructed.

At the exit end of the drum the refuse should discharge through the exit door onto the rotating screen that is attached to and part of the drum. The screen should consist of screen plates with 65mm holes.

The inside of the drum should also have <sup>provision</sup> sharp spears for the opening of plastic bags.

At the discharge end, the oversize material (rejects) should be discharged onto a conveyor and the undersize <sup>compostable</sup> material should be discharged onto a conveyor that transfers it to the compost bay. The design of both of these discharge points are of the utmost importance <sup>to prevent</sup> as blockages <sup>that</sup> can occur here due to the high moisture content of the material.

Allowable eccentricity or vibrations shall be stated.

The driving unit shall be covered.

*Friction drives are not permissible.*

#### Compost Belt

The compostable material discharged from the drum shall be transferred to the compost bay by a conveyor belt. ~~This belt shall be 2m wide.~~ Scrapers shall be fitted top and bottom, the pulleys shall be self cleaning, the roller bearings shall be sealed for life and a tensioning device shall be fitted.

#### Reject Belt

The oversize rejects discharged from the screen shall be transferred to the rejects bay by a conveyor of the same specification as the Compost Belt.

*All conveyors shall be self supporting structures without the need of external support such as guy ropes.*

### Front End Loaders

Three front end loaders will be required. These should be standard production machines capable of operating at high altitudes. All spare parts should be available in Ecuador. They should be wheeled machines powered by normally aspirated, water cooled diesel engines. They should be two or four wheeled drive. The bucket capacity should be <sup>2m<sup>3</sup></sup> and the dump height should be 3m. *Tires and wheel sizes shall be readily available in Ecuador*

Final Screen  
A feed hopper should be provided to feed the matured compost via a conveyor belt to a flat bed, inclined, oscillating screen with a capacity of 8 tonnes per hour. The rejects shall be discharged into a bay and the compost shall be discharged onto an inclined belt stone separator and then into a storage bay. The screen shall be supplied with easily interchangeable screen plates of 25, 12 and 8mm hole size.

### Spare and Wear Parts

The supply shall include necessary wear and spare parts for <sup>Two</sup> ~~one~~ years normal operation in <sup>one</sup> ~~two~~ shifts.

The quantity and value of these parts must be submitted in the tender and the working life for these must be stated.

### Compost Quality

The process offered shall be guaranteed to produce compost that:-

*Has a pH over 7.0*

Is safe and free of pathogens

*Has a moisture content of less than 40%*

Does not contain material that is harmful to the soil or to plant or animal life.

*Has 80% of the original organic matter digested.*

Has been through a temperature of 55° for three days and has received

a minimum of three turnings during the windrowing period.

Has a Carbon / Nitrogen Ratio of 20:1 or lower and in which the emergence of nitrates has commenced.

*Is the small size free of objectionable material.*

### Performance Specification For Electrical Equipment

Material and works shall be in accordance with International Standards taking into consideration the elevation and climatic conditions of Cuenca.

The installations shall be well arranged to permit easy maintenance and operation.

~~All materials used shall be obtainable in Ecuador.~~

#### Transformers

Standard oil insulated transformers shall be supplied. The rated output shall include a suitable excess over the power requirements of the plant.

#### Main Switchboard

The main switchboard shall be placed in a separate room. A circuit breaker with the necessary overloads and protection relays shall be provided. The switchboard shall be metal enclosed and shall include all the necessary protection for each item of equipment on the plant.

A system of intertripping shall be included to prevent material being passed on to a piece of equipment that has become non functional for any reason.

#### Cables

All cables shall be of copper conductors covered with plastic insulation. Underground cables shall be at a depth of 60cm. Other cables are to be placed on trays or in steel pipes and protected against mechanical-thermal effects. For motor and control components flexible pipes shall be used.

#### Power Factor Correction

Automatic power factor correction shall be supplied to compensate  $\cos \phi$  to:  $0.9 > \cos \phi < 0.95$

#### Earthing

A suitable earthing system is to be provided for all the electrical equipment.

#### Motors

Motors shall be according to international standards and suitable for use in the tropics.

#### Maintenance

Isolation switches shall be placed at all motors and emergency stop buttons shall be placed at all operating places.

#### Civil Engineering

To the normal Ecuadorian standards.

#### DRAWINGS

All drawings supplied by the client are of an advisory nature only and are not part of any contractual agreement.

SPECIFICATION FOR ELECTRICAL EQUIPMENT:

The work comprises delivery and installation of the complete electrical installation both high and low voltage.

Materials and works shall be in accordance with <sup>ECUADORIAN OR</sup> international standards.

The installation shall be well arranged to permit easy maintenance and operation, as well as ease of extension and change of the installation.

