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September 1988

ASSISTANCE WITH A COMPOST PLANT

SI/OMA/88/802

The Sultanate of Oman

Expert Report *

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

Based on the work of Mr. Willibald Lutz,
Consultant in
Compost production from municipal solid waste

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

United Nations Industrial Development Organization
Vienna

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UNIDO SI/OMA/88/802/11-51/J134424 Vienna, 23 September 1988

Sultanate of Oman

REPORT

Dr. Willibald Lutz, UNIDO Consultant

1. Composting Plant:

The composting plant is owned and operated by a private company, Oman Organic Fertilizers & Chemical Industries SAO (OOFCI). The plant designed and supplied by the French company OTV (Siloda process) was constructed in 1985 and started up on December 10, 1985. The capacity amounts to 160 TPD MSW respectively 35,000 TPY to produce 14,000 TPY mature and refined compost delivered in 25 kg plastic bags. Rejects in the range of 13,000 TPY have to be hauled to the landfill. The balance of quantities are fermentation losses in the aerobic process.
The capital investment amounted to RO 2.8 million (US $ 7.4 million).
Because of compost marketing problems the garbage receiving was stopped in April 1987. 11,500 tons had been stored in the outdoor curing area at that date. During the past 16 months about 4,700 tons refined compost were sold. There is still 5,500 tons of unrefined compost stock piled in the plant.
The demand of compost in the entire Sultanate was estimated in 1986 to be 30,000 tons, whereas almost 10,000 tons are imported peat and other soil conditioners such as compost produced in the U.A.E. Prices tend to vary depending on the time of season, availibility and market situation. The average sales price of the OOFCI plant in 1988 amounts to RO 36 per ton in 25 kg plastic bags ($ 95/t). The buyers are 80 % private people and 20 % governmental agencies.
It so happened that after the commissioning of the factory, a housing colony came up in the vincinity of the composting plant. Within a distance of 45 m (fence to fence) north of the factory the housing complex includes 250 homes with approximately 2,500 people and one school. Depending on the direction and velocity of wind and air movements unpleasant odours are carried into the residential area. Usually during day time the wind is blowing from the houses to the factory and during night time on the contrary.
The purpose of the expert mission is the evaluation of process employed at the plant, investigation of the characteristics of the feedstock and operating procedures to recommend solutions solving the odour problems. There appear to be two alternatives:

a) Eliminate/contain the unpleasant odour so that there may be no inconvenience/ nuisance to the residents of the neighbouring housing colony.
b) Closing down the factory temporarily and shifting it to a far away place.
Financial and other consequences for the recommended solution have to be considered.

2. Nuisance odours:

According to information from the Ministry of Environment and Water Resources on September 6, 1988 there had been 6 complaints on undesirable odours in the adjacent housing complex.
There are several sources of unpleasant odour generated by the input material as well as in the composting process such as:

a) garbage pit:
The storage capacity of the garbage pit is 1,000 m^3 equivalent to 2.5 days. Usually there is a daily collecting cycle in the municipalities on six days per week. Once the MSW is stored either in the housholds (Friday) or in the garbage pit at the composting plant, anaerobic conditions may occur resulting in undesirable odours. This source of odour can be reduced to a certain extend by cutting the residence time of MSW in the garbage pit which is already practiced.

b) ballistic air separation:
The shredded and screened garbage passes a ballistic air separator to remove heavy inert particles. A fan blows the exhausted air without any further treatment into the ambient atmosphere.

c) Siloda unit:
The fermentation hall includes 10 horizontal silos and a wheel type compost turning machine (Siloda wheel) which transports the material from one silo into the next. The total retention time in the silos amounts to 10 days. During the turning cycle nuisance odour may occur and escape into the atmosphere. In addition the material is slightly aerated by means of blowers pushing air into the silos and the atmosphere.

d) curing piles:
Final curing occurs in outdoor piles during 60 days. The piles are 6 m high and no aeration system is installed. Composting is an aerobic process that needs oxygen. Once the aerobic fermentation is stopped due to a shortage of oxygen, anaerobic conditions follow and create bad smell.

There is no odour control system installed in the factory.
The effectivenes of waste air treatment systems is determined by the substance concentrations and/or the odour concentrations as the number of odour units in the inlet and outlet air.
Determining odour concentrations and odour units is problematical as an odour is usually made up of several, often unknown substances and fluctuating operating conditions continually alter their composition and intensity. Measuring and sampling methods must be adapted accordingly. The operating cycles of the installations must be taken into account when making the measurements.
Analytical measuring methods for determining individual components or determining them all only play a subordinate role, particularly when measuring odours as emissions of odours mainly have a very complex composition and quantitative substance ratios determined by chemical analysis are not usually odour specific to the same degree. The following methods can be used for a substance specific evaluation of the source of odours and the waste air cleaning efficiency.

* gas-chromatographic analysis
* spectrometric analysis
* total carbon determination
* olfactometry

The latter method has frequently been used recently for determining the odour concentration where the human nose is used as a detector. Both static or dynamic methods are used for the presentation of the sample, while dynamic methods have become well established.
The measurement is made with the aid of an olfactometer which essentially consists of a dilution device and a sniffing section (pipe, mask, sniffing cabin). The panelists are offered different, defined dilutionstages from neutral and odouriferous air for assesment. There are guidlines on the olfactometric technique of odour threshold determination existing.
No odour measurement had been performed in the organic fertilizer factory, but the odour concentrations can be compared with other composting plants. The concentration in the garbage pit may achieve 1,000 odour units while the highest data in the range of 60,000 odour units may occur in the fermentation silos. The concentrations in the curing piles depend on the age of the pile and may vary between 2,000 and 20,000 odour units.
There are several methods used for odour control. First of all the curing area has to be sealed. The exhausted air will be cleaned in a biocompost-filter with an

efficience of more than 90 %. The exhausted waste air from the garbage pit and air separator is treated in a second compostfilter. The highly polluted air from the fermentation silos should be cleaned in two steps. The first step is a bio-scrubber followed by a separate compostfilter. With such a combined system decomposition rates of 99 % can be achieved. The concentration in the cleaned air should be less than 200 odour units per m^3.
More details are contained in Annex 7, Odour Emission Control.

3. Recommendations:

Additional measures in accordance with the latest technology can reduce undesirable odours to an acceptable level to the human beings but not completely. The capital investment for enclosing the curing piles, enhanced ventilation and treatment of the exhausted gases in bioscrubbers and biocompost-filters is estimated in the range of RO 1.5 million ($ 4 million) plus increased operation and maintenance costs of 20 % to 30 %.
Closing down the factory temporarily and shifting to a far away place will cause capital costs of approximately RO 2.4 million ($ 6,3 million). In addition to that, even in a remote area enhanced odour control might be necessary and increase the capital investment. Furthermore the hauling costs of MSW as well as compost and rejects will increase because of the longer distances. The following recommendations can be made:

a) It is recommended to take all possible steps to eliminate the unpleasant odours to an acceptable level to the human beings in the existing plant and explain them to the neighbouring people. There is no need for the relocation of the composting plant. A monitoring system for complaints before and after the relevant measures should be established by the Ministry of Environment and Water Resources.
b) It is recommended to establish a beautification programme around the organic fertilizer factory such as planting trees along the fence and others.
c) It is recommended to use sewage sludge and mix it together with MSW to eliminate health risks of uncontrolled sludge disposal and increase the nitrogen content in the final compost product. The heavy metal concentration in the sewage sludge has to be monitored by the concerned authorities. Also animal manure can be used as feedstock in the factory.
d) It is recommended to instal a secured landfill for MSW, commercial and industrial waste and composting rejects, including leachate control (groundwater protection)

and biogas collection.

e) It is recommended to use domestic produced organic fertilizer in the Sultanate of Oman instead of imported soil conditioners. A secondary classifier could be installed in the factory to achieve further improvements of the compost material.

4. Technical informations:

More detailed and technical informations are included in the annexes.

(Dr. W. Lutz)

BRIEF REPORT

ENGLISH

ARABIC TRANSLATION

Muscat 1-9 September 1988

BRIEF REPORT

Dr. Willibald Lutz, UNIDO Consultant

1. AREA

The MUSCAT AREA along the north shore of the Sultanate of Oman reaches from the Al Khawd Residential Area to Al Bustan and includes the municipalities of Muscat, Muttrah, Ruwi and others. The total length of this area north-west to south-east is approximately 50 km. The Muscat area population amounts to 236,000 inhabitants. The composting plant is located in Baushar in the geographic center of this area.

2. WASTE DISPOSAL SYSTEM

About 250 TPD domestic refuse are collected by the municipalities and 70 TPD commercial and industrial waste by private haulage companies. Since the composting plant was closed in April 1987 all waste is dumped in two unsecured landfills, whereas 90 % goes to Sunub and 10% to Wadi Hatat.

The greater Muttrah Sewerage Project includes a waste water treatment plant with the capacity of 53,300 population equivalent. The excess sludge amounts to 20 TPD with 18 to 20 % solids. Most of the sludge is disposed in a storage (landfill) owned by the Municipality.

3. COMPOSTING PLANT

The composting plant is owned and operated by a private company, Oman Organic Fertilizers & Chemical Industries SAO (OOFCI), Baushar. At the plant site there is an old composting plant supplied by the French company Hydromer, which was started up in 1983 with a total capacity of 100 TPD municipal solid waste (MSW). After 6 months of unsuccessful operation the plant was closed at the end of 1983.

The new composting plant designed and supplied by OTV (Siloda process) was constructed in 1985 and started up on December 10, 1985. The capacity amounts to 160 TPD MSW respectively 35,000 TPY to produce 14,000 TPY mature and refined compost delivered in 25 kg plastic bags. Rejects in the range of 13,000 TPY have to be hauled to the landfill. The balance of quantities are fermentation losses in the aerobic process.

The capital investment amounted to RO 2.8 million. The composting process and mechanical equipment is of modern standard and well maintained by the operating company. There are practically no odour pollution control devices installed.

Due to the mixed refuse collecting system in the municipalities using mainly KUKA- Rotopress vehicles only 110 TPD MSW generated in selected residential areas can be accepted in the composting plant. To maintain the optimum moisture in the fermentation process water has to be added. Sewage sludge as a source of moisture and nitrogen is not used.

The plant consists of three parts:

- physical processing of the MSW
- fermentation stages (Siloda system and curing piles)
- refining and bagging of the end product.

Because of compost marketing problems the garbage receiving was stopped in April 1987. 11,500 tons had been stored in the outdoor curing area at that date. During the past 16 months about 4,700 tons refined compost were sold. There is still 5,500 tons of unrefined compost stock piled in the plant.

The demand of compost in the entire Sultanate was estimated in 1986 to be 30,000 tons, whereas almost 10,000 tons are imported peat and other soil conditioners such as compost produced in the U.A.E. Prices tend to vary depending on the time of season, availability and market situation. The average sales price of the OOFCI plant in 1988 amounts to RO 36 per ton in 25 kg plastic bags ($ 95/t). The buyers are 80 % private people and 20 % governmental agencies.

4. NUISANCE ODOURS OF THE COMPOSTING PLANT

According to information from the Ministry of Environment and Water Resources there had been 6 complaints on undesirable odours in the adjacent housing complex.

There are several sources of unpleasant odour generated by the input material as well as in the composting process such as:

a) garbage pit:

The storage capacity of the garbage pit is 1,000 m3 equivalent to 2.5 days. Usually there is a daily collecting cycle in the municipalities on six days per week. Once the MSW is stored either in the households (Friday) or in the garbage pit at the composting plant, anaerobic conditions may occur resulting in undesirable odours. This source of odour can be reduced to a certain extent by cutting the residence time of MSW in the garbage pit which is already practiced.

b) ballistic air separation:

The shredded and screened garbage passes a ballistic air separator to remove heavy inert particles. A fan blows the exhausted air without any further treatment into the ambient atmosphere.

c) Siloda unit:

The fermentation hall includes 10 horizontal silos and a wheel type compost turning machine (Siloda wheel) which transports the material from one silo into the next. The total retention time in the silos amounts to 10 days. During the turning cycle nuisance odour may occur and escape into the atmosphere. In addition the material is slightly aerated by means of blowers pushing air into the silos and the atmosphere.

d) curing piles :

Final curing occurs in outdoor piles during 60 days . The piles are 6 m high and no aeration system is installed. Composting is an aerobic process that needs oxygen. Once the aerobic fermentation is stopped due to a shortage of oxygen, anaerobic conditions follow and create bad smell.

5. SUMMARY

The composting plant faces two different problems:

a) nuisance odours:

Within a distance of 45 m (fence to fence) there is north of the composting plant located a housing area including 250 homes with approximately 2,500 people and one school. These houses were built after the construction and start up of the composting plant. Depending on the direction and velocity of wind and air movements unpleasant odours are carried into the residential area. Usually during day time the wind is blowing from the houses to the plant and during night time on the contrary (see meteorological data in the final report). By means of additional odour control systems such as enclosing the curing piles, enhanced ventilation and treatment of the exhausted gases in bioscrubbers and biocompost filters, the bad smell can be reduced to an acceptable level to the human beings. The Ministry of Environment and Water Resources should establish a register for odour complaints of the neighbouring people during a long term range. The estimated odour reduction after completion of the described system is in the range of more than 90%. Nuisance odours are not only a technical problem but also a matter of psychology, education and information of the affected people.

The investment costs for sealing and aeration of the

curing area (3,500 m2), installation of ventilation systems in the receiving hall, processing hall, fermentation hall and construction of filters are estimated to be RO 1.5 million (RO 630,000 construction costs for the curing hall and three compost filters, RO 870,000 equipment costs for one bioscrubber and ventilation system). The operation and maintenance costs include mainly electrical power and personnel. More technical information will be included in the final report.

b) compost marketing:

The market for compost seems to be expandable especially for governmental agencies. Because of the strong competition and low prices of imported organic fertilizer, a tipping fee for MSW as a separate source of income should be considered. Composting of municipal residues is also a recycling process and helps to get more independence from imports.

6. RECOMMENDATIONS

Additional measures in accordance with the latest technology can reduce undesirable odours to an acceptable level to the human beings but not completely. The capital investment is estimated in the range of RO 1.5 million plus increased operation and maintenance costs of 20% to 30%.

Closing down the factory temporarily and shifting to a far away place will cause capital costs of approximately RO 2.4 million (RO 1.2 million site development and buildings, RO 0.8 million start up costs, RO 0.4 million replacing and shifting composting equipment).

In addition to that, even in a remote area enhanced odour control might be necessary. Furthermore the hauling costs of MSW as well as compost and rejects will increase because of the longer distances. The following recommendations can be made:

a) It is recommended to take all possible steps to eliminate the unpleasant odours to an acceptable level to the human beings in the existing plant and explain them to the neighbouring people. There is no need for the relocation of the composting plant. A monitoring system for complaints before and after the relevant measures should be established by the Ministry of Environment and Water Resources. Furthermore, it is recommended to plant trees along the fence of the composting plant to improve the view.
b) It is recommended to use sewage sludge and mix it together with MSW to eliminate health risks of uncontrolled sludge disposal and increase the nitrogen content in the final compost product. The heavy metal concentration in the sewage sludge has to be monitored by the concerned

authorities.

c) It is recommended to install a secured landfill for MSW, commercial and industrial waste and composting rejects, including leachate control (ground water protection) and biogas collection.

d) It is recommended to use domestic produced organic fertilizer in the Sultanate of Oman instead of imported soil conditioners.

