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EGYPT

Technical report: Evaluation of potentials and constraints for the development of artemia production in Egypt*

Prepared for the Government in Egypt
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of W. Tackaert, Artemia Cyst Expert

Substantive officer: M. Judt
Chemical Industries Branch

Backstopping officer: V. Koliakine
Section for Integrated Industrial Projects

United Nations Industrial Development Organization
Vienna

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INTRODUCTION

This document reports on the results of a 2 weeks consultancy mission (performed from November 14 to November 28, 1989) of an *Artemia* expert from the Artemia Reference Center, Ghent Belgium assigned by UNIDO to the *Artemia* project DP/EGY/88/032/11 in Egypt. The purpose of this report is to provide technical advisory assistance to the Government of the Arab Republic of Egypt in exploitation of brine shrimp *Artemia* from solar salt works. During this mission the consultant was charged with the investigation of potentials and constraints for the development of commercial production of *Artemia* cysts and biomass in the coastal satterns of Port Said, El Mex, Bourg El Arab and Cebeka controlled by the Mining and Refactory Industries Corporation (MARIC) and operated by El Nasr Salines Company (ENSC).

The purpose of this report is as follows:

- to evaluate present configuration and biological conditions of the salterns with regard to their suitability for *Artemia* culturing
- to identify present potentials and constraints for the development of commercial production of *Artemia*
- to provide advise on structural and operational modifications/management procedures required for commercial production of *Artemia*.
- to provide recommendations on general strategies to be adopted for the development of *Artemia* production.

A list of local counterparts from MARIC and ENSC is provided in Annex I.

ABSTRACT

In the framework of the _Artemia_ project DP/EGY/88/032/11, a 2 weeks consultancy mission was performed to evaluate the potentials and constraints for the development of commercial production of _Artemia_ in the coastal solar salt works of Port Said, El Mex, Bourg El Arab and Cebeka operated by the El Nasr Salines Company.

Commercial production of _Artemia_ in these salterns is not obvious, mainly because of persistence of predators eleminating _Artemia_ up to salinities of 18°Be and low phytoplankton productivity (at least in Cebeka and Bourg El Arab), and will require accurate follow up of the recommendations made with regard to infrastructural modifications (pond configuration), predator control, introduction of a new strain of _Artemia_ with high productivity and producing small cysts, fertilization, _Artemia_ population management, etc.

It is advised _Artemia_ production be developed on a step by step basis (in close cooperation with the _Artemia_ project of the Suez Canal University), i.e. verification of the feasability of _Artemia_ production in Port Said (results to be assessed by the end of 1990 by an _Artemia_ expert assigned by UNIDO), prior to considering further development of the other sites and the establishment of a sophisticated processing plant for cysts and possibly biomass.

Key words: _Artemia_ - solar salt works-aquaculture

I. PORT SAID

A. Observations/Findings

- Lay out/brine flow

  Located on the east bank of the mouth of the Suez Canal into the Mediterranean Sea, this saltern with a total area of about 975 ha produces 250,000 ton of common salt per year and consist of 4 consecutive evaporation ponds and a series of small crystallizers with a total surface of 120 ha.

  Seawater with a salinity of 3.5 to 5 °Be is fed via a seawater canal connected to the Suez Canal into the reservoir and gravity flown towards the crystallizers in order to build up the salinity. A second pumping station feeds fresh water directly into the second pond as to allow for correction of the salinity.

  The surfaces and salinity gradient in the successive evaporation pond is as follows :

  1. reservoir : 520 ha; 3.5-8 °Be
  2. evaporator : 95 ha; 8-12 °Be
  3. evaporator : 75 ha; 12-18 °Be
  4. evaporator : 70 ha; 18-24 °Be

  Under normal operation these ponds are maintained at waterdepths of about 80 cm.

  During our visit waterdepths were slightly lower while the salinities were considerably higher (e.g. outlet reservoir : 11.4 °Be; outlet evaporator 1: 17.9 °Be) due to interrupted pumping.

- Unlike the new salina's of Cebeka and Bourg El Arab (see further) Port Said demonstrates a much higher primary productivity probably due to the fact that seawater is taken from the Suez Canal (higher nutrient levels than Meditterranean Sea ?) and also owing to the fact that this saltern which is already operating for a long time, has accumulated significant quantities of organic matter in its evaporation ponds.

  Especially evaporator 1 is showing a deep green color. Probably the type of algae dominating this pond is similar to what is found in the evaporation pond facilities operated by the Egyptian Salt and Mineral Company near Fayoum and could be Nannochloropsis sp. (to be verified). This Chlorella type algae, though containing high levels of essential fatty acids (w3-HUFA) may have a low nutritional value to Artemia because it is poorly digested.

The downstream ponds (especially evaporator 2) are rather cloudy and have a grey brown color derived from precipitation of gypsum, rather than from algae.