Electrical Supplies:

A complete transformer station including foundations, buildings, switch-gear, transformer and low voltage installations shall be supplied.

Switch-gear:

- The switchgear shall be metal clad switchgear containing:
- Cable panels with oil cooled switch disconnecter.
- Metering panel with terminal for external meter.
- Transformer panel with oil cooled circuit breaker with magnetic release and fuse.

The plant shall be equipped with earthing switch, short circuit indicator and control equipment for the transformer. The neutral point of the transformer shall be earthed.

Transformer:

Standard oil insulated transformers shall be supplied according to international standards. Rated output to be min. 25% higher than the power requirement of the plant.

Rate Voltage ..... volts.      6400    3200    1100

Frequency .... 60 ... cycles/sec.

The transformer shall be supplied with:

- Oil Expansion tank
- Buchloz relay.
- Silicagel/

- Silicagel filter (moist separator)
- Oil level indicator.
- Minimum thermograph and contact thermograph.

*Assump of 200% volume of the oil capacity*

The transformer shall be supplied with travel rolls.

The distribution system of the low voltage installation shall be.....volts, 3 phase plus neutral. The connection of the transformer should suit the outside network.

Low voltage Installations:

The distribution system will be built up as a 3 phase network with neutral ..... volt.....c/s. From the transformer, busbars shall be lead to the low voltage switchboard. Installations for lighting and control voltage supply for the signal ~~and~~ and operating equipment shall be included.

Switchboards

The main switchboard of the plant shall be placed in a separate room. A circuit breaker with necessary overloads, short circuit and under tension relays shall be provided with three phase indicator lamps.

The switchboard shall be metal enclosed and contain voltagemeter, ammeters ~~maximum~~, circuit breakers for secondary switchboards of the installation. *A mimic diagram shall be included*

Automatic electric switches with necessary protection shall be provided for each equipment of the plant.

All cable inlet to the switchboards shall be made with glands.

Cables:

All wires shall be made of copper conductors covered with plastic insulation. Underground cables shall be laid in 60 cm depth. Other cables are to be placed on trays or in steel/

steel pipes and shall be protected against mechanical and thermal effects. For motor connections and control components flexible pipes shall be used.

Earthing:

A suitable earthing system is to be provided for all the electric equipment. An earthing installation with depth electrodes of copper welded rod electrodes shall be erected. The joints shall be made by means of press connection sleeves. All metal parts of the switchboards shall be earthed and equalizing connections shall be made on the machine installation.

Motors:

Motors shall be according to <sup>ECUADORIAN OR</sup> international standards. and shall be tropicalised.

Power Socket Outlets:

The installations and the buildings shall contain an ample number of ..... V socket outlets with suitable power.

Automatic Control Installations:

The plant shall be supplied with control cubicles. The power switchboard shall contain motor protection, fuses and auxiliary relays. The cubicle shall contain operating push buttons, lamp indications, alarm installations and visual instruments. Automatic control installations shall be erected in a centrally placed control room.

The control installation shall be built up with relay technique. An interlock system shall be placed between the installation parts with possibility for testing start of the individual motors during test running and repair. Emergency push buttons shall be placed at all operating places and along the lines.

Lighting Installations:

All rooms (offices, workshops...etc) and working premises shall be executed with fluorescent lamps as working and local lighting. Lighting levels in accordance with normals. Lighting shall/



shall be placed at all working and inspection locations and  
all roads.

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SPECIFICATIONS FOR CIVIL WORKS:

The civil works shall principally include the following items:-

- Soil investigation and site preparation.
- Foundations.
- Fences and gates.
- Parking area.
- Administration building and laboratory.
- Weigh office.
- Transformer room.
- Reception building, control rooms, workshop and stores.
- Fine screening building.
- Fermentation, maturation and storage areas.
- Water supply including hydrants.
- Drainage and foul water connections.
- Roads and green areas.

Soil Investigation and Site Preparation:

The contractor shall survey and consider the levels of the site and prepare his layout accordingly. Necessary soil investigation including field and laboratory tests are to be carried out by the contractor on his own accounts and on his own responsibility.

Site preparation comprises all possible works such as excavation, backfilling, trimming and shaping of slopes, formation levels, removing of surplus materials etc.

Foundations:

The contractor shall carry out the design of all foundations and shall present proper documentation for adequate safety against failure and unacceptable movements and differential movements.

The foundation design shall be carried out in accordance with <sup>Ecuadorian or</sup> international standard codes.

Fences/

~~the~~

Fences and Gates:

The plant shall be fenced and shall follow the contour lines of the site. One main entrance gate with a width not less than 8 m shall be provided. Next to the main gate a minor gate for pedestrians shall be provided.

Parking Area:

Next to the administration building a parking area for cars is to be constructed.