Dr.W.Lutz

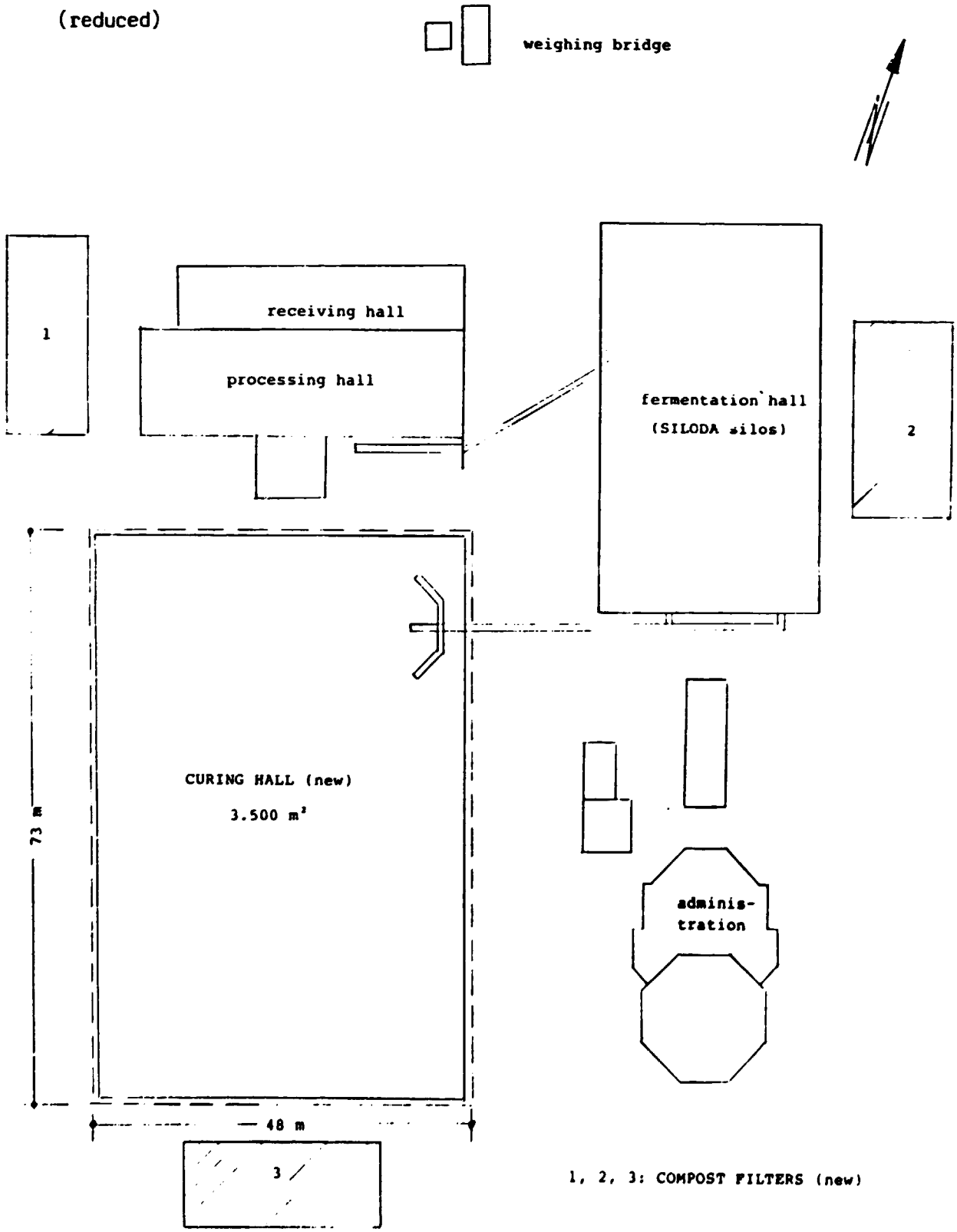
encl:
Composting Plant - Lay Out Draft

VISITS

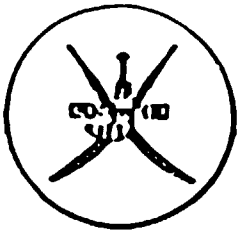
Ministry of Commerce and Industry
Ministry of Environment and Water Resources
Council for Conservation and Water Resources
Sewage Treatment Plant, Darsayt
Composting Plant of Oman Organic Fertilizer & Chemical Ind.
Landfill Site, Sunub
Directorate General of Meteorology,Seeb International Airport
UNDP, United Nations Development Programme

COMPOSTING PLANT - LAY OUT

SCALE 1:500
(reduced)



1, 2, 3: COMPOST FILTERS (new)



سلطنة عمان
وزارة التجارة والصناعة

ملخص الدراسة التي أعدها الدكتور/لوتز
بشأن الروائح المنبعثة من مصنع
شركة عمان لتصنيع الأسمدة العضوية والكيماوية المحدودة ببوشر

سبتمبر ١٩٨٨

بسم الله الرحمن الرحيم

Ministry of Commerce & Industry
Muscat
Sultanate of Oman

وزارة التجارة والصناعة
مسقط
سلطنة عمان

ملخص الدراسة التي أعدها الدكتور لوتز
بشأن الروائح المنبعثه من شركة عمان
لتصنيع الاسمدة العضوية والكيماوية المحدودة ببوشر

قام الدكتور / ويليبالد لوتز بتكليف من منظمة الأمم المتحدة للتنمية الصناعية (UNIDO) بدراسة مشكلة انبعاث الروائح من مصنع عمان لتصنيع الاسمدة العضوية والكيماوية المحدودة . وقد شمل التقرير المختصر (نسخة مرفقة) على المواضيع التالية :

١ ـ النظام المتبع في السلطنة للتخلص من النفايات .
٢ ـ نبذة مختصرة عن المصنع والعمليات الصناعية ومشكلة التسويق . حيث أشاد الدكتور بأن ادارة عمليات التشغيل والصيانة في هذا المصنع تتم بصورة جيدة اضافة الى أن المكائن والمعدات المستخدمة وطريقة الانتاج مطابقة للمواصفات الحديثة .
٣ ـ مصادر انبعاث الروائح .
بين ان مصادر انبعاث الروائح هي :
(أ) حفرة استقبال النفايات غير المعالجة (garbage pit)
(ب) وحدة تقطيع وفصل النفايات غير المعالجة (ballistic air separation)
(ج) وحدة التخمير (fermentation - Silode unit)
(د) وحدة الانضاج (curing piles)
٤ ـ التوصيات :

يتم تقليل الروائح المنبعثه من هذا المصنع الى الحد المقبول لدى الانسان وليس ازالتها نهائيا باستخدام الاجهزة والمعدات المذكورة ادناه حيث أنها تقلل من نسبة تلك الروائح بأكثر من ٩٠٪ .

- غلق مكان انضاج الاسمدة وتزويده بساحبات هوائية .
- معالجة الروائح بواسطة استعمال مرشح بيولوجي (ذو مواد صلبة) ومرشح بيولوجي رطب (استعمال الماء) .

فاكس ٧٩٤٢٣٨_٧٩٤٢٣٩

بسم الله الرحمن الرحيم

وزارة التجارة والصناعة
مسقط
سلطنة عمان

Ministry of Commerce & Industry
Muscat
Sultanate of Oman

علما بأن موضوع الروائح ليست مشكلة فنية فقط ولكنها ذات علاقة نفسية للانسان . لذا فالامر يحتاج توعية المواطنين .

وتقدر التكلفة الاستثمارية لتلك الاجهزة والمعدات ومتطلباتها ٥ر١ مليون ريال عماني . على النحو التالي :

- ٨٧٠ر٠٠٠ ريال عماني تكاليف المرشحات
- ٦٣٠ر٠٠٠ ريال عماني تكاليف البناء

١ر٥٠٠ر٠٠٠

في حين تقدر تكاليف التشغيل والصيانة (الكهرباء والعاملين) حوالي ٢٠٪ الى ٣٠٪ من التكلفة الاستثمارية .

وتقدر تكاليف نقل المصنع حوالي ٤ر٢ مليون ريال عماني على النحو التالي :

- ٢ر١ مليون ريال عماني تكاليف تجهيز الموقع الجديد والبناء .
- ٨ر٠ مليون ريال عماني تكاليف التشغيل والاجور لفترة مابين بداية الانتاج والحصول على المنتج النهائي .
- ٤ر٠ مليون ريال عماني تكاليف ازالة ونقل المكائن .

٤ر٢ مليون ريال عماني

وجود المصنع سواء في مكانه الحالي أو نقله الى مكان آخر يحتاج الى تركيب أجهزة ومعدات السيطرة على الروائح . وفي حالة نقل المصنع الى مكان آخر سوف يؤدي الى زيادة في تكاليف نقل النفايات والمنتج .

فاكس ٧٩٤٢٢٨_٢٢٩:٠٠

Ministry of Commerce & Industry
Muscat
Sultanate of Oman

وزارة التجارة والصناعة
مسقط
سلطنة عمان

- ٢ -

١ - يوصي الخبير بتركيب الاجهزة والمعدات في المصنع في موقعه الحالي والتي سوف تقلل الروائح الى الحد المقبول لدى الانسان . لذا لا يوجد داعي لنقل المصنع الى موقع آخر . وان يتم اخطار قاطني تلك المساكن بهذه الاجراءات . وأن تقوم وزارة البيئة وموارد المياه باعداد نظام خاص لتحليل الشكاوي قبل وبعد تركيب تلك الاجهزة والمعدات .

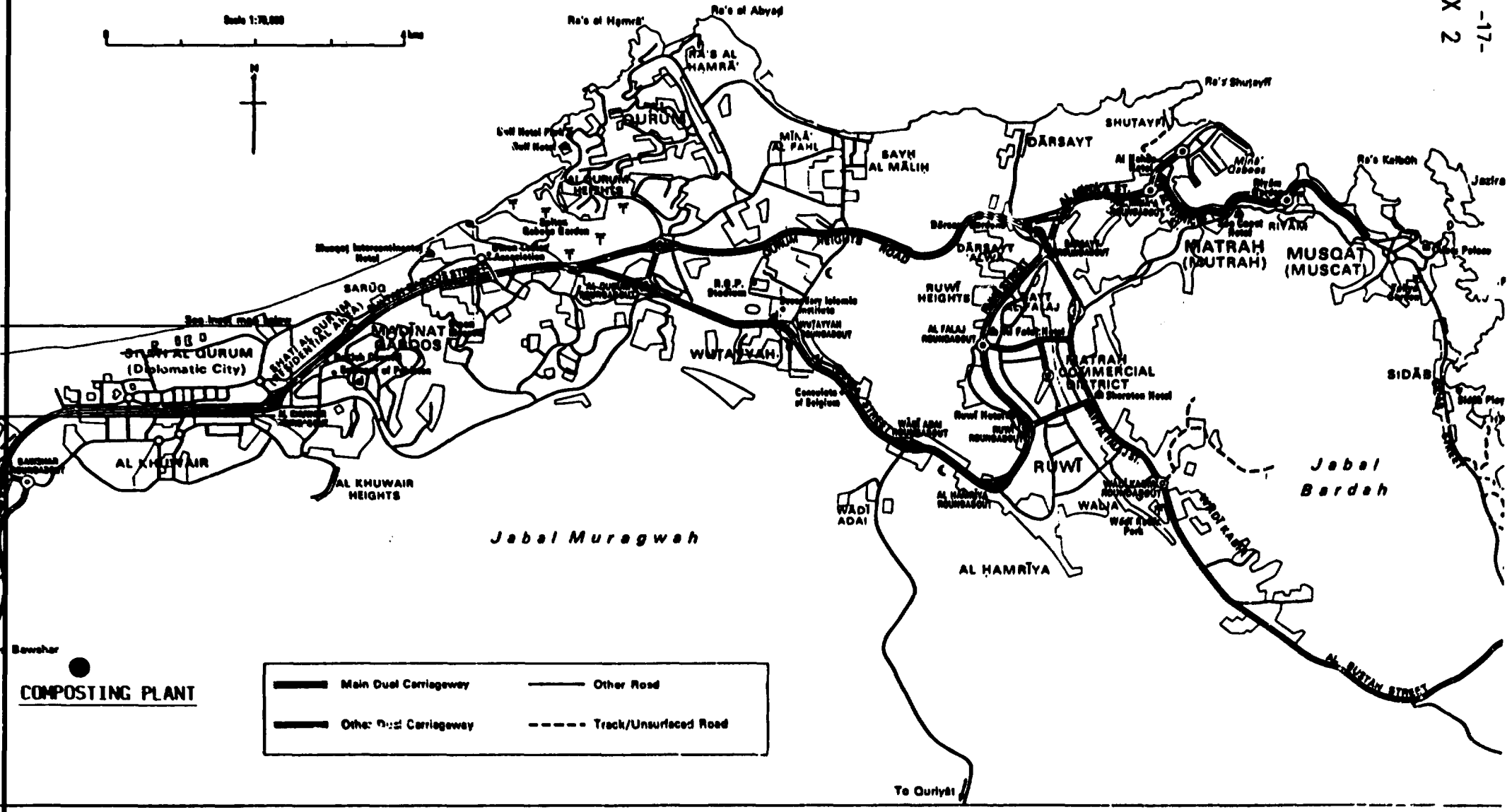
٢ - تشجير المنطقة الواقعة على جانب المصنع المطل على المساكن وذلك لتحسين المنظر العام .

٣ - يوصي الخبير باستعمال الحماه (sewage sludge) وخلطها مع النفايات لانتاج الاسمدة العضوية من أجل زيادة مكونات النيتروجين فيها . على أن تقوم الجهات المعنية بتحليل تلك الحماه لمعرفة نسبة المعادن الثقيلة الموجودة فيها . وبهذا يتم تحسين نوعية المنتج وتقليل الآثار المحيطة الناتجة من التخلص من الحماه .

٤ - يوصي بأن يكون مكان دفن النفايات المنزلية والتجارية والصناعية محكمه ومعزوله وذلك لحماية المياه الجوفية . وضرورة توفير وحدة تجميع الغاز المنبعث من مكان الدفن .

٥ - يوصي الخبير باستعمال الاسمدة المنتجة من هذا المصنع في السلطنة بدلا من المستورد .

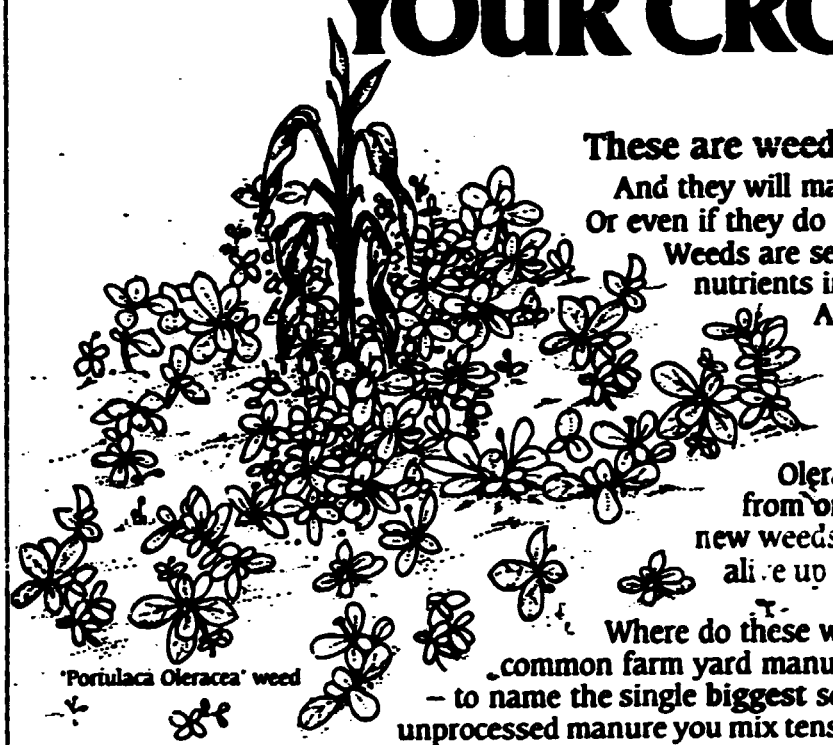
THE MUSQAT AREA



OMAN عمان DAILY

OMAN DAILY OBSERVER, SUNDAY 4 SEPTEMBER 1988

ARE WEEDS KILLING YOUR CROPS?



'Portulaca Oleracea' weed

These are weeds.

And they will make sure your plants don't grow. Or even if they do – they do not grow healthy! Weeds are selfish. They corner all the rich nutrients in the soil for themselves. And the way they multiply – there isn't any food left for your crop.

Weeds multiply from seeds. A common weed like 'Portulaca Oleracea' produces upto **70,000 seeds** from one single plant. That's 70,000 new weeds for you and these seeds stay alive up to **30 years!**

Where do these weed-seeds come from? From common farm yard manure (chicken or cow manure) – to name the single biggest source. Every time you use unprocessed manure you mix tens of thousands of these seeds into the soil. Within days your field will be blanketed by weeds. And your crops will begin to die!

So now you have to decide! Are you going to spend your money to grow weeds? Or crops?

Try using OMAN ORGANIC COMPOST, for a start. We make sure our compost is completely hygenized; processed and treated at 70°C temperature to contain no weed-seeds, germs or parasite. Our compost brings you value for money. For example • **Improves soil structure and prevents soil erosion.** • **Acts as a store-house for soil nutrients, and regulates its release throughout plant growth.** • **Increases resistance to attack by parasites and disease.**

Using our compost, you can sleep easy with the thought that this year, and years to come your fields and farms will grow **higher-yields of vegetable, fruits, dates, fodder** or other plants.

Would you like to know more?

Contact your nearest Agricultural Extension Centre. You can get more details, as well as our compost itself, from there. Or get in touch with us.

OMAN ORGANIC COMPOST
Enriches soil for better growth.