- This visit, no Artemia are observed in the evaporation ponds. Small quantities of cysts have accumulated in evaporator 3 and the north eastern corner of the reservoir adjoining evaporator 3. Before, Artemia has been observed mainly in evaporator 3 and sometimes in the reservoir. This summer the population reportedly consisted of bisexual Artemia, while last winter mainly parthenogenetic Artemia was found.

  Analysis of cyst samples provided by ENSC (harvested during winter 88/89) and the SCU (harvested May 1989) revealed a cyst diameter of 250 to 256 µm which could point to the fact that a parthenogenetic strain was indeed inhabiting the ponds until at least last winter or early spring. Analysis of a cyst sample taken during this mission however showed a much smaller diameter (231 µm) which could indicate that a new strain producing small cysts has been introduced and has largely outcompeted the endemic parthenogenetic strain. It is to be verified if this new strain is of the A. franciscana species.

- This visit large quantities of fish (Aphanius) are observed at the outlet (gate) of evaporator 1 (17.9 °Be). During winter when temperatures are lower, the salinity resistance of this predators is lower and the fish tend to swim upstream to the lower salinity ponds. They have however become very weak and apparently do not succeed to pass the gates where the current is too strong. In summer Aphanius is reportedly distributed over the entire ponds to salinities of over 18 °Be, eliminating Artemia in the reservoir, evaporator 1 and 2.

B. Drawbacks to Artemia production in Port Said

Commercial production of Artemia in Port Said is actually very limited as a result of the following drawbacks :

- Presence of predators tolerant to high salinities. As a consequence, present area suitable for Artemia production is restricted to evaporator 3 only. At these high salinities however, availability of food (algae) to Artemia becomes very restricted and Artemia become severaly stressed resulting in a poor growth and reproductivity.
- Presence of an Artemia strain with a poor productivity (to be verified)
- Possibly poor digestability of algae resulting in a low productivity of Artemia (to be verified)

C. Recommendations

1. Gradually increase waterdepths to maximum levels possible

2. Elimination/eradication of predators (fish)
   - screening of intake of seawater from both pumping stations by installing a series of screens in the supply canals with gradually decreasing meshwidths (up to about 1 mm or smaller) made of durable materials (e.g. stainless steelwire, UV resistant nylon) and which allow for regular cleaning
   - screening of interconnection gate between reservoir and evaporation pond 1 by 2 series of screens of 0.5 cm resp. 1 mm (or smaller). Clogging of the latter can be reduced by increasing the surface f.i. by using a corral surrounding the

gates. Clogging of screens may furthermore be reduced by allowing water to fall/splash onto the screens. This may be accomplished by maintaining a higher waterlevel (f.i. by installing a board) just before (5 cm) the screen.

- eradication of remaining predators (after screening) by application (during winter) of CaO and $(NH_4)_2SO_4$ to increase the pH to 12 at locations where fish are accumulating (mainly gates). If this proves to be ineffective even after repeated applications, complete desinfection of evaporator 1 could be considered, provided economically justified (calculate quantities required and cost)

3. Perform comparative bioassay culture tests as to evaluate the nutritional value (digestability) of phytoplankton currently found in evaporator 1.

4. Introduction of a new more productive strain showing good growth and reproduction over a wide range of temperatures and producing small cysts in evaporator 1 and 2 at a density of about 2 to 5 nauplii/l during early spring. Strain selection will furthermore be function of the results obtained in the evaporation pond facilities near Fayoum which are being inoculated by the Artemia project of the Suez Canal University (SCU).

5. Controlled fertilization of reservoir and evaporator 1. As a rule of thumb nutrient levels of about 1 ppm N and 0.1 ppm P should be maintained by regular application (at least once a week) of locally available area (36:0:0) and superphosphate (0:16:0). Application rates and ratio's of N to P should further be function of the phytoplankton standing crop (transparancy) and species and nutritional value (digestability) of algae developing. The latter may be evaluated in comparative bioassay fertilization tests in combination with a bioassay culture test as recommended above.

For optimal distribution and dissolving, the fertilizers will be applied at both seawater intakes when there is pumping of fresh seawater in the reservoir or directly into evaporator 1. If possible superphosphate should be predissolved (in freshwater) prior to application.

6. Regular harvesting of biomass (mainly from evaporator 1) as to maintain maximum sustainable yields, i.e. equillibrium between availability of phytoplankton and grazing rate of Artemia. Unsufficient harvesting may result in a total removal of phytoplankton (even in ponds with high nutrient levels) due to the high grazing pressure of Artemia, eventually leading to a total collapse of the population. Simarly, over-harvesting may reduce the grazing pressure on planktonic algal blooms which may deleteriously affect the salt production.
   Both recommendation 4 and 5 will require regular monitoring of physico-chemical and biological parameters, i.e. nutrient levels, phytoplankton standing crop, dominant algal species, Artemia standing crop and population composition, etc. Harvested biomass (live or possibly frozen in a local freezing plant) can be used in local shrimp/fish farms and/or could be transferred to higher salinity downstream ponds as to control possible proliferation of phytoplankton threathening saltproduction. Methods and devices for harvesting Artemia biomass will be developed according to recommendations given in the report of Mr. H. Teruel and the Suez Canal University.