Buildings:

The design of the buildings shall be determined by the contractor. ~~and will require agreement by the client.~~  
All concrete floors shall be smooth. All local conditions such as soil bearing pressures, wind, climate, static and dynamic loads, etc... should be taken into consideration upon designing any Civil works which the contractor shall be fully responsible for. The buildings are to be well ventilated. All roof constructions shall be weather proof.

Administration Building:

This building shall include rooms for the manager, engineers and the clerks, laboratory, kitchen, canteen, first aid room, locker room and toilets.

- One room for the manager equipped with desk and chair, chairs for visitors, one conference table with chairs and one lockable filing cabinet and a photocopying machine.
- ~~One room~~ <sup>the</sup> for clerks and ~~typists~~ <sup>Two</sup> equipped with ~~two~~ desks and chairs, ~~two~~ <sup>one</sup> typewriters, two cupboards and four chairs (in each room).
- One room for engineers equipped with two desks and chairs, four chairs for visitors and one cupboard.
- One room equipped with two desks and chairs, four chairs and one cupboard.
- One laboratory of area not less than 24m<sup>2</sup>, equipped with work benches, ceramic sink, desks and chairs, cupboard and all necessary fittings for laboratory works. The walls shall be covered with white tiles.
- First/

- First aid room equipped for first aid purposes.
- Kitchen equipped to serve staff, with walls covered with white tiles.
- ~~Canteen room for all personnel~~
- Locker rooms and toilets to serve staff with walls covered with white tiles.

Weigh Office:

The weighing of incoming and outgoing trucks shall be supervised and registered. The room shall have a size of about 6m<sup>2</sup> and be placed near <sup>to the</sup> main gate of the plant. In addition to weighing equipment a desk and chair shall be provided .

Transformer Room:

Adequate room facilities for transformers as well as the high and low voltage switchboards shall be supplied in a separate building. The room shall be well ventilated and provided with a protective earthing system.

Reception Building:

The refuse trucks shall be unloaded in the receiving area which shall be designed to hold at least <sup>1 day's supply of</sup> ~~7 days~~ <sup>tons of</sup> ~~refuse~~ <sup>wastage</sup>. The receiving area shall be roofed and surrounded by walls from the three sides. ~~The front side shall be equipped with doors.~~ Efficient natural ventilation should be achieved through special vents in the walls and the roof. The floor of the reception area should be covered with reinforced concrete and treated against chemical reactions with the refuse. ~~Two~~ water valves and hoses with sufficient length and diameter shall be available for fire extinguishing purposes.

The Control Room:

A centrally placed control room must be constructed for the control cubicles. The control room should be placed and constructed to avoid dust problems and allow a good view of the machinery. This room must be air-conditioned.

The Workshop/

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The Workshop:

The workshop shall be ~~not less than 60m<sup>2</sup> with a headroom~~ <sup>as in the attached drawing.</sup> of ~~at least 4.5 m.~~ The workshop shall be fully equipped for maintenance and repair of the machinery of the entire plant.

The doorway from the outside to the workshop shall be approximately 4 m wide and 4.5 m high. In this door, a small door for daily access can be installed. The lighting in the workshop shall be based on ~~electric~~ <sup>fluorescent</sup> light. A water supply valve with a 20 m hose shall be installed.

Stores:

A room shall be established for storage of spare parts and tools. The room shall be equipped with the necessary shelves and drawers. Lockable doors shall be included.

Oil, Lubricant Stores:

A room for storage of oils, and lubricants shall be provided. The room shall be equipped with the necessary steel shelves. A lockable door to the ~~workshop~~ <sup>outside</sup> shall be provided. The room shall be properly ventilated in order to avoid dangerous vapour concentrations (flammable).

Kitchen:

In the kitchen a working top with a sink shall be installed, both made of stainless steel. The size of the room shall be ~~about 6m<sup>2</sup>~~ <sup>as drawn.</sup> Three electrical sockets should be furnished above the working top. The walls shall be covered with white glazed tiles to height of 3m.

Fine Screening Building:

A building shall be constructed for the fine screen. The building must be shielded against sunlight and prevent compost from being blown away during treatment. The building shall be supplied with water for cleaning purposes and increasing the water content of the compost before storage.

Roads/

Roads, Fermentations, Maturation, Storage Areas:

All internal roads as well as compost storage areas shall be paved with asphalt in accordance with local standards. *and that is suitable to resist the effects of the heat generated during the process.*

Connection of internal roads within the site to the outside public roads is also the responsibility of the tenderer.

The roads shall have a width sufficient to permit two arbitrary vehicles to pass each other easily anywhere on the site.

Water Supply and Drainage Works:

The contractor shall install all the water pipes, fittings and valves inside the plant.