OMAN ORGANIC FERTILIZER & CHEMICAL INDUSTRIES SAO
P. O. Box 6781 Ruwi, Sultanate of Oman.
Telephones: 601012/14 Telex: 5407 OOFCI ON

CHARACTERISTICS OF THE FEEDSTOCK

1. MUNICIPAL SOLID WASTE (MSW)

total quantity of domestic refuse,	250 TPD
total quantity of commercial and industrial waste,	70 TPD
accepted waste quantity at the composting plant,	110 TPD
moisture of acceptable MSW,	25 %
analysis of acceptable MSW:	% dry basis
vegetable, animal waste and other organics,	41
paper, cardboard	22
plastics	12
metals (ferrous and non ferrous)	11
textiles, rags	6
glass	5
others (wood, rubber, sand, etc.)	3
total	100 %

2. SEWAGE SLUDGE (OPTION)

total quantity of aerobic stabilized sludge,	3,6 TPD solids
quantity of dewatered sludge,	20 TPD
moisture,	82 %
analysis of sewage sludge:	on dry weight basis
Phosphorus P_2O_5	1,03 %
Potash K_2O	1,58 %
Silicia SiO_2	0,44 %
Iron Fe_2O_3	1,60 %
Total Nitrogen N	5,82 %
Calcium CaO	1,89 %
Magnesium MgO	1,89 %
Sulphur SO_3	0,92 %
Chloride Cl	0,14 %
Sodium Na_2O	1,23 %
Oil & Grease	6,6 %
Volat. Solids	78,1 %

heavy metals in sewage sludge:	mg/kg on dry weight basis
Lead Pb	950
Zinc Zn	1.283
Cadmium Cd	13,6
Copper Cu	648,1
Cobalt Co	19,5
Chromium Cr	82,3
Nickel Ni	117,0
Manganese Mn	150,0
Molybdenum Mb	3,2

CHARACTERISTICS OF COMPOST

particle size,	99 % passing 10 mm sieve
moisture,	35 %
pH-value,	6
water retention capacity,	287 %
chemical analysis:	% dry weight basis
organic matter	55
Carbon C	25
Nitrogen N	1,3
Phosphorus P_2O_5	0,4
Potash K_2O	0,5
C/N ratio	19
bactriological analysis:	
total count 37 °	7 million/gm
Coliform	130/gm
E. Coli	NIL
Salmonella	NIL
Shigella	NIL
Vibrios	NIL
Staph. Aureus	NIL
Moulds	10
Clostridium sp.	NIL

OMANI COMPOST MARKET 1986

TOTAL DEMAND

	TPY (tonnes per annum)
Omani produced manure,	20.000
imported peat,	4.500
OOFCI company's product,	740
other imported soil conditioners,	4.760
total	30.000

PRICES

Approximate typical delivered price per tonne in Omani Rials:

		RO
cattle manure,		30
poultry manure:	processed	68
	unprocessed	24
peat		56
OOFCI company's product		40
UAE compost (imported)		45

NOTE:

From April 1987 to August 1988 the company sold 4.700 tonnes compost. The average price was RO 36 per ton delivered in 25 kg plastic bags.

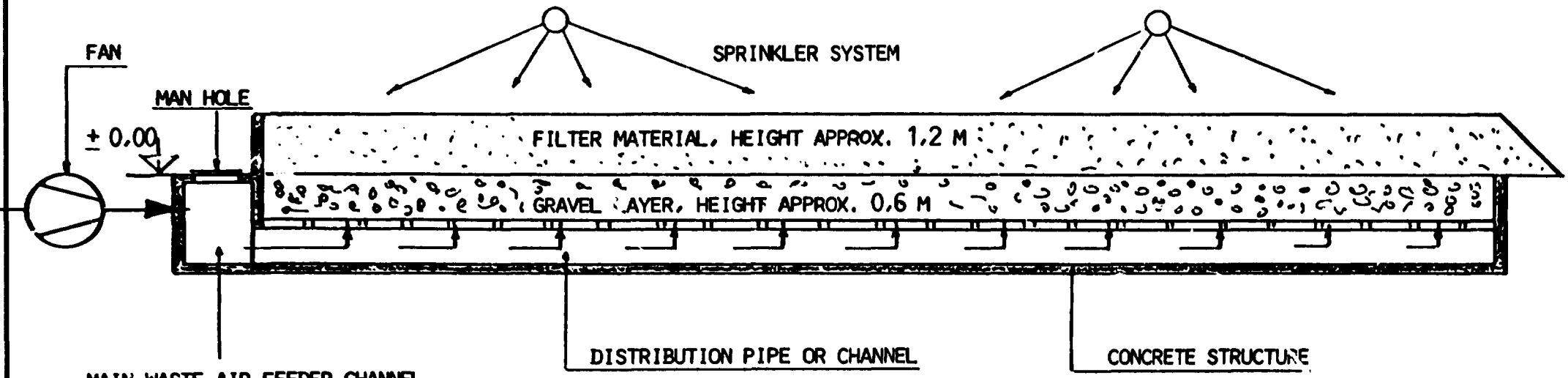
ANNEX 7

ODOUR EMISSION CONTROL

1. Biocompost-filter:

The waste air from the garbage pit, Siloda silos and curing piles contains odour intensive decomposition products such as ethanol, diacetyl, limonene, mercaptane, etc. and therefore has to be deodorized before release to the atmosphere. Deodorization occurs in a biofilter. Mature, screened compost is used as filter material which is placed in a layer above a suitable air distribution system. The waste air passes through the filter material which absorbes the odour intensive substances. The microorganisms contained in the filter material then degrade in turn biochemically these substances. The environmental condition in the filter layer (humidity, pH, etc.) have to be kept optimal for microbial activity.
The efficiency of the compost filter is maintained through suitable operation measures. Of great importance is the moisture content which should not fall below 30 %. Since the waste air from the composting process is saturated with water vapor, the moisture content of the filter will be maintained. Howewer, changes in the temperature, uncontrolled composting conditions, changes in the water capacity, age of the filter, etc. could cause problems. Therefore the proper moisture content is adjusted by means of an irrigation system (sprinkler system).
After a long operating time the filter material will be degraded or poses too much resistance to the passing of the air despite mechanical surface treatment, it looses efficiency and has to be replaced by new material. During a normal operation the filter material will last at least six months. At the time of replacement the material will be saleable compost of espacially high quality.
Compare schematic drawing of a compostfilter (biofilter).

COMPOSTFILTER



THE DIMENSION OF THE COMPOST FILTER DEPENDS ON:

- QUANTITY OF WASTE AIR,
- CONCENTRATION OF ODOUR COMPOUNDS,
- TYPE OF ODOUR COMPOUNDS,
- REQUIRED ODOUR REDUCTION

WILLIBALD LUTZ, DR., P.E.
CLEAR-BUREAU FOR CONSULTING & ENGINEERING

A-1140 VIENNA, JAKOB GREMDLINGER-STRASSE 22
AUSTRIA TELEPHONE 0222 · 97 41 04

2. Bioscrubber:

The high polluted waste air from the Siloda silos will be cleaned in a bioscrubber prior to the final treatment in the compostfilter. The process principals are as follows.
In the case of absorption, gas components are absorbed from a gas mixture by means of a selectively acting fluid (absorbent). The absorption process takes place in absorbers where the absorbent is brought into contact with the gas mixture to be purified and the scrubbing fluid is charged with the gas components to be removed.
The absorbed contaminants must be removed from the absorbent after the absorption process. This stage of the process is known as absorbent regeneration. It affects the scrubbing efficiency and the energy requirement of the absorber. The lower the absorbate concentration in the scrubbing water after regeneration, the greater the absorption of gas components by the scrubbing water with the same scrubbing fluid/ gas ratio. The absorbent is regenerated by means of microorganisms which use the removed gas components as a substrate. The microorganisms are either finally dispersed in the scrubbing water (activated sludge installations) or colonise the scrubber parts (percolating filters) to form biological mat. The speed of biological degradation is relatively low.

a) Activated sludge installations:

The removal of impurities in water with the aid of microorganisms is a proven, economic process used in effluent technology. The impurities (absorbate) are used by aerobic oxygen-consuming microorganisms as a substrate and are thus removed from the water. These microorganisms, floating freely in the water, form the activated sludge together with undissolved pollutant substances. As not all microorganisms are able to degrade certain atmospheric pollutants, a natural selection process takes place in the scrubbing process. A certain period of adaption is necessary in this respect. Essential changes in the composition of the crude gas may require another adaption. It is possible to check the activity of these microorganisms by determining their oxygen consumption (respiratory activity).
As the reaction speed of the biological degradation process is relatively low, correspondingly large activated sludge tanks must be provided. This tanks must be aerated if they are large or if the installation is shut down for a protracted lenght of time. Oversizing of the tank and protracted downtimes should be avoided as otherwise a lack of nutrients occurs. If downtimes cannot be avoided, e. g. at weekends, the activity of the microorganisms can be maintained by means of a substrate additive.

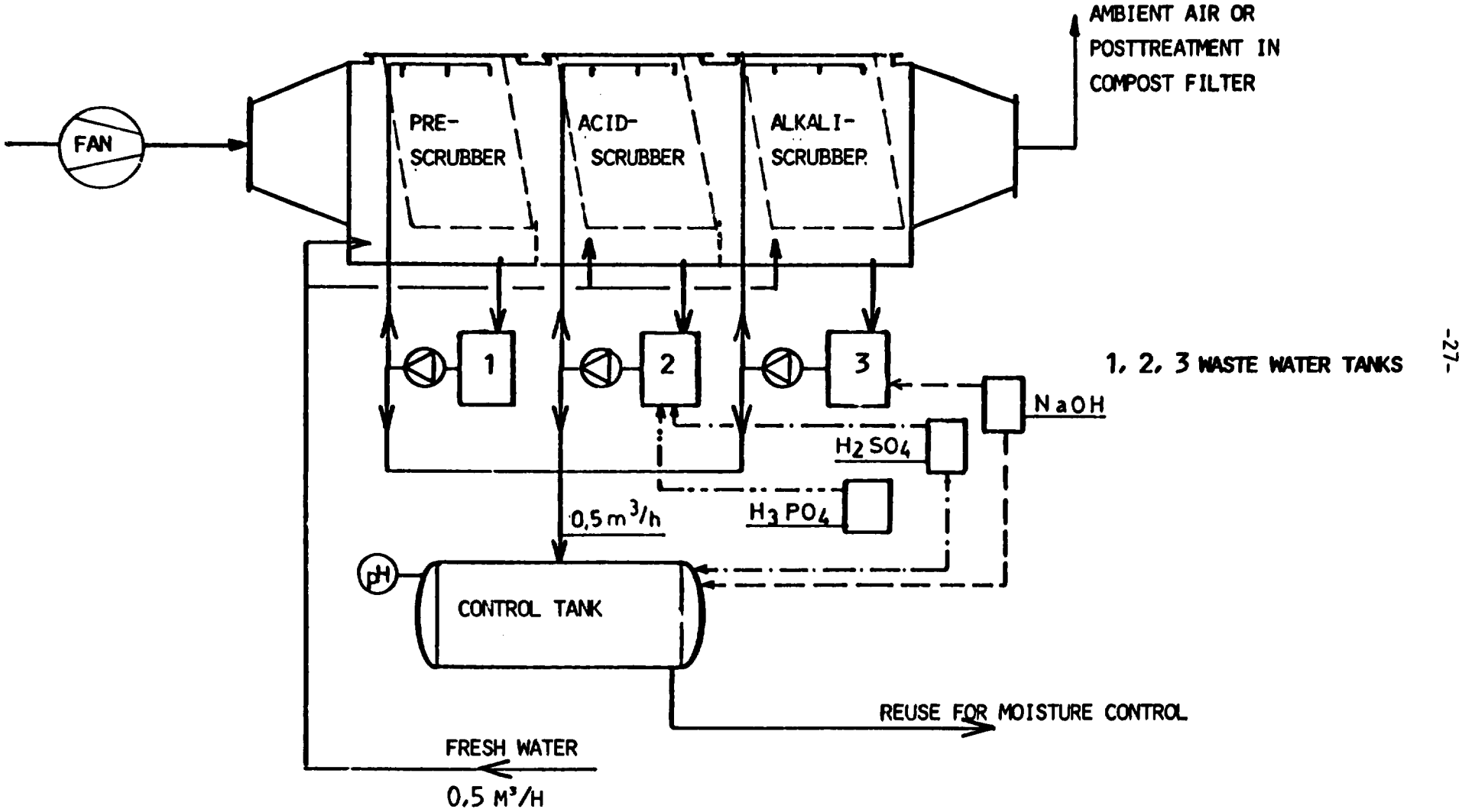
b) Percolating filter installations:

If the microorganisms have permanently colonised the internals or packing of the scrubber, then this is referred to as a biological mat. The scrubbing water (absorbent) flowing across this mat supplies the microorganisms with oxygen and substrate. The scrubbing water is then regenerated.

Percolating filters consists of installations with a large specific surface over which the scrubbing water is distributed to be purified. The efficiency of the percolating filter depends on the size of the biological mat and is expressed in m^2 area per m^3 of installation volume. Uniform wetting of the installation is particularly important in order to avoid dry areas and clogging. The wetting rate only plays a part in connection with the transfer of odourous substances to the scrubbing water but not for the biological degradation process. A trough to collect the water is located under the percolating filters which can be operated according to the counter flow or cross flow principle.

Compare schematic drawings of both installations.

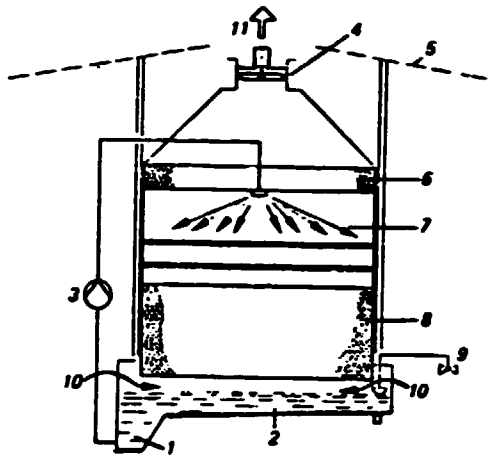
BIOSCRUBBER - ACTIVATED SLUDGE SYSTEM



WILLIBALD LUTZ, DR., P.E.
CLEAR-BUREAU FOR CONSULTING & ENGINEERING

A-1140 VIENNA, JAKOB GREMDLINGER-STRASSE 22
AUSTRIA TELEPHONE 0222 - 97 41 04

BIOSCRUBBER - PERCOLATING FILTER



1. WATER TANK
2. TROUGH
3. PUMP
4. FAN
5. ROOF OF BUILDING
6. PACKING WITH THE FUNCTION OF A MIST COLLECTOR
7. WATER DISTRIBUTION SYSTEM
8. PACKED SECTION
9. FLOAT SWITCH
10. WASTE AIR
11. CLEAN AIR

COMPOSTING PLANT BAUSHAR/MUSCAT

CAPACITY: 160 TPD MUNICIPAL SOLID WASTE (MSW) INPUT

52 TPD COMPOST OUTPUT

HISTORY:

APRIL 1985,	BEGINNING OF CONSTRUCTION
AUGUST 1985,	BEGINNING OF ERECTION
NOVEMBER 1985,	MECHANICAL TESTS
10 DECEMBER 1985,	BEGINNING WITH MSW INPUT
APRIL 1987	STOP WITH MSW INPUT BECAUSE OF HIGH COMPOST STOCKS

CAPITAL INVESTMENT:

0,9 MILLION RO	CIVIL WORKS, SITE DEVELOPMENT
1,3 MILLION RO	EQUIPMENT
0,6 MILLION RO	START UP
2,8 MILLION RO	TOTAL COSTS

CONTENTS:

PRESENTATION OF NEW PLANT (PLANT DESCRIPTION)

BACTERIOLOGICAL AND PARASITOLOGICAL ANALYSIS OF COMPOST

BACTERIOLOGICAL EXAMINATION OF AIR FROM THE COMPOSTING--PLANT

OMAN ORGANIC FERTILIZER & CHEMICAL INDUSTRIES SAO

PRESENTATION OF NEW PLANT

OMAN ORGANIC FERTILIZER & CHEMICAL INDUSTRIES SAO

PRESENTATION OF NEW PLANT

1 INTRODUCTION

The plant will be supplied on turnkey basis by Messrs Ominium de Traitements et de Valorisation or in short called O.T.V. of France. This plant is based on their patented 'SILODA' process for composting of domestic refuse. Messrs O.T.V. have over 20 years of experience in building refuse treatment and composting plants all over the world including middle east. A reference list of the plants designed and built by O.T.V. is presented in Annexure-I.