7. Management of brine flow as to create sudden salinity shocks of 2 to 3 °Be in evaporator 1 and 2 by direct pumping of fresh seawater into evaporator 1 and/or by controlling brine flow from reservoir to dowstream ponds, i.e. stepwise (f.i. every 2 to 3 weeks depending on evaporation rate) rapid intake of brine (instead of continuous flow through) as to abruptly decrease the salinity, starting about 2 months after inoculation. Regular

application of salinity shocks will induce the population to cyst production.

8. Regular harvesting of cysts. Methods and materials required for processing of cysts is described in Annex II and III of this manuscript. Harvesting and processing of cysts as well as quality control of cysts will further be developed according to recommendations given by the SCU.

9. The development of Artemia production in Port Said will be performed in close cooperation with the Artemia Project of the SCU (Mr. Peter Baert; Dr. Samir Ghoneim).

D. Estimation of economics of Artemia production in Port Said

Provided accurate follow up of the recommendations and succesfull elimination of predators as well as good digestability of algae enveloping in the pond, the potential outputs and inputs required are estimated as follows

OUTPUTS

cyst production (dry weight)

- 1990 (a rato of 6 production months)
  . evaporator 1 : 1,140 kg (a rato of 2.0 kg/ha/month)
  . evaporator 2 : 1,125 kg (a rato of 2.5 kg/ha/month)
  . evaporator 3 : 210 kg (a rato of 0.5 kg/ha/month)

  Total : 2,475 kg
- following years (a rato of 7 production months per year and assuming the same production rate as obtained in the first year) total : 2,887 kg

biomass production (wet weight)

- 1990 (5 production months)
  - evaporator 1 : 9,500 kg (a rato of 20 kg/ha/month)
  - evaporator 2 : 3,750 kg (a rato of 10 kg/ha/month)
  - evaporator 3 : -

  Total :13,250 kg
- following years (a rato of 7 production)
  total : 19,770 kg

Revenues from cyst production

The price of the cysts produced will be mainly determined by their quality and is function of the hatchability, the nutritional value and the size of the cysts produced. Actually, the larger part of the world production of cysts (estimated at a few hundred tons/year) are of fairly large size (cyst diameter of > 250 µm) less suitable to the early larval stages of marine predators, and of poor to moderate nutritional value for marine organisms because they contain low levels of essential highly unsaturated fatty acids (w3-HUFA) such as eicosapentanoic acid (EPA, 20:5w3).
Actually prices for this type of cysts (canned product) is about 25 to 40 US$/kg depending on their hatchability. While there is an abundant supply of this quality (new sources are expected to be developed in the Soviet Union, and China), there is actually a shortage of high quality cysts producing small nauplii with a high content of w3 HUFA as well as showing an excellent hatchability. As a result this grade is commanding much higher prices actually ranging from about 60 to 100 US $. The quality to be produced in Port Said is expected to be of good nutritional value (actual satisfactory levels of 6.5 to 8.6 mg/g DW of w3-HUFA found in cyst are expected to further increase as fertilization will be applied). Since the local strain has probably a poor productivity (to be

verified) as compared to A.*franciscana* type populations, it is expected that already the first year (1990), the larger part of the cyst produced (about 70 %) will be of small size (derived from the newly introduced strain). The following years, this new strain, provided reinoculation with pure material is going to completely outcompete the local strain, eventually leading to a total disappearance of the endemic strain. Provided appropriate processing, hatchability of the cyst produced should approach the standards required for top quality cysts (i.e. over 250 000 nauplii/g). The following revenues assuming production of "good quality" cysts (high levels of w3-HUFA, high hatchability, mixture of 70 % small and 30 % large endemic cysts) in 1990 at a price 60 US$/kg*, and top quality cysts (same as above but nearly 100 % of small cysts) in the following years commanding a price of 80 US$/kg*, may be obtained :

- 1990 : 148,500 US $
- following years : 230,960 US $

These figures do not take into account the revernues that may be obtained from selling biomass. Actual prices of frozen product are about 3 to 5 US $/kg

* Actual prices. May alter in function of future supply and demand.