..... shall provide a suitable source of fresh water. The contractor shall be responsible for the installation of the complete drainage system.

Fire-Fighting Works:

The contractor shall install all fire fighting pipes, fittings and valves together with necessary hoses complete with their fittings. In addition, all necessary manual fire extinguishing equipments shall be provided inside the buildings. Special attention shall be paid to provide the necessary special kinds of fire extinguishing equipment for the laboratory, the workshop, and the electrical equipment.

Number and type of portable fire-extinguishers shall be specified in the tender.

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**Appendix B**

**The composting process**

EL PROCESO DEL COMPOST

POR

E. GLYNN HUGHES



Los residuos municipales se componen de tres categorías: Orgánicos, no orgánicos y agua.

Los residuos que están compuestos de materia no orgánica serán removidos lo más posible. El contenido de agua será del 50-60% y la materia orgánica será reducida en tamaños para que el área superficial o radio de volumen sea conveniente para una eficiente actividad microbiológica.

La materia no orgánica es removida en una etapa inicial por selección manual y separación magnética.

El contenido de agua puede ser ajustado si es necesario, por adición de agua. En Cuenca no es requerido en verano ni en invierno, el contenido de agua de los residuos está en el rango requerido de 50-60%.

Los residuos orgánicos ricos son colocados en el cilindro, en el cual están rotando.

La acción de rotación provoca que el material duro de los residuos se reduzcan a un tamaño de materia suave.

El material de deshecho está girando en el cilindro por 2 ó 3 horas y luego saldrá a la cernidora al final del cilindro.

Esta cernidora tiene orificios de 65 mm de diámetro, el material que cruza los orificios es básicamente materia orgánica que ha sido reducida a un tamaño apropiado para el compost, a pesar de que todavía contendrá algunos materiales no orgánicos.

El material que no atravieza los orificios es principalmente materia no orgánica tales como vidrio y plástico que no son descompuestos.

Este material es llevado a un batadero para ser enterrado.

El material compuesto que ha pasado a través de los orificios en la cernidora es llevado al área de fermentación donde se coloca en largas pilas triangulares de 3mt. de alto y 7-9mt. en la sección transversal de la base. Estas pilas son llamadas hileras (tierra). Debido a la actividad biológica la temperatura en las hileras llega a 45°C. Este rango de temperatura es llamado rango "Mesofílico". Cuando la temperatura pasa sobre los 45°C., la Bacteria Mesofílica muere y es reemplazada por la Bacteria "Termofílica", las cuales provocan una continua elevación de temperatura a 70-80°C. Los prin

principales Bacterias comprendidas son Bacilos *ESTereothermophilus* y Bacilos Circulares. Esto ocurre naturalmente. Otros organismos involucrados en el proceso incluyen Penicilina, Actinomicetas, Micellus y Protozoarios.

Las partículas no orgánicas duras aún presentes tales como vidrio y minerales etc. asegura que la estructura permanezca abierta y provee poros para la retención de oxígeno que es necesario para el proceso.

Si el oxígeno está presente el proceso es aeróbico y no hay mal olor. Si el oxígeno no está presente debido a que las partículas han sido muy pequeñas o los poros han sido llenados con agua debido a que la mezcla ha sido humedecida entonces el proceso comienza anaeróbicamente y resultan malos olores.

Al mismo tiempo que todas las actividades biológicas están ocurriendo cambios físicos y químicos; los ácidos son eliminados y el PH de la masa está cambiando entre 3.0-5.0 a 7.0-8.0.

El calor biológico generado ha levantado corrientes de convección - en la cual hay escape de vapor de agua desde la masa y secado.

El calor extraído es suficiente para matar patógenos, mosquitos, - larvas.

El Carbón en la masa se transforma en Bioxido de Carbono y es extraído con el vapor de agua.

Durante esta etapa el material está rotando (girando) cada 7 días para liberar el vapor de agua para volver a reabastecer el suministro de oxígeno.

Después de que la intensa actividad microbiológica en la etapa de fermentación ha pasado, la temperatura desciende y la etapa Mesofílica ha regresado.

Las hileras de tierra son ahora movidas al área de maduración formando una planicie de 3 metros de altura donde el compost permanece cerca de un mes.

En esta etapa ocurre la maduración final de la materia y la actividad biológica continua a más baja velocidad que la etapa de fermentación.

Mientras el material está madurando este permanece calmado (inalterado) y no es movido. Este está madurado cuando la temperatura es estable. El C/N del radio es 20:1 o menos y la presencia de Nitratos puede ser detectado.

Después de que el Compost es madurado este es cernido para remover la materia dura no orgánica que ha sido usada para formar y retener los-vacíos de oxígeno necesario para el proceso.

**Appendix C**  
**Sample of prepared drawings**