The present facility at the new plant will be treatment of domestic refuse upto 160 Tonnes/day or 20 Tonnes/hour. Fine urban matured compost will be produced confirming to French Standard NFU-44051 of 7th Dec 1981 (revised). The capital area municipality are obliged to supply at the plant daily collections of household garbage through their own refuse disposal system. The finished product will be marketed all over the country both in bulk carriers and bags as per the requirement of consumers. The plant will have in-house quality control laboratory adequate for the plant needs. A copy of the French Standard NFU-44051 of 07 Dec 1981 is presented in Annexure-II.

cont'd.....2

2. HOW THE PLANT WORKS & DESCRIPTION OF EQUIPMENT

The working of the plant can be seen by observing the progress of refuse through the entire system.

2.1 RECEPTION OF REFUSE

On its arrival in plant the household refuse will be directed in the concrete receiving and storage pit without any special technical requirements or danger for the environemtn or treatment equipment. The pit is provided with remotly controlled, electrically operated steel rolling shutters to facilitate opening for tipping of Garbage trucks directly into the pit. The gantry crane is semi-automatic and is operated from control room.

Activated sewage sludge (TSS about 5%) is received from the Municipal Sewage Treatment Plant and is stored in the existing plant where air is bubbled constantly to keep it aerobic. Alternatively fresh water is used in place of activated sewage sludge.

The refuse is picked up by the hydraulic polyarms (81-MG-01-01.1) of the Gantry Crane (81-MP-01-01.1) is emptied into a hopper and metal feed conveyor assembly which is feeding it to the physical treatment line.

2.2 PHYSICAL TREATMENT

The objective of this line is size reduction and screening of refuse in order to prepare it for fermentation.

The refuse is fed to a vertical grinder (82-BB-01-01.1) by means of the metal plate conveyor (81-MI-01-01.1). As the refuse falls into the grinder, heavy and undesirable objects are rejected by grinder screen and are collected separately in the waiting skip. The remainder of the refuse continues to the foot of grinder where it is discharged on to a conveyor (82-MJ-01-01.1) after having been shredded to smaller granulometry. The extended time the refuse remains in the grinder ensures good oxidization of the ground matter which is a natural deterent to rodents and flies.

cont'd....3

The discharge conveyor fitted at the head end with a magnetic drum discharges the shredded refuse on to a double mesh rotary screen (82-ST-01-01.1).

The 60 mm holes screen removes the coarser particles which are led directly to the mixer with the help of conveyor belt. The 15 mm holes screen removes the fine particles. This fraction which contains predominantly broken glass, stones and other heaviers etc is fed to a flat deck vibrating screen with blower air facility (82-SU-01-01.1). The hard particles are removed here and fed on to the rejects conveyor. The recovered organic matter is fed to the mixer along with the granulometry between 15 mm and 60 mm from the rotary screen. The fludized air loaded with dust and small light particles is cleaned up in a cyclone separator before being discharged into atmosphere. The centrifugal blower employed for this purpose has a capacity of about 16000 M^3/hr. The solid fraction collected at the cyclone separator is discharged via rotary valve into closed skips which are periodicaliy emptied in the mixer.

The mixer (82-AM-01-01,1) which receives the solids as described above and water/activated sewage sludge from a small overhead vessel, homogenizes the humidity content to about 55% and discharges to a conveyor (82-MT-06-01.1) and conveyor (82-MT-07-01.1) installed in series. These conveyors discharge the matter to a shuttle conveyor (83-MN-01-01.1) which feeds SILODA SYSTEM.

2.3 FERMENTATION AND CURING

2.3.1 Introduction

The Biological Treatment of the shredded and sieved refuse is carried out in the "SILODA SYSTEM". The Siloda process is patented by M/s OTV and is designed to transform the organic matter and cellulose contained in the refuse into a

cont'd...4

soil ameliorant that can be used without danger or risk i.e. there are no pathogens liable to create health risk for human beings or animals and fermentation is continued to completion for full maturation so as to avoid secondary effects on plant life.

2.3.2 Principle of Fermentation

The transformation of organics into compost is performed by micro organisms in an aerated environment, acting in aerobic phase. These microbes breathe in the oxygen contained in the air and change the carbon in the refuse to carbon dioxide. They feed on the organic nitrogen from which they derive necessary proteins.

During this transformation lot of heat is generated and the temperature of the mass is maintained close to 70°C by a careful control of air which acts both as a coolant and supplier of necessary oxygen.

2.3.3 The "SILODA PROCESS"

Fermentation takes place in the "SILODA BUILDING" containing two series of five open horizontal silos on each side. Each silo represents one full day's volume of shredded refuse.

While the silo on one side is being automatically filled by the shuttle conveyor, the paddle wheel (83-00-01-01.1) discharges like contents of the fifth silo on the other side into the discharge conveyor (83-MT-11-01.1). The paddle wheel therefore empties the successive silos from fourth to fifth, then from third to fourth and so on until the first one is empty at the end of day and ready ro receive on the following day.

The next day first silo of the second series is filled by the same mobile shuttle conveyor while paddle wheel repeats cycle similar to first series done on the earlier day.

cont'd...5

In this way the refuse is turned over by the SILODA PROCESS, chopped into thin slices, mixed with water if necessary and transferred every other day, undergoing regular and continuous aeration during the 10-11 days residential time in the fermentation building.

The temperature rises in the heap of shredded refuse and reaches 70°C in less than first 48 hours. A considerable amount of oxygen is consumed. The depletion of oxygen level is made up by continuously blowing air with the help of two twin lobe air compressor discharging air through distribution pipes located underneath each pile. The blowers have sufficient capacity to ensure that under every eventuality sufficient oxygen is available and there is no possibility of anaerobic conditions being formed.

The paddle wheel is essentially a hollow cylinder turning on its own axis and of the same width as that of the silo (4.0 M). It is equipped with slicing blades to pick up the product in fine slices. During rotation the matter is lifted and then falls into a trough inside the hollow cylinder. From there a discharge mechanism of two Archimedian screws drops it into the adjacent silo/conveyor. The movement of paddle wheel from one end of silo to the other is fully automatic. The paddle wheel is positioned opposite each silo by means of a transfer cab running on rails and electrically operated (83-MY-01-01.1).

On completion of the accelerated fermentation phase raw compost is discharged out of this building by a conveyor and led to the maturation area by means of another overhead totally enclosed conveyor (83-MT-12-01.1). In the open maturation area, the compost is piled up with the help of a front end loader and mobile conveyor (83-MF-01-01.1) in heaps about 6 metres high. Slow fermentation takes place here essentially to break down

cont'd.....6

cellulose by actinomycetes. Sufficient maturation is completed in about six to eight weeks. The heaps are constantly moistured on the outer layer by water sprinklers installed around the maturation area. This also helps in checking the loss of material from pile surface due to winds.

2.4 REFINING AND BAGGING

Fully matured compost from the heaps in the maturation area is picked up with the help of a front end wheel loader and fed into a hopper and conveyor system (84-M1-02-01.1) which delivers this material to the top of a light duty vertical grinder (84-BA-01-01.1). The discharge from the bottom of grinder is fed to an inclined vibratory screen (84-ST-02-01.1) by means of a conveyor (84-MJ-02-01.1). The rejects from the sieve are collected and sent to the rejects collection chamber of the refuse pit via conveyor (84-MT-13-01.1). The finer from the sieve which form the product are fed to a mixer (84-AM-02-01.1) where additives for enrichment of compost constituents i.e. N, P & K are added. The mixer is a solid to solid phase mixer and discharges the finished compost on to a pivot conveyor (84-AM-02-01.1).
The pivot conveyor has two possibilities. It can either discharge the material into a silo from where it can be loaded directly into trucks for shipment of compost in loose form to the various distribution centres/consumers. Alternatively the pivot conveyor feeds the finished compost to another conveyor & hopper arrangement (85-MT-01-01.1). The finished product from here is fed to the semi-automatic weighing & bagging machine (85-GG-01-01.1).

The filled bags are transported to a bag stitching machine (85-GH-01-01.1) via a conveyor (85.MT-02-01.1). The bagging & stitching machine has the capacity to bag the entire product should it be so required.

The finished product bags are removed at the end of conveyor and stored in the open area in the plant before onward despatch to consumers/ distribution centres. During the storage in the plant the bags are kept covered under tarpaulins.

cont'd.....7

2.5 QUALITY CONTROL & INSTRUMENTATION

The plant has most upto-date testing equipment for the process control and product testing. Routine analysis like moisture, particle size, organic matter, C/N ratio; determination of N, P and K, plant growth test and product maturity test can be very quickly carried out.

The plant is equipped with necessary instrumentation to control the process in such a way as to produce the compost without creating health hazards due to excessive noise and/or vibrations, dust, smell or swarms or flies etc.

The process itself will not generate undesirable smell.

2.6 PROCESS WASTES

It can be observed from the description of the plant on the earlier pages that there are no wastes generated as such because of the process. The raw material of the plant itself is municipal waste. Part of this raw material is converted into a useful product as compost. Non useful part of household waste is separated at various points described below. A central rejects recovery conveyor collects all the solid wastes and brings it to a separate chamber in the refuse pit. From here this waste is filled in the waiting tippers by means of the Gantry crane. The tippers carry it for dumping in the municipal dumping area for sanitary land fill.

2.6.1 Solid Wastes Collection

Solid wastes are collected from the following points in the process:

a) Visible large objects at the Reception Pit
b) Ballistic Separation at Grinder (82-BB-01-01.1)
c) Ferrous rejects from magnetic drum (82-MJ-01-01.1)
d) Sieve rejects from Rotary Sieve (82-ST-01-01.1)

cont'd..8

e) Heavy rejects from Flat Deck Vibrating Screen (82-SU-01-01.1)

f) Rejects from Refining section inclined vibrating screen (84-ST-02-01.1)

2.6.2 Liquid Wastes

There are no liquid wastes generated in this process. Even the drained liquid collected in the refuse pit is used in the mixer prior to the fermentation process. The only liquid wastes that can be ever generated are out of equipment washing when the same is opened for repairs. These are discharged through the normal plant drains into the septic tank.

2.6.3 Gaseous Wastes

The process adopted here does not produce any harmful gases. Air is released in the system at two points. Firstly at the Flat Deck Vibrating Screen where it is used to create a fludized bed for heavy particles separation. This air is sucked into the system, dedusted in cyclone separator before being discharged to atmosphere.

The second point where air is fed into the system is to replenish oxygen level in compost piles in the SILODA PROCESS. As the excess air leaves these piles along CO_2 produced due to microbes respiration and water vapours into the large volume of totally enclosed SILODA BUILDING, it gets infinitely diluted in terms of CO_2 content. This building is ventilated through large exhaust fans mounted on the roof top.

2.6.4 General

It must once again be emphasized here that the process adopted in this plant namely 'SILODA PROCESS' just enhances

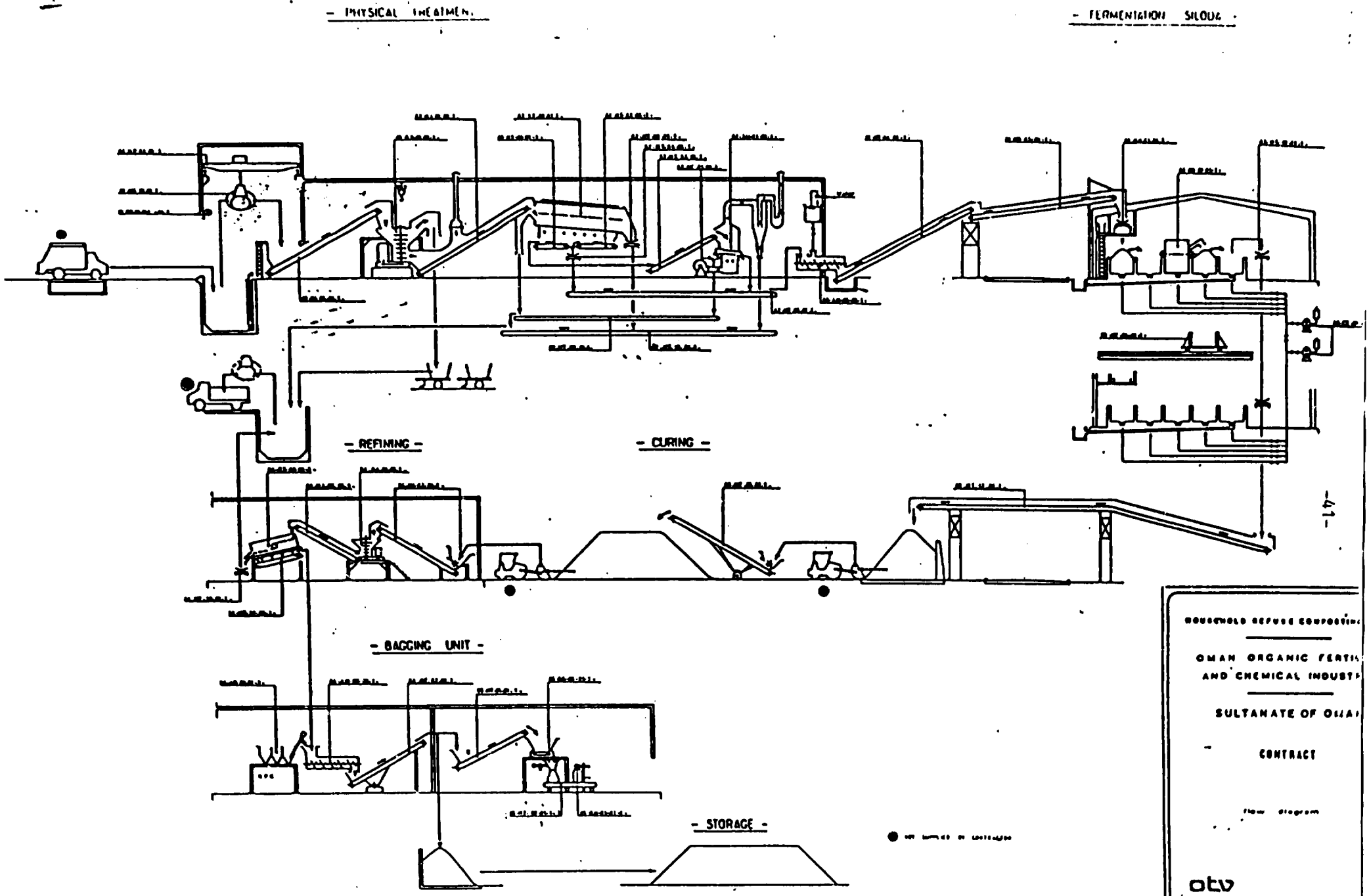
cont'd...9

the natural way of producing compost by providing ideal conditions for natural fermentation. The design of the plant ensures fully aerobic conditions thus preventing generation of any foul smells. An effective temperature control is obtained around 70°C for nearly one week ensuring production entirely safe for handling by human beings. The plant operations envisage a very high degree of automation leading to lesser human errors.

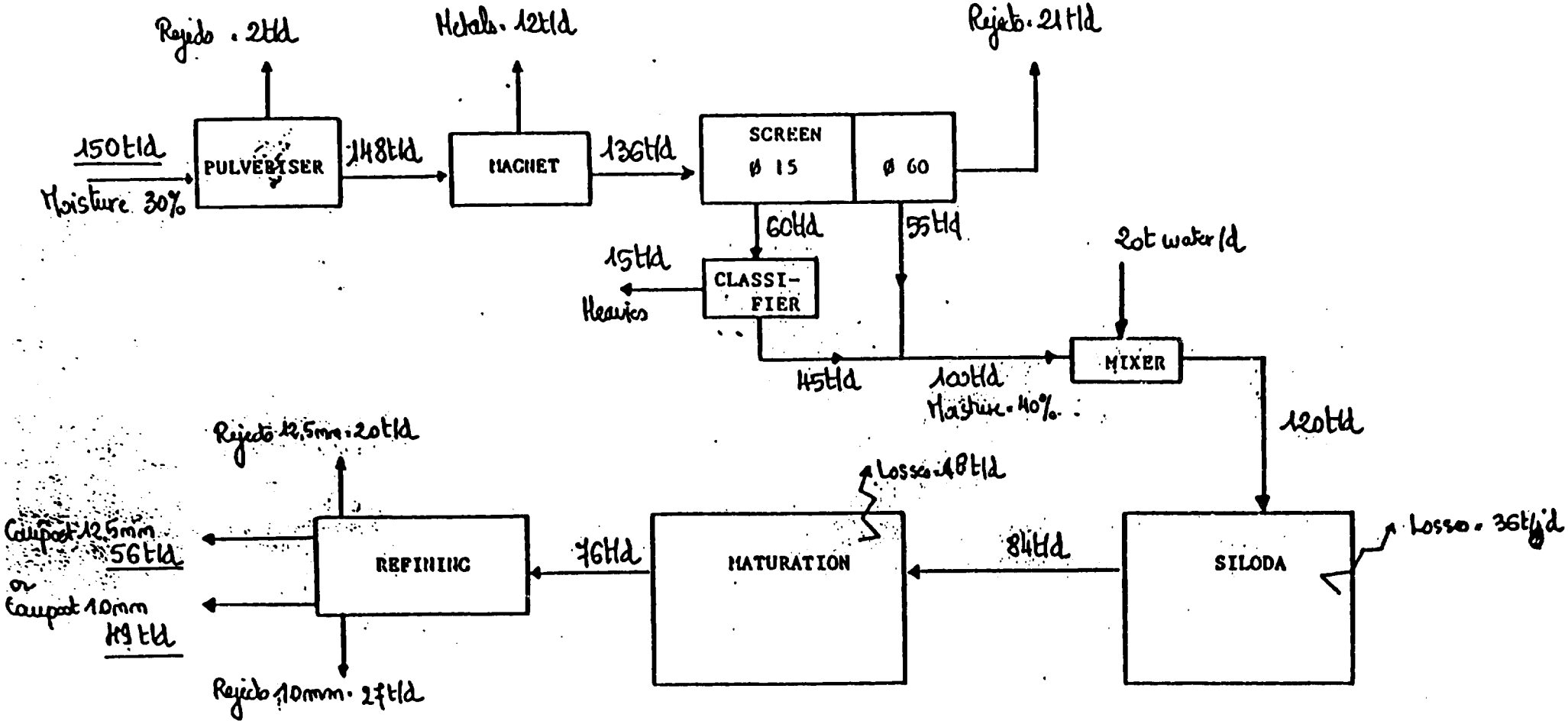
3. PLANT EQUIPMENT

The facilities proposed to be installed in the new plant will mainly consist of :

- Gantry crane with Grapple
- Concrete Reception pit with steel rolling shutter doors
- Metal plate conveyor
- Refuse grinder
- Grinder outlet conveyor with magnetic drum
- Rotary sieve
- Flat deck vibrating screen
- Aspiration blower with cyclone separator
- Screen reject conveyor
- Conveyor for product 15 mm - 60 mm size
- Mixer feed conveyor
- Mixer
- Set of conveyors discharging to SILODA
- Shuttle conveyor
- Paddle wheel and crab
- Recovery conveyor
- Stacking conveyors for curing piles
- Belt conveyor with light duty pulverizer
- Feed conveyor for screen
- Rejects conveyor
- NPK doping bins and feeders
- NPK and compost mixer
- Pivot conveyor
- Bagging machine feed conveyor
- Bagging machine with inlet hopper
- Bag stitching machine


- PHYSICAL TREATMENT -
- FERMENTATION SILOS -
- REFINING -
- CURING -
- BAGGING UNIT -
- STORAGE -
HOUSEHOLD REFUSE COMPOSITION
OMAN ORGANIC FERTI
AND CHEMICAL INDUST
SULTANATE OF OMA
CONTRACT
otv

Expected Mass Balance : 150 t/d 30% Moisture (300 t/y)



Compost production after refining

- either 16,800 T/year (56 T/day) at 12.5 mm mesh
- or 14,700 T/year (49 T/day) at 10 mm mesh

6. COMPOST OUTPUT AND QUALITY GUARANTEES

6.1 Output

At the anticipated operation time i.e. 8 effective working hours per day (excluding daily maintenance and cleaning time), 6 working days per week (300 days per annum) the proposed facility is guaranteed to produce the following:

. either : 14,000 t/year (an average of 47 tons/day of compost screened at 10 mm mesh)

. or : 15,500 t/year (an average of 52 tons/day of compost screened at 12.5 mm mesh)

If, in a first phase, only half the Siloda unit is built and operated, the compost production will be reduced by 50%.

To obtain the above output the plant shall be able to treat daily up to 160 metric tons of raw household refuse, the composition of which is specified in the attached schedule and, notably, containing an average of 70% dry solids.

6.2 Quality of Compost

Whatever the granulometry of the product (12.5 or 10 mm), the final product having the usual compost flavour, shall have the following overall qualities.

- Solids content - at least 55% of the total weight of the compost
- Total organics content - at least 50% of the total weight of the dry solids contained (content analysed by calcination at 550°C of a dry solids sample)

cont'd...12

- The carbon/nitrogen ratio of the compost without addition of N, P, K, will be at maximum 70% of the carbon/nitrogen ratio of the incoming refuse. The organic matter to organic nitrogen ratio of the final product with addition of chemicals if necessary will confirm to French Standard NFU 44051 (7 Dec 81), applicable to fully matured urban compost.

- There will be no rise in temperature in the compost bags, due to further fermentation.

- Total impure matter = all dimensions 30% maximum of the total dry solids weight.

- Total residual impurities in compost:

  . Plastic particles (polyethylene, expanded polystyrene), over 5 mm in size = 2% maximum of the total dry solids.

  . Heavy impurities (glass, metal, heavy plastics) over 5 mm in size = 6% maximum of the total dry solids.

- During the fermentation in the SILCDA, the product will be heated at a temperature held equal or above 70°C for seven days. So, the product will be hygienized in stronger conditions than those described in French or W.H.O. norms.

Lastly, the granulometry specified for the 2 categories of the compost shall be such that 99% of the product will pass through the corresponding square 12.5 mm or 10 mm mesh.

5.3 Environmental Protection

The composting plant is designed to operate without creating health hazards due to excessive noise and/or vibrations, dust, smell or swarms of flies.

The composting process will not generate undesirable smells.

cont'd...15

7. ENVIRONMENTAL IMPACT

As explained previously under 'PROCESS WASTES' section 2.6 this plant is designed for hygienic treatment of all municipal solid wastes thus helping to clean the environment. As a first step almost all the biodegradables are removed for composting leaving behind inerts like cans, wood, glass, plastics etc which are sent back for sanitary land fill.

The remainder i.e. all biodegradables with some light plastics and paper etc are fermented in the SILODA PROCESS under fully aerobic conditions. The residence time in this system is 11-12 days. A guaranteed 70°C temperature is held for a minimum of seven days. The transforming from Silo to Silo (minimum four times in the cycle), a thorough mixing of the entire meass takes place and no particles escape the thermophilic stage of fermentation. Air is constantly fed to limit the temperature at 70°C and to provide the necessary oxygen to microbes. Holding of the entire mass at such a high temperature of 70°C and for such a long period (more than seven days) ensures that all types of pathogens are killed and a fully hygienized product obtained.

The product is further cured for a period of six to eight weeks before refining, doping and finally bagging in polyethylene woven bags. The bagged product is stored on the premises before its despatch to various consumers/distribution centres.

At no stage of the process there is a direct human contact with the waste till it has passed through the fermentation as the process is fully automatic or remotely controlled. The main principal of the present process is to enhance the natural composting by providing the ideal conditions by way of removal of nondegradables, proper size and sufficient oxygen level for intense microbial activity. The temperature conditions during fermentation stipulated in this plant are for more stringent than prescribed under French or WHO norms. The French norms specify achievement of 60°C for four days while as guarantees in the proposed system are for 70°C for seven days.

cont'd..16

MINISTRY OF HEALTH
... Box 393
...MAT

وزارة الصحة
... البريد ٣٩٣
...

EHU/L/86/309 24 May 1986

Mr. V. K. Dingra
Plant Manager
OMAN ORGANIC FERTILIZER & CHEMICAL INDUSTRIES S.A.O.
P. O. Box 6781
Ruwi

Dear Sir,

With reference to the organic compost samples analyzed at teh Central Bacteriology Laboratory BL/36/5 on 3 May 1986 and BL/45/5 on 19 May 1986, we hereby provide you with the specific results of both samples:

I. BACTERIOLOGICAL ANALYSIS

	Sample No. 95 (3/5/86)	Sample No. 121 (19/5/1986)
Total Count	2 million/cm	8 million/cm
Coliform	40/gm.	100/cm
E. Coli	N I L	N I L
Salmonella	N I L	N I L
Shigella	N I L	N I L
Vibrios	N I L	N I L
Staph. Aureus	N I L.	N I L
Moulds	10	10
Clostridium sp.	N I L	N I L

II. PARASITOLOGY ANALYSIS

1) Sample No. 95 - NOT TESTED
2) Sample No. 121 - No parasites Detected

The results indicated above are satisfactory in that they do not contain any pathogenic bacteria or parasites. However, the total count seem to be unusually high. Tests have indicated that no anaerobic bacteria were present, therefore we can safely assume that the high total count is a result from the aerobic bacteria responsible for digesting the organics.

/ / / 2

SULTANATE OF OMAN
MINISTRY OF HEALTH
DEPARTMENT OF PREVENTIVE MEDICINE
CENTRAL BACTERIOLOGY LABORATORY

سلطنة عمان
وزارة الصحة
دائرة الطب الوقائي
شعبة المعامل المركزية البكتريولوجية

Number : EL 103/11 — الرقم :
Date : 26 November 1986 — التاريخ :
From : Head of Environmental Health Section — الى :
To : Head of Bacteriology Laboratory — من :
Subhect : Bacteriological and Parasite Analysis of Compost Sample from Oman Organic Fertilizer & Chemical Industries (OOFCI) — الموضوع :

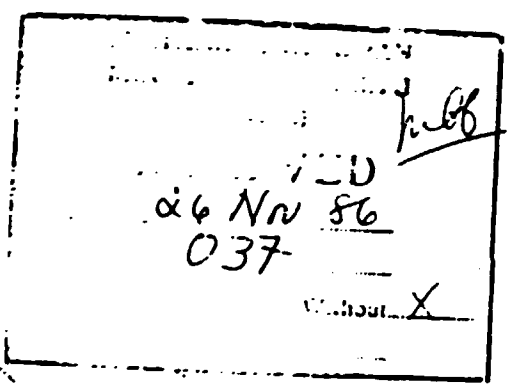
After Compliments,

Reference to your letter EHU/M/86/419 regarding compost sample received by us on 23rd November 1986. Given below is the result of bacteriological and parasitology analysis:

I) Bacteriological Analysis

Laboratory No. ٦٦٦

Nature of sample	-	Organic Compost
Total Count 37°	-	7 million/gm
Coliform	-	130/gm
E. Coli	-	Nil
Salmonella	-	Nil
Shigella	-	Nil
Vibrios	-	Nil
Staph. Aureos	-	NIL
Moulds	-	10
Colistridium sp.	-	Nil



II) Parasitology Analysis

NO parasites seen.

Thanking you,

(ABDUL-RAHMAN BIN MOHAMED AHMED AL-ZEDGALY)
HEAD, CENTRAL BACTERIOLOGY LABORATORY

cc: Director of Preventive Medicine
File

ARM:mbb
26 November 1986

Number : BL / 8 الرقم :
Date : 15 - 8 - '87 التاريخ :
To : Head of Environmental Health Section إلى :
From : Head of Bacteriology Laboratory من :
Subject : Bacteriological and parasitic Analysis of Compost Sample from Oman Organic Fertilizer & Chemical Industries (OOFCI) الموضوع :

After compliments.

Reference to your letter EHU/M/87/388 regarding compost sample received by us on 11-8-87. Given below is the result of bacteriological and parasitology analysis.

I. Bacteriological Analysis.

Laboratory No: 135

Nature of Sample - Organic Compost

Total Count 37°c	-	4.8.00000 / gm
Coliforms	-	120 / gm
E. Coli	-	NIL
Salmonella	-	NIL
Shigella	-	NIL
Vibrios	-	NIL
Staph. aureus	-	NIL
Moulds	-	NIL
Clostridium spp.	-	NIL

II Parasitology Analysis

No parasites seen.

Thanking you.

(Dr. Sulaiman Abd. Al. Awf)

cc. Director of preventive Medicine

Ministry of Health — وزارة الصحة

Department of Preventive Medicine — دائرة الطب الوقائي

Central Bacteriological Laboratory. — شعبة المعامل المركزية البكتيريولوجية

Ref. No. : B.L. 36/5 — الرقم :

Date : 5-5-86. — التاريخ :

To : THE HEAD, ENVIRONMENTAL HEALTH SECTION — الى :

From : HEAD, CENTRAL BACTERIOLOGICAL LAB — من :

Subject: Bacteriological analysis of compost sample from Oman organic Fertilizer & Chemical Inderties S A O. — الموضوع :

After compliments,

Your letter No: ERU/L/86/250 and the Compost sample were received by us on 20-4-86. Given below in the report of the Bacteriological analysis of the said sample.

Lab No: 36.

Nature of sample = Organic compost

Total count (37°C)	= 2 million/g
Coliform	= 40/g
E.Coli	= Nil
Salmonella	= Nil
Shigella	= Nil
Vibrios	= Nil
Staph-aureus	= Nil
Moulds	= 10
Clostridium Sp	= Nil

Thanking you,

(ABDUL RAHAMAN BIN MOH'D)
Head, Central Bacteriological Lab/C

عمان — وزارة الصحة — Ministry of Health — Sultanate of Oman

C.C. Director of Preventive medicine
Ministry of Health.

Sultanate of Oman
Ministry of Health
Department of Preventive Medicine
Central Bacteriological Laboratory.

سلطنة عمان
وزارة الصحة
دائرة الطب الوقائي
شعبة المعامل المركزية البكتيريولوجية

Number: BL 74/8 : الرقم
Date : 11.8.1986 : التاريخ
To : Head, Environmental Health Section, MOH : الى
From : Head, Central Bacteriological Laboratory, Wadi Kabir : من
Subject: Report of the test of air samples collected from Oman Organic Fertilizer & Industry Barka. (Bacteriological reports) : الموضوع

Sir,

Kind compliment

The reports of the tests carried out with the air samples collected from various sites of the above named company on our visit on 6/8/1986 to their plant and surroundings is attached herewith

Thanking you

yours sincerely

Abdul Rehman Bin Mufid Bin Ahmed Al Zeidy

وزارة الصحة — سلطنة عمان
Ministry of Health — Sultanate of Oman

: OF OMAN
/ OF HEALTH
NTIVE MEDICINE DEPARTMENT

-51-

سلطنة عمان
وزارة الصحة
دائرة الطب الوقائي

المعمل البكتريولوجي المركزي
CENTRAL BACTERIOLOGICAL LAB.

REQUEST FOR BACTERIOLOGICAL EXAMINATION طلب عمل تحليلات بكتريولوجية

Diagnosis/Clin. Details		Name : Combat Plast	
		Nation.	Sex
		Address Bahrain	Age
			Lab. No. 158
Date of Onset	Antibiotic Treatment	Exam. Required Culture for pathogenic bacteria	
Nature of Specimen : Dir from Main Capt Tanks	Date of Collect : 6/8/'86	Name & Sign. of M.O.	
Date received	Reported on :	R=Resist. — S=Sensit.	ORGANISM
		ANTIBIOTIC	
LABORATORY REPORT : culture — Staph coagulase negative — No pathogine bacteria — Fungi isolated from the Sample.			

FOR LABORATORY USE ONLY

Lab. Technician

Head of Section

M-166

المعمل البكتريولوجي المركزي
CENTRAL BACTERIOLOGICAL LAB.

REQUEST FOR BACTERIOLOGICAL EXAMINATION طلب عمل تحليلات بكتريولوجية

Diagnosis/Clin. Details		Name : Concrete plant	
		Nationality :	Sex :
		Address : Bahrain	Age
			Lab. No. 159
Date of Onset	Antibiotic Treatment	Exam. Required : Culture for pathogenic bacteria	
Nature of Specimen : Air from Curing Area near pile 1 mouthfold	Date of Collect	Name & Sign. of M.O.	
Date, received	Reported on :	R = Resist. — S = Sensit. ANTIBIOTIC	ORGANISM

LABORATORY REPORT :

Culture :
- No pathogenic bacteria
- Fungi isolated from the Sample.

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Lab. Technician

Head of Section

M-166

المعمل البكتريولوجي المركزي
CENTRAL BACTERIOLOGICAL LAB.

REQUEST FOR BACTERIOLOGICAL EXAMINATION طلب عمل تحليلات بكتريولوجية

Diagnosis/Clin. Details	Name : Cambast plant
	Nationality : / Sex
	Address : Bashei' / Age
	Lab. No. 160
Date of Onset / Antibiotic Treatment	Exam. Required: Culture for pathogenic bacteria
Nature of Specimen : Air from inside physical Treatment Building / Date of Collect :	Name & Sign. of M.O.
Date received / Reported on :	R=Resist. — S=Sensit. / ANTIBIOTIC / ORGANISM

LABORATORY REPORT :

culture.

- Staph Coagulase Negative
- Fungi Isolated from the Sample.

FOR LABORATORY USE ONLY

S.S
Lab. Technician

Head of Section

M.166

المعمل البكتريولوجي المركزي
CENTRAL BACTERIOLOGICAL LAB.

REQUEST FOR BACTERIOLOGICAL EXAMINATION — طلب عمل تحليلات بكتريولوجية

Diagnosis/Clin. Details	Name : Compost plant
	Nationality : / Sex :
	Address : Bashaer / Age :
	Lab. No. 161
Date of Onset / Antibiotic Treatment	Exam. Required : Culture for pathogenic bacteria
Nature of Specimen : Air from Ambient in final product Storage & 30.M deep Pit / Date of Collect :	Name & Sign. of M.O.
Date received / Reported on :	R=Resist. — S=Sensit. / ANTIBIOTIC / ORGANISM

LABORATORY REPORT :

Culture

- No pathogenic bacteria
- Fungi isolated from the Sample.

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Head of Section

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المعمل البكتريولوجي المركزي
CENTRAL BACTERIOLOGICAL LAB.

REQUEST FOR BACTERIOLOGICAL EXAMINATION طلب عمل تحليلات بكتريولوجية

Diagnosis/Clin. Details		Name: Combast plant	
		Nationality :	Sex
		Address: Barbar	Age
			Lab. No 162
Date of Onset	Antibiotic Treatment	Exam. Required: Culture for pathogenic bacteria	
Nature of Specimen : Air from Ambient in final product storage 42M from exit	Date of Collect :	Name & Sign. of M.O.	

Date received	Reported on :	R=Resist. — S=Sensit.	ORGANISM
		ANTIBIOTIC	

LABORATORY REPORT :

Culture

- No pathogenic bacteria
- Fungi isolated

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Lab. Technician

Head of Section

M-166

المعمل البكتريولوجي المركزي
CENTRAL BACTERIOLOGICAL LAB.

REQUEST FOR BACTERIOLOGICAL EXAMINATION طلب عمل تحليلات بكتريولوجية

Diagnosis/Clin. Details	Name : Composting plant, Baushar
	Nationality / Sex
	Address / Age
	Baushar / Lab No 163
Date of Onset / Antibiotic Treatment	Exam. Required: Culture for pathogenic bacteria
Nature of Specimen : Air from the surroundings of the house (No 51)	Date of Collect : / Name & Sign. of M.O.
Date received / Reported on :	R=Resist. — S=Sensit / ORGANISM
	ANTIBIOTIC

LABORATORY REPORT :

Culture

No pathogenic bacteria

Fungi isolated

FOR LABORATORY USE ONLY

Lab. Technician

Head of Section

M-166

المعمل البكتريولوجي المركزي
CENTRAL BACTERIOLOGICAL LAB.

REQUEST FOR BACTERIOLOGICAL EXAMINATION طلب عمل تحليلات بكتريولوجية

Diagnosis/Clin. Details	Name: Compost plant, Barka
	Nationality / Sex :
	Address : Barka / Age .
	Lab. No. 164
Date of Onset / Antibiotic Treatment	Exam. Required: Culture for pathogenic bacteria
Nature of Specimen : Swab taken from the window of Home Nursing by Social Affairs / Date of Collect :	Name & Sign. of M.O: No 51 (outside the window)
Date received / Reported on :	R=Resist. — S=Sensit. / ANTIBIOTIC / ORGANISM

LABORATORY REPORT :

Culture :- NO pathogenic bacteria

Fungi isolated

FOR LABORATORY USE ONLY

S. S
Lab. Technician

Head of Section

M-166

SEWAGE WATER TREATMENT PLANT IN DARSAYT

CAPACITY: 53.300 CONNECTED POPULATION (EXISTING)

75.000 CONNECTED POPULATION (EXTENSION)

TREATMENT PLANT:

INLET LIFT PUMPING STATION

PRETREATMENT UNIT

BIOLOGICAL TREATMENT BLOCK

CHLORINATION BUILDING

FILTER BUILDING

PROCESS DIAGRAM - SEWAGE TREATMENT PLANT

PROCESS DIAGRAM - FILTER PLANT

SLUDGE ANALYSIS

ROYAL DECREE 5/86:

LIMITS FOR REUSE AND DISCHARGE OF WASTE WATER

LIMITS FOR DISPOSAL OF SLUDGE

phone No 70 2134 4.9.1988
S.T.P. (Dar Es Salaam)
Syed Tameel Ahmed/
Mohd. Zakaria.

There are:

a Control building with
- Officies
- Laboratory
- Workshop and store
- Control panel (and electrical equipment existing part)
- Personnel facilities

b Machine Building (Power Station) with
- Electrical equipment
- Four standby dieselgenerators

c Store-garage building

Of these a) and c) are existing.

2.2 Detailed Description of the Plant

2.21 Sewage Treatment

2.21.1 Inlet Lift Pumping Station (Existing)

The pumping station consists mainly of two screw lift pumps, each with a capacity of 1200 m^3/h. With a per capita sewage flow of 170 l per day and a peakfactor of 2.4 this corresponds hydraulically with a connected population of approx 75 000 p for each pump. Thus up to 75 000 p there is 100% standby capacity.

The capacity of the pumping station can be further extended in the future by installing a submersible centrifugal pump in the pump sump with a pressure main to the inlet channel. This will in the future give sufficient standby capacity up to 100 000 p if one of the screw pumps is closed off e.g. for maintenance.

2.21.2 Pretreatment Unit

The inlet measuring flume has a maximum capacity of 800 l/s, which is sufficient for the peak flow at a connection of at least 100 000 pe.

The mechanically cleaned bar screen has a capacity of 1200 m^3/h (75 000 p) and there is space for another one with the same capacity. For emergency there is a handraked screen in place until the future mechanically cleaned bar screen will be installed.

The two preaeration and grit removal chambers have together a volume of 160 m^3 which gives the following retention time:

At peak flow	1200 m^3/h	(75 000 p)	8 minutes
" design flow	600 "	(75 000 p)	16 "
" " "	830 "	(100 000 p)	12 "
" peak "	1660 "	(100 000 p)	6 "

At least 5 minutes is desirable at peak flow. Thus these units are sufficient for a connection of approx 100 000 p.

The two flotation and sedimentation units have together the following data:

Volume m^3			930
Surface area m^2			265
Detention time (DT) at design flow	600 m^3/h	(75 000 p) h	1.55
" " " " " "	830 "	(100 000 p) h	1.12
Surface overflow rate (SOR) at	600 "	(75 000 p) m/h	2.3
" " " " "	830 "	(100 000 p) h	3.1

For the actual type of primary settling tank the values for SOR and DT at design flow range between 2-4 and 1.7-0.9 respectively. Thus the capacity is adequate for a connection of up to 100 000 p.

The surface area for flotation is approx 120 m^2 and the SOR values are as follows:

At design flow	600 m^3/h	(75 000 p) m/h	5.0
" " "	830 "	(100 000 p) m/h	6.9

Max load for this type of oil and grease separation unit is 4-5 l/s x m^2 = 14.4 - 18 m/h. With 120 m^2 this will give a max load of 1700-2200 m^3/h. Thus the area is sufficient at peak flow for 100 000 p i.e. 1660 m^3/h.

2.21.3 Biological Treatment Block

The aeration tanks will receive a BOD_5 load of 75% of the incoming load due to the reduction in the pretreatment unit. With an extension up to and including totally 4 lines, complete nitrification cannot be achieved but with totally 6 lines, the biological treatment process allows for nitrification and to a certain extent denitrification of the sewage.

The design data are as follows:

		4 lines	6 lines
Connected population p		53 300	53 300
BOD_5 load per capita	0,75 x 50 g/d	37.5	37.5
Total BOD_5 load	kg/day	2 000	2000
Total tank volume	m^3	2 000	3100
Design flow	m^3/h	450	450
Detention time	h	4.4	6.9
Sludge return flow	min m^3/h	180	180
" " "	max m^3/h	500	500
" " "	design m^3/h (0,7% DS)	340	340
Design sludge load (2 points steped aeration)	kg BOD_5/kg SS	0.3	0.2
Design sludge age	days	4	6
Aeration capacity under std cond	kg O_2/day	3600	5400
Field conditions:	temp	35°C	35°C
	DO conc in liquid mg/l	2	2
	α factor	0.8	0.8
	β "	0.9	0.9
	altitude factor	1.0	1.0
Excess sludge at design load	kg DS/day	1800	1800
" " " " "	m^3/day (0,7% DS)	257	257
" " " " "	m^3/h	10.7	10.7

The activated sludge process falls then within the range for the normal loaded type with 4 lines and the low loaded type with 6 lines.

The secondary settling tanks have the following data:

		4 lines	6 lines
Connected population	p_3	53 300	53 300
Design flow (DF)	m^3/h	450	450
Peak flow (PF)	m^3/h	900	900
Total volume	m^2	1700	2550
" surface area	m^2	486	730
Detention time (DF)	h	3.8	5.7
SOR (DF)	m/h	0.9	0.6

For the actual type of secondary settling tank used as final stage after activated sludge treatment the values for SOR and DT at design flow range between 1.0-1.2 and 3.5-2.9 respectively. Thus the values allow for some future increase of the per capita sewage flow.

The chlorine contact chambers have the following data:

Connected population	p_3	53 300	53 300
Design flow (DF)	m^3/h	450	450
Peak flow (PF)	m^3/h	900	900
Total volume	m^3	216	324
Detention time at (DF)	h	0.5	0.7
Further detention time in outfall pipe at DF,	h	0.2	0.2
Total chlorine contact time at DF,	h	0.7	0.9

The new chlorination building includes three chlorinators, which have each a max capacity of 20 kg Cl_2/h, corresponding to 40 mg/l at DF and 20 mg/l at PF.

One chlorinator is standby and the other two are used for chlorination of biologically treated sewage and filtered water respectively.

The measuring flumes are of the venturi type and each is designed for a maximum capacity of 500 l/s. Each flume serves two treatment lines and shall be able to cope with the total peak flow when two other treatment lines are closed off.

In case of four or six lines, the four or six aerobic secondary and the two or four aerobic primary sludge stabilization tanks have the following data (denitrification not applied).

	Four lines		Six lines	
	Secondary sludge	Primary sludge	Secondary sludge	Primary sludge
Connected population, p	53 300	53 300	53 300	53 300
Excess sludge, kg DS/d	1800	2700	1800	2700
Excess sludge, m^3/d	257 (0.7%)	90 (3%)	257 (0.7%)	90 (3%)
Total volume, m^3	670	512	1030	1024
Detention time, d	2.6	5.7	4	11.4
Excess sludge age, d	4.0	-	6	-
Total stabilization time, d	6.6	5.7	10.0	11.4

If denitrification is applied (six lines required) the six aerobic secondary sludge stabilization tanks are used for the denitrification. Two of the four primary sludge stabilization tanks are then used for primary sludge solely and the two other for mixed primary and secondary sludge. The following data are then valid.

	Secondary sludge	Primary sludge	Mixed primary and secondary sludge
Connected population, p	53 300	53 300	53 300
Excess sludge, kg DS/d	1800.	2700.	4500
Excess sludge, m^3/d	257 (0.7%)	90 (3%)	347
Total volume, m^3	-	512	512
Detention time, d	-	5.7	1.5
Excess sludge age, d	6.0	-	-
Total stabilization time, d	7.5	7.2	-

The stabilized sludge pumping station has two pumps, each with a capacity variable from 20 to 65 m^3/h. The pumps are working intermittently. One pump is standby.

The biological treatment block can be extended with another two treatment lines between the service area and the sludge treatment area. Thus there is space for a future extension of the biological treatment block up to a total capacity of approx 75 000 connected people.

2.21.4 Chlorination Building

The new chlorination building shall serve both the chlorination of biologically treated sewage before sand filtration and chlorination of the final effluent after filtration and aeration.

For the purpose two separate lines are arranged for chlorine water solution, one for the chlorination chambers at the biological treatment block and one for the filter building before the low reservoir.

There are three chlorinators, each with a capacity of 20 kg cl_2/hour, and three feed pumps for solution water, one for each line and one as a reserve for either of the two lines, respectively.

The chlorine store room has space for five numbers of 3-ton containers, of which one on the balance.

Both the dosage and the storage room are equipped with forced draught ventilators and gas warning system and the storage room is furthermore equipped with a sprinkler system. Emergency shower and emergency equipments are available outdoors.

The chlorine dosage is controlled from the flow meters at the biological block and the dosage and the consumption will be as follows at a connection of 75 000 p:

	Biological block Average	Max	Filter building Average	Max
Dosage, mg/l	5	15	5	10
Consumption, kg/day	75	225	45	150
Max consumption (peak), kg/h	-	18	-	12

2.21.5 Feed Pumping Station to Filters

There are four submersible pumps of which one is normally standby. The capacity will be the following:

One pump in operation (approx)	1 x 120 l/s at 11.5 m	430 m^3/h
Two pumps in operation (approx)	2 x 110 l/s at 12.4 m	790 m^3/h
Three pumps in operation	3 x 100 l/s at 13.5 m	1080 m^3/h
Four pumps in operation (approx)	4 x 90 l/s at 14.3 m	1300 m^3/h

The pumps are controlled from the water level in the pump sump. The delivery pipe terminates in the inlet channel to the filters. The flow is measured before the inlet to the channel.

The controls from the level in the pump sump are as follows:

- Pump No 1 starts at +4.00, stops at +3.00
- Pump No 2 starts at +4.25, stops at +3.25
- Pump No 3 starts at +4.50, stops at 3.50
- Pump No 4 starts at +4.75, stops at +3.75.

Alarm for low water level at +2.75.

Alarm for high water level at +4.90.

2.21.6 Filter Building

Filters

The filter unit comprises 5 open filter chambers connected in parallel. The filtration takes place form the top of a two-media filter bed of antracite-sand resting on a bottom with filter nozzles.

The sewage is evenly distributed from the inlet channel to the filter chambers in operation by means of rectangular weirs. Each chamber can be shut off at the inlet side by a penstock. The filtered water flows from the space below the filter bottom through a pipe into the aeration tank. The pipe discharges above the level of the filter material which makes sure that the filter can never run dry.

The water level above each filter bed is regulated at a fixed level (approximately 100 mm below the weir of the backwash flume) by the throttling of the valve on each filter outlet pipe.

When the filter resistance increases to a certain value, the filter shall be backwashed.

Backwash is carried out with air and water. Each filter chamber is to

be backwashed separately (one at a time). The backwash is automatically operated but can also be started manually.

Amount of water to be used when backwashing 600 to 1200 m^3/h

Amount of air to be used when backwashing 1200 m^3/h

The amount of backwash water is controlled by the throttling of the gate valve mounted after the backwash water pump and the flush air is controlled by means of a bypass exhaust valve.

When starting up and trimming in the backwashing it is essential that the backwash water flow is controlled and set so that no filter material will escape, especially when washing with water and air simultaneously.

The backwash water is taken from the reservoir for filtered water. The backwash is blocked at too low a level in the reservoir in order to prevent backwash pumps running dry.

The backwash water is drawn off in flumes and collected in an equilization tank from which it flows in a gravity pipe to the inlet pumping station.

For improvement of the filtration, polymer may be added to the sewage effluent before passing through the filters. The polymer to be used shall be specially made for use in connection with filtration. For the preparation of polymer solution and dosage of the solution an automatic polymer preparation and dosing plant shall be installed in the filter building.

Design Data

Average daily flow	m^3/d	9000
Maximum daily flow	m^3/d	15000
Filter flow rate, average	m/h	5
Filter flow rate, maximum	m/h	10
Required filter area	m^2	75
Filter unit sizes	m^2	22
Filter units (one of which is reserve)	Nos	5
Units to be washed simultaneously	No	1
Backwash rate, water	m/h	30-60
Backwash water max capacity	m^3/h	1200
Backwash time (approx)	min	6
Backwash rate, air	m/h	60
Backwash air max capacity	m^3/h	1200
Backwash time (approx)	min	5
Filter media, sand, particle size	mm	0.7-1.5
sand, layer depth	m	0.5
anthracite, particle size	mm	1.4-2.5
anthracite, layer depth	m	0.5

Aeration Tank

The aeration tank has a volume of 155 m^3, which gives the following data:

Connected population equivalent, pe	53 300	75 000
Design flow (DF), m^3/h	450	600
Retention time, minutes	20	15
Oxygenation capacity (std cond), kg O_2/h	10	10
Oxygenation capacity (field cond), kg O_2/h	5.5	5.5
Oxygenation capacity at DF, mg/l	12	9
Oxygenation capacity at max daily flow, mg/l	6.3	4.7

The oxygenation capacity is always adequate to ensuring an oxygen content of more than the required 2 mg/l.

Low Reservoir

The low reservoir has a regulation volume of approximately 1800 m^3, which is approximately 20% and 15% of the daily flow at a connection of 53 300 pe and 75 000 pe, respectively.

On Diagram (Appendix 5) the average daily variation in flow to the sewage treatment plant is shown as an accumulated curve expressed as a percentage of the total flow per day. From this diagram the required reservoir volume for different operation cases can be calculated. The diagram is based on records from the sewage treatment plant in May, 1982 (Appendix 6).

If the irrigation of the daily available quantity is performed during 12 hours, i e from 6.00 AM to 6.00 PM, the required reservoir volume is 8.4 + 27.1 = 35.5% of the available quantity per day. (Appendix 5, page 1.)

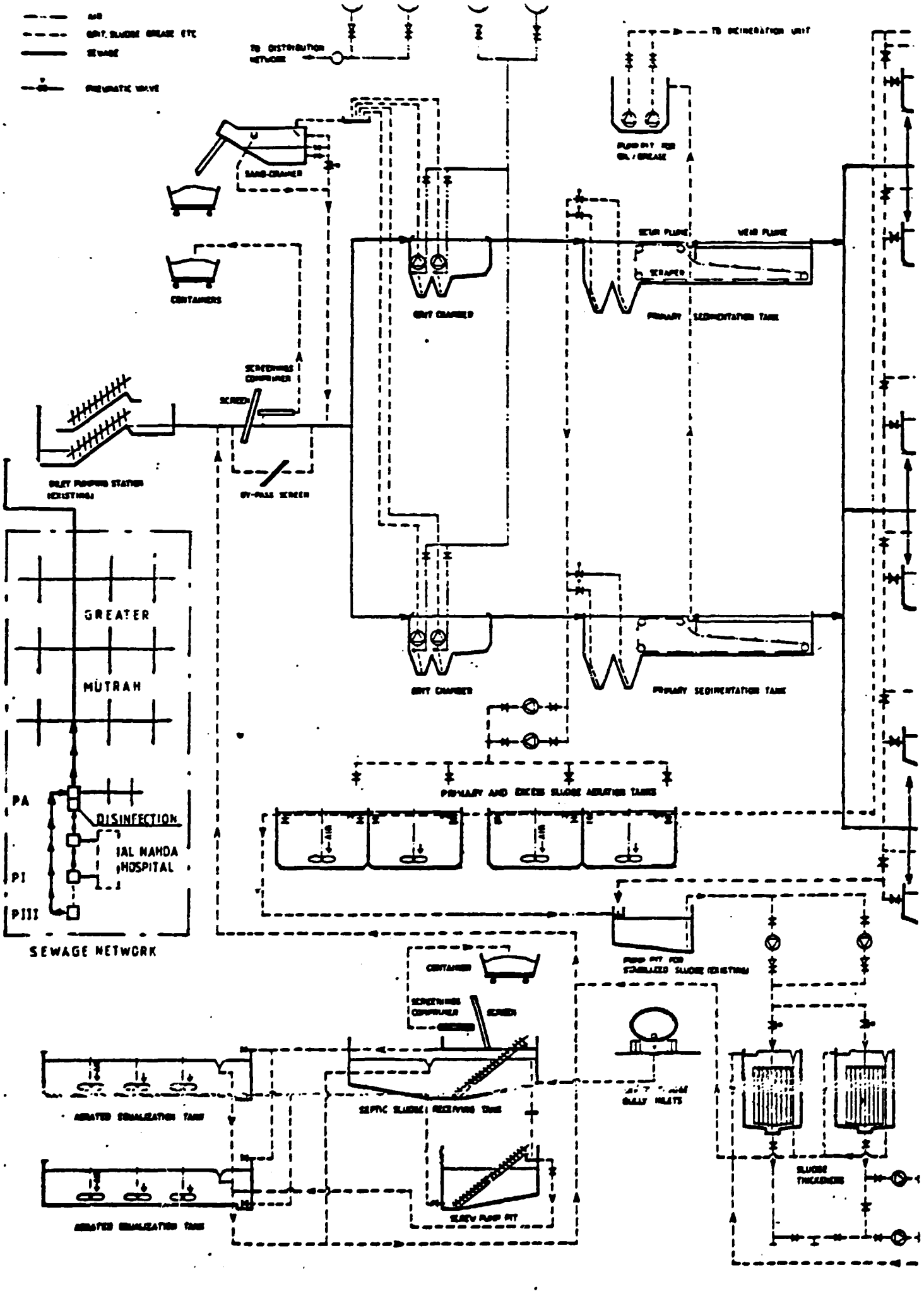
The elevated reservoir at Jibro has a volume of 1200 m^3. The total reservoir volume is then 3000 m^3. The daily quantity which can be fully regulated at 12 hours equilized irrigation per day is then approximately 8500 m^3. This quantity is approximately the available quantity at a connection of 53 300 people to the sewage treatment plant.

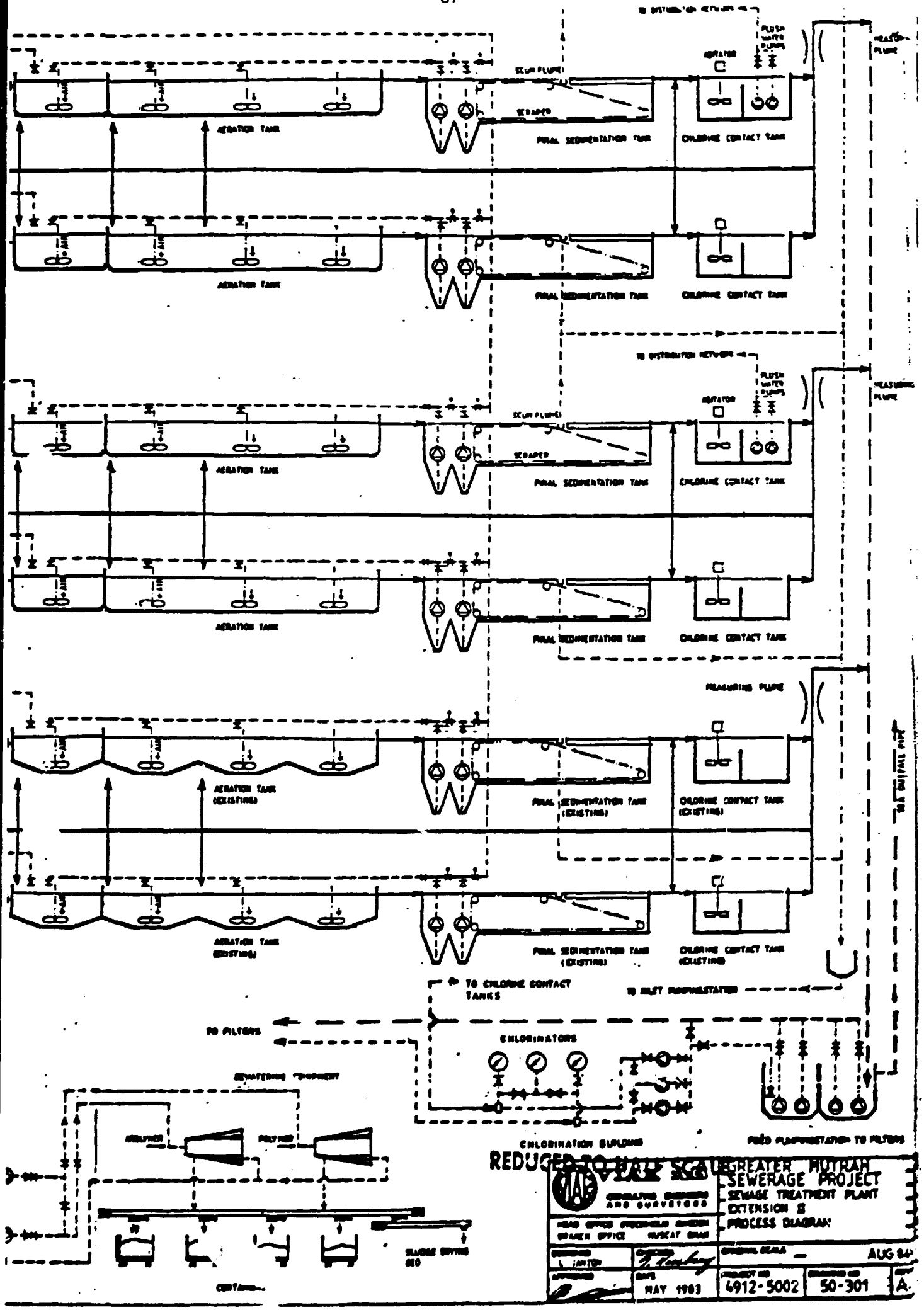
If the irrigation is performed during 14 hours, i e from 6.00 AM to 8.00 PM, the required reservoir volume is 25.6% of the daily available quantity. With a reservoir volume of 3000 m^3 the corresponding daily quantity is 11 700 m^3, which in turn corresponds to a connected population of approximately 75 000 p.

If the irrigation is performed during less than 12 or 14 hours respectively, it has to be divided into two periods of the day, e g 4 to 5 hours in the morning and 4 to 5 hours in the afternoon, or more reservoir volume has to be added either at the treatment plant or at the respective irrigation areas. (Appendix 5, pages 2 and 3.)

Pumping Station for Irrigation Water

At this stage three pumps and, in the future, totally four pumps will be installed. One pump shall be standby and maximum three pumps shall

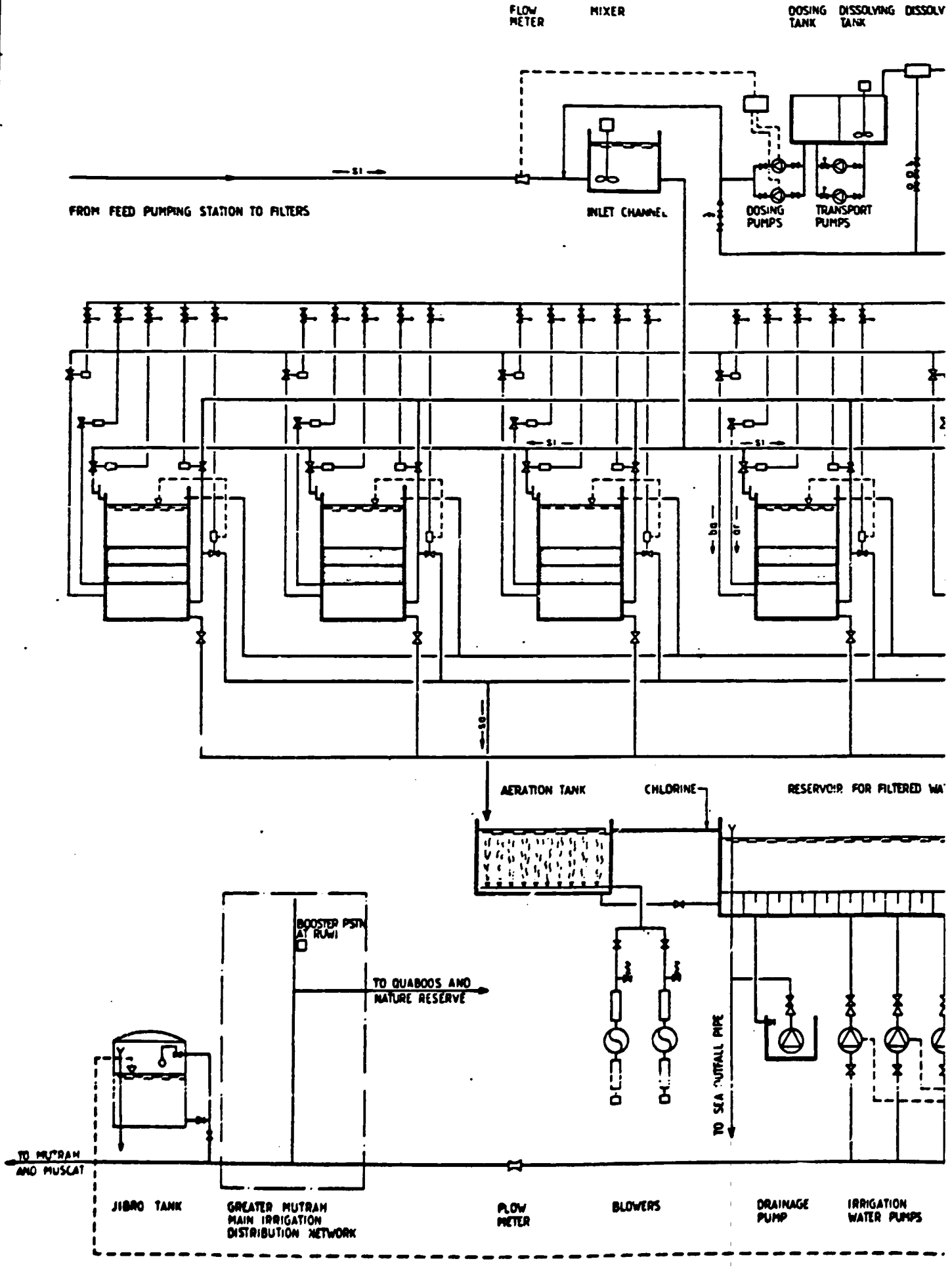

AIR
SEWAGE
PNEUMATIC VALVE
TO DISTRIBUTION NETWORK
TO DEWATERING UNIT
SAND-CRAWLER
CONTAINERS
GRIT CHAMBER
SCUM PLUME
VEIN PLUME
SCRAPER
PRIMARY SEDIMENTATION TANK
SCREENINGS CONTAINER
SCREEN
BY-PASS SCREEN
GREATER
MUTRAH
PA
PI
PIII
DISINFECTION
IAL NAHDA HOSPITAL
SEWAGE NETWORK
PRIMARY AND EXCESS SLUDGE AERATION TANKS
AIR
PUMP PIT FOR STABILIZED SLUDGE (EXISTING)
CONTAINER
SCREENINGS CONTAINER
SCREEN
AERATED EQUALIZATION TANK
SEPTIC SLUDGE RECEIVING TANK
SLUDGE PUMP PIT
SLUDGE THICKENERS

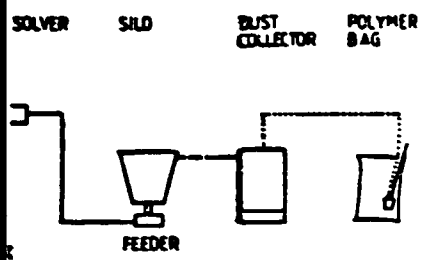


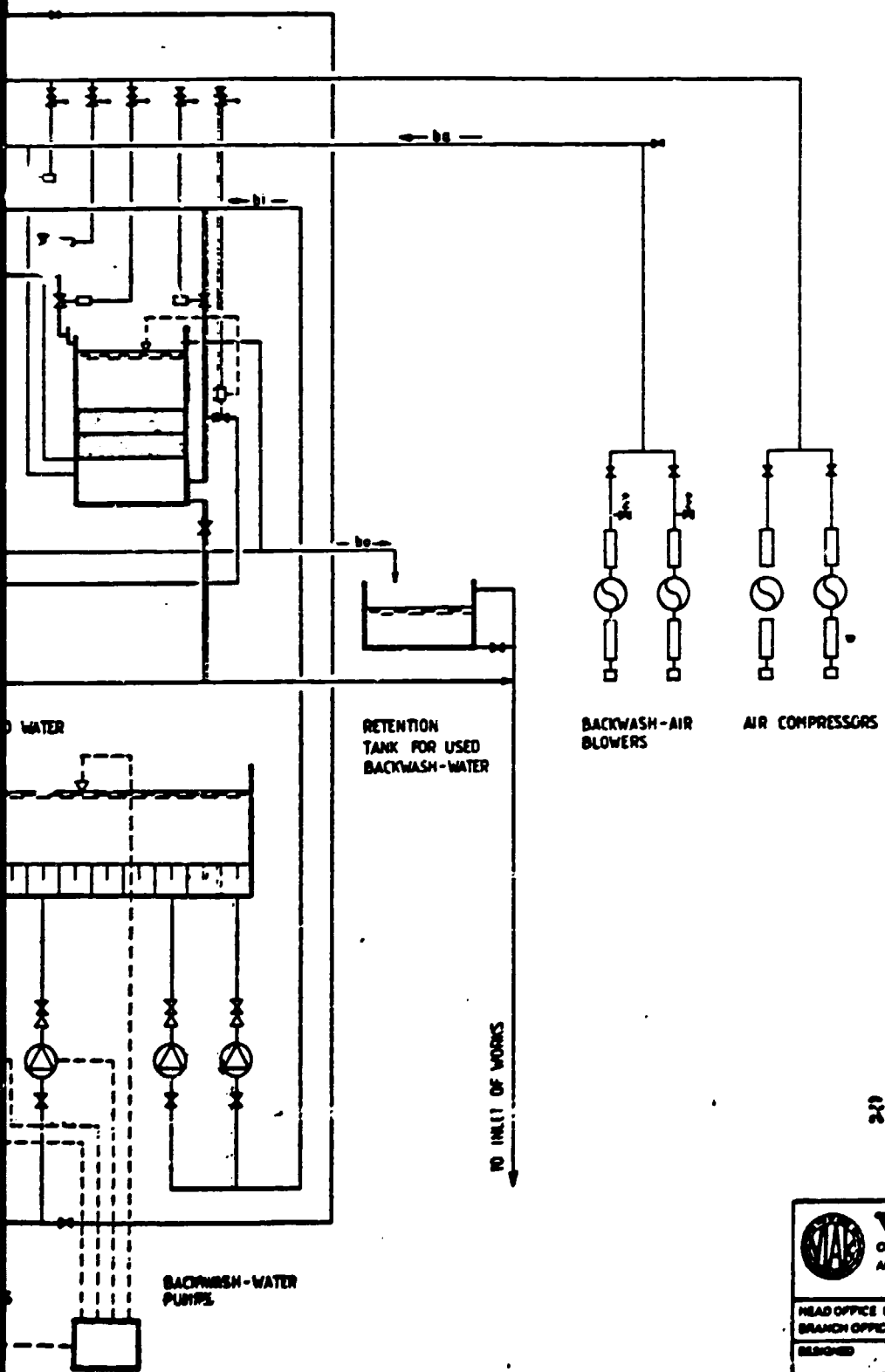
REDUCED TO HALF SCALE

GREATER MUTRAH SEWERAGE PROJECT
SEWAGE TREATMENT PLANT EXTENSION II
PROCESS DIAGRAM

MAY 1983 | 4912-5002 | 50-301 | A


FLOW METER
MIXER
DOSING TANK
DISSOLVING TANK
DISSOLV
FROM FEED PUMPING STATION TO FILTERS
INLET CHANNEL
DOSING PUMPS
TRANSPORT PUMPS
AERATION TANK
CHLORINE
RESERVOIR FOR FILTERED WA
BOOSTER PSTN AT RUWI
TO QUABOOS AND NATURE RESERVE
TO SEA OUTFALL PIPE
TO MUTRAH AND MUSCAT
JIBRO TANK
GREATER MUTRAH MAIN IRRIGATION DISTRIBUTION NETWORK
FLOW METER
BLOWERS
DRAINAGE PUMP
IRRIGATION WATER PUMPS





NOTES

- si — SEWAGE IN
- so — SEWAGE OUT
- bi — BACKWASH-WATER IN
- bo — BACKWASH-WATER OUT
- ba — BACKWASH-AIR
- ar — AIR RELEASE

REDUCED TO HALF SCALE

REV	NOTES	DRGN	DATE

VIAK AB CONSULTING ENGINEERS AND SURVEYORS
HEAD OFFICE STOCKHOLM SWEDEN
BRANCH OFFICE MUSCAT OMAN

GREATER MUTRAH SEWERAGE PROJECT
SEWAGE TREATMENT PLANT
EXTENSION II
PROCESS DIAGRAM
FILTER PLANT

DESIGNED	CHECKED	ORIGINAL SCALE
APPROVED	DATE: AUG 1984	PROJECT NO: 4912-5002
		DRAWING NO: 50-302

وزارة التجـــارة والصنـــاعة
Ministry of Commerce & Industry
Directorate General for Specifications & Measurements
المديرية العامة للمواصفات والمقاييس
بسم الله الرحمن الرحيم
سلطنة عمان
SULTANATE OF OMAN

SLUDGE ANALYSIS

Laboratory No. :2208/10/87

Source :CAPITAL MUNICIPALITY DIRECTORATE GENERAL OF TECH.AFFAIRS.

Analyst :SK,SM,GH,ATTA,FI,SS

Date Analysed :01/11/87

RESULTS

Phosphorus P2O5	:1.03	%	Oil & Grease	:65,800.0	Mg/Kg
Potash K2O	:1.58	%	Cadmium	:13.62	Mg/Kg
Silica SiO2	:0.44	%	Zinc	:1776.6	Mg/Kg
Iron,Fe2O3	:1.60	%	Copper	:646.10	Mg/Kg
Aluminum,Al2O3	:NOT DONE	%	Cobalt	:19.50	Mg/Kg
Total Nitrogen,N	:5.82	%	Chromium	:82.30	Mg/Kg
Calcium,CaO	:1.89	%	Nickel	:117.0	Mg/Kg
Magnesium,MgO	:1.89	%	Manganese	:150.0	Mg/Kg
Sulphur,SO3	:0.92	%	Molybdenum	:3.20	Mg/Kg
Chloride,Cl	:0.14	%	Protein	:NOT DONE	Mg/Kg
Sodium,Na2O	:1.23	%	T.Dry Solids	:16.20	%
Lead,PbO	:0.12	%	Volat.Solids	:78.10	%

Comments:ALL FACTORS ARE CALCULATED ON DRY WEIGHT BASIS.

Director of Laboratory

Chief Chemist

ص.ب: ٥٥٠ مسقط - تليفون: ٧٠٤٩٣٣/٧٠٤٧٨٣/٧٠٤٩٤٣ - برقيا: وزارة - تلكس: أوان ٣٩٩٥ جواب التلكس: وزارة مسقط
P.O. Box 550 MUSCAT - Tel.: 704933, 704783, 704942, 795993 Cable: WIZARA - Telex: ON 3665 WIZARA MUSCAT
FAX No. 795992 MUSCAT فاكسميلي: ٧٩٥٩٩٢ مسقط

وزارة التجـــارة والصنـــاعة
Ministry of Commerce & Industry
Directorate General for Specifications & Measurements
المديرية العامة للمواصفات والمقاييس
السلطنة عمان
SULTANATE OF OMA

SEWAGE ANALYSIS

Laboratory No. :3093/12/87

Ref. No. :!

Source :DIWAN OF ROYAL COURT AFFAIRS

Origin :SLUDGE STP DARSAIT

Analyst :GALILA

Date Analysed :6/1/87

RESULTS

BORON	:!	MG/L
CADMIUM	:!	MG/L
COPPER	:!	MG/L
LEAD	:697.84	MG/L
NICKEL	:!	MG/L
ZINC	:788.95	MG/L
COBALT	:!	MG/L
CHROMIUM	:!	MG/L

COMMENTS :!

Director of Laboratory

Chief Chemist

ص.ب: ٥٥٠ مسقط - تليفون: ٧٠٤٩٣٣/٧٠٤٧٨٣/٧٠٤٩١٢ - برقيا: وزارة - تلكس: أوان ٣٦٦٥ جواب التلكس: وزارة مسقط
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EXTRACT FROM ROYAL DECREE 5/86

LIMITS FOR REUSE AND DISCHARGE OF WASTE WATER

UTILIZATION AND DISPOSAL OF SLUDGE

LIMITS FOR REUSE AND DISCHARGE OF WASTEWATER

All units as mg/l unless otherwise stated

Parameter	Limits not greater than	
	Maximum	Monthly average over any four consecutive weeks
Physical		
Total dissolved solids	1500	1000
Total suspended solids	15	10
Turbidity (K.T.U.)	5	2
Chemical		
Aluminium	5	1
Ammoniacal Nitrogen (as N)	5	1
Arsenic	0.2	0.05
Barium	2	1
Beryllium	0.3	0.1
Biochemical Oxygen Demand (5 Day)	15	10
Boron	2	1
Cadmium	0.03	0.01
Chemical Oxygen Demand	100	50
Chloride	350	250
Chlorine, Free Residual (after 60 min. contact time)	0.5 (min)	0.5 (min)
Chromium	0.5	0.1
Cobalt	0.5	0.1

Parameter	Limits not greater than	
	Maximum	Monthly average over any four consecutive weeks
Copper	0.3	0.2
Cyanide	0.1	0.05
Dissolved Oxygen	2.0 (min)	2.0 (min)
Fluoride	2	1
Iron	5	1
Lead	0.5	0.1
Lithium	10	2.5
Magnesium	150	30
Manganese	1	0.2
Mercury	0.005	0.001
Molybdenum	0.05	0.01
Nickel	0.5	0.2
Oil and Grease	5	2
pH (pH units)	6-9	6-9
Phenols	1	0.1
Phosphorus (total as P)	30	20
Selenium	0.05	0.02
Sodium	200	70
Sulphate	400	200
Sulphide	0.1	0.05
Organic Nitrogen (Kjeldahl)	10	5
Total Nitrogen	50	30
Total Organic Carbon	50	20

Parameter	Limits not greater than	
	Maximum	Monthly average over any four consecutive weeks
Vanadium	1	0.1
Zinc	5	2
<u>Bacteriological</u>		
Total Coliforms (MPN/100 ml)	23 (Not to be exceeded in any sample)	2.2 (Determined over last 7 days of completed analyses)
Viable Pathogenic Ova and Cysts	Non-detectable	Non-detectable

Note :- Only those parameters specified in the consent to discharge need to be analysed.

Utilization and Disposal of Sludge

3.7 All sludge shall be treated for disposal to the limits given in Table 2.

Table 2

LIMITS FOR DISPOSAL OF SLUDGE:

All units as grammes per ton of dry matter.

Parameter	Limit (not greater than)
Cadmium	30
Chromium	1000
Cobalt	100
Copper	1000
Lead	1000
Molybdenum	20
Mercury	10
Nickel	200
Zinc	1000

3.8 Owners of wastewater treatment plant shall not deliver sludge to contractors or users unless the latter have obtained prior approval from the Ministry or other authorities approved by the Ministry for the proper disposal of such sludge.

3.9 Owners of wastewater treatment plants delivering sludge to contractors or users shall keep records specifying at least:

a) date of delivery,
b) name & address of contractor/user,
c) quantity delivered.

3.10 Sludge which is not being delivered to contractors or users shall either be utilized in an approved manner or be disposed of by the owners in an approved manner such as land fill or incineration.

METEOROLOGICAL DATA

ANNUAL CLIMATOLOGICAL SUMMARY 1987

WIND ROSES FOR SEEB INTERNATIONAL AIRPORT 1987

SULTANATE OF OMAN
MINISTRY OF COMMUNICATIONS
DIRECTORATE GENERAL OF CIVIL AVIATION
AND METEOROLOGY
DEPARTMENT OF METEOROLOGY

Table : 3.5.1

STATION : SEEB

YEAR : 1987

LATITUDE : 23 35N
LONGITUDE : 58 17E
HEIGHT ABV. MSL: 14.6M

ANNUAL CLIMATOLOGICAL SUMMARY

MONTH	STATION LEVEL PRESSURE (hPa)			AIR TEMPERATURE (C)					VAPOUR PRESSURE (hPa)			RELATIVE HUMIDITY HUMIDITY (%)					WIND			
		EXTREME		MEAN			EXTREME			EXTREME		MEAN			EXTREME		PREV. DIR	SPEED(knots)		
	MEAN	MAX	MIN	MEAN	MAX	MIN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MAX	MIN	(Deg)	MEAN	MAX Sust 10min	MAX Gust
JAN	1017.8	1023.8	1011.7	21.4	25.9	17.2	29.9	12.5	15.3	24.1	7.5	61	77	43	92	22	210	4	-	18
FEB	1015.1	1020.9	1009.2	22.5	26.6	18.5	30.4	15.0	18.9	24.9	7.2	70	87	49	97	19	060	5	14	30
MAR	1010.4	1017.3	1003.5	25.8	30.5	21.6	38.9	16.4	17.9	27.3	6.5	56	79	36	95	13	060	5	21	46
APR	1009.2	1015.9	1002.2	29.1	34.0	22.5	42.2	17.5	18.7	35.3	5.6	49	73	29	100	10	330	4	13	34
MAY	1004.8	1010.8	999.0	34.5	39.5	28.7	44.4	25.2	21.5	37.9	5.3	42	64	22	94	6	060	6	17	32
JUN	998.6	1007.4	992.8	35.2	40.6	30.6	46.7	24.5	25.8	40.3	4.6	48	74	26	95	5	060	5	19	36
JUL	997.3	1004.4	993.7	36.3	40.7	32.1	47.0	29.5	28.1	44.7	7.0	50	71	28	95	9	060	6	16	29
AUG	998.7	1005.4	993.1	32.5	36.5	29.6	46.5	27.0	32.1	39.9	14.6	68	85	49	98	16	060	5	15	21
SEP	1004.3	1011.6	999.0	32.1	36.0	28.9	43.2	25.8	30.1	38.6	14.6	65	82	45	98	22	060	5	19	24
OCT	1010.8	1016.6	1003.5	29.5	34.1	25.3	40.7	20.3	22.7	36.7	6.0	58	76	34	94	13	030	4	21	29
NOV	1013.6	1020.0	1008.7	25.5	30.2	20.8	33.2	17.2	21.4	30.5	8.1	66	85	44	96	16	030	4	15	19
DEC	1017.7	1025.0	1011.3	21.5	25.8	17.3	29.3	14.4	15.7	23.4	6.7	61	76	45	96	24	030	4	17	21
YEAR	1008.2	1025.0	992.8	28.8	33.4	24.4	47.0	12.5	22.4	44.7	4.6	58	77	38	100	5	060	5	21	46

SEEB

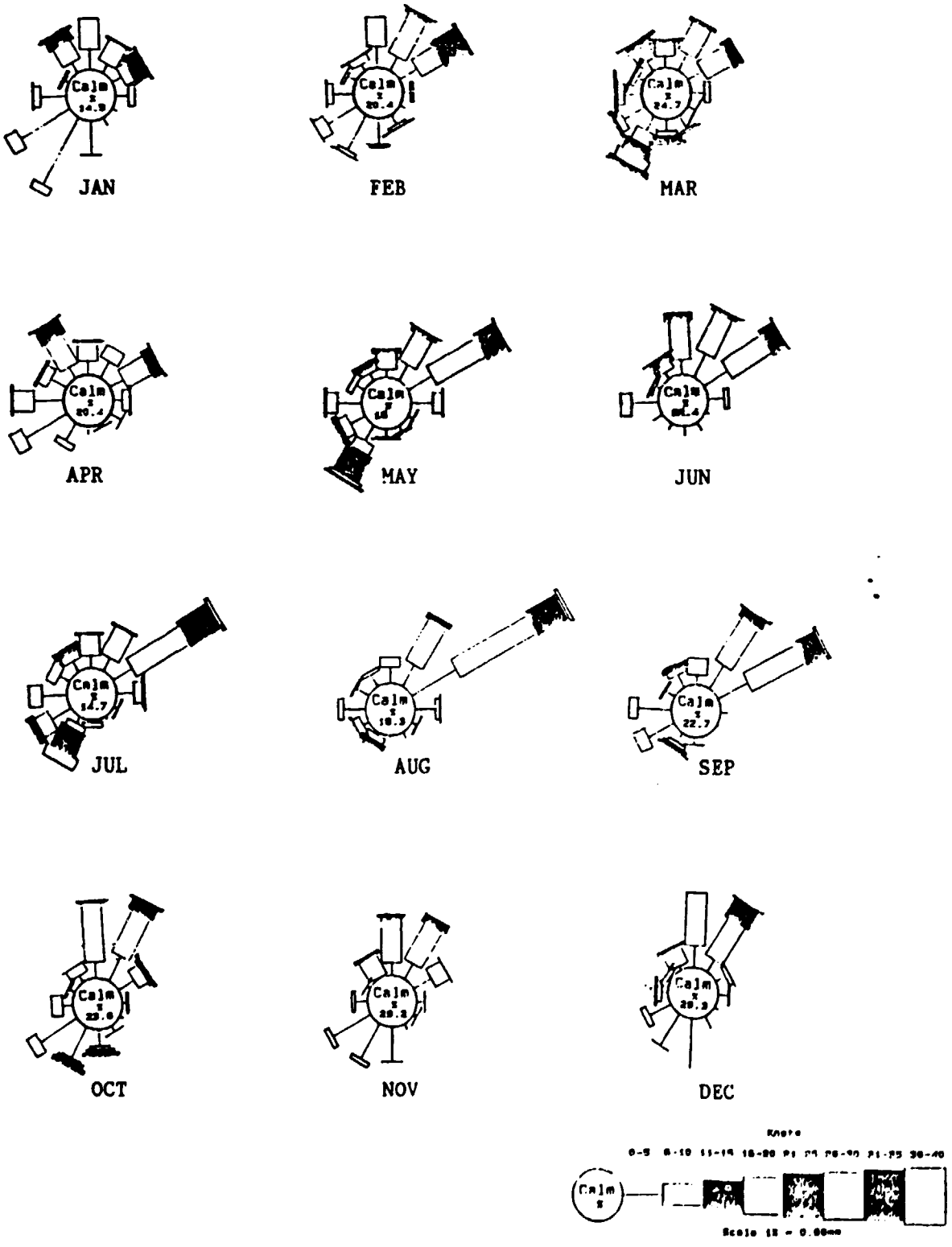

Fig. 3. Wind-Roses for Seeb - 1987