INPUTS

Cyst material for inoculation (assuming a stocking density of about 3 nauplii/l using a cyst batch producing 200,00 nauplii/g)

- 1990 (evaporator 1 and 2) :
  25 kg x 60 US $/kg = 1,500 US $
- following years (evaporator 1 only) :
  15 kg x 60 US $/kg = 900 US $

Chemicals to eradicate fish

$CaO + (NH_4)_2SO_2$ in order to increase pH to 12. Quantities required function of local application (at gates) or total desinfection of evaporator 1.

Fertilizers

Quantities of fertilizer required will be function of the natural nutrient levels in the ponds. These are expected to be much higher than in the other salterns for reasons discussed earlier in this report. In addition nutrient ratio's of N to P should be adjusted in order to promote phytoplankton which is easily digested by Artemia (to be assessed from bioassay fertilization tests). Fertilizer is to be applied only to the reservoir and evaporator 1. Assuming a weekly addition of 0.5 ppm N and 0.05 ppm P using urea (36:0:0) and superphosphate (0:16:0), the following quantities are required :

- 1990 (a rato of 26 production weeks)
  - urea : $615.10^7 \times \frac{0.5}{10^9} \times 26 \times \frac{100}{36}$ ton = 222 ton
  - superphosphate : $615\ 10^7 \times \frac{0.05}{10^9} \times 26 \times \frac{100}{19}$ ton : 42 ton

- following years (a rato of 30 production weeks)
  - urea : $222 \times \frac{30}{26}$ ton = 256 ton
  - superphosphate : $42 \times \frac{30}{26}$ ton = 48 ton

Assuming a price of 116 US $/ton for urea and 58 US $/ton for superphosphate the cost for fertilization are estimated at :

- 1990 : 25,800 + 2,400 US $ = 28,200 US $
- following years : 29,700 + 2,800 US $ = 32,500 US $

In estimating the profitability of Artemia production in Port Said, also capital investment for materials and equipment (e.g. for screening of gates and intake canals, for harvesting and processing of cysts and biomass) as well as costs involved for monitoring and quality control (in cooperation with the Suez Canal University) should be included.

II. BOURG EL ARAB

A. Observations/findings

- Lay out/brine flow
  Located about 30 km west of Alexandria in a natural depression parallel to the Mediterranean Sea, this newly constructed solar salt work of about 2400 ha, basically consists of a large evaporator of 1500 ha, a series of 5 crystalliser ponds (400 ha) and a drainage area for storing the bittern (98 ha).
  Seawater from the Mediterranean (3.5 °Be), after passing a sump for sedimentation of organic material, is pumped through a pipeline which opens into a supply canal serving the northwest side of the evaporator. The evaporator is divided by a dike in a large pond of 1360 ha and a small pond of 140 ha (adjoining the crystallizers). At this point, brine (24°Be under steady state conditions) is relifted into a canal from where the crystallizers are fed. From the crystallizers, the bitterns are drained into a canal which eventually drains into the bittern collector (drainage area)

- Actual dephts in the concentrator are 30 to 50 cm, while salinity ranges from 7°Be (at intake) to 9.6°Be (near crystalliser pump). Steady state conditions resulting in an average depth of 1 m and a density gradient from 3.5 to 24°Be is expected by the end of 1991.
  The water in the seawater feeding canal and concentrator is very clear indicating a low productivity. Nutrient analysis of the water at the intake revealed extremely low levels of especially nitrogen (nitrate: 2µg/l; nitrite: 0,01 µg/l; ammonia: 0.3 µg/l; posphate: 10 µg/l) limiting phytoplankton growth indeed.

- No Artemia are (yet) observed in the concentrator. Fish (Aphanius, Cyprinidon), however are present over the entire concentrator and in the crystallizer feeding canal (at least near the brine pump) as well.

- The crystallizers are gradually being filled with brine in order to establish a salt floor. To alleviate infiltration problems (i.e. formation of an organic layer prior to establishing the salt floor) and aiming at demonstrating Artemia production following recommendations made by UNIDO expert H. Teruel, crystallizer 1 (70 ha) was inoculated with Artemia nauplii collected from the El Mex saline in November 1988. Reportedly, the population only developed considerably after a weak bloom of algae established (transparancy of 65 cm), following an increase of the water level from 74 to 100 cm and application of 10 ppm of urea and 10 ppm of superphosphate in April 1989. By the end of June however, the transparancy had again increased to more than 100 cm (bottom visible) whereafter the population gradually decreased.
  Evaluation of the sex ratio (females/males) of adult Artemia (from March onwards) revealed that females were present in relatively larger numbers than males already in March (sex ratio : 3.6) and tend to become gradually more dominant as temperatures are increasing. By May (maximum temperatures about 20 to 27 °C) the sex ratio had increased to more than 6. By the end of July (maximum temperatures up to 30 °C) the males had completely disappeared from the population.

- During the experiment in crystallizer 1, fish have been observed (Cyprinidon fasciatus, Aphanius) in small mbers up to a salinity of 17°Be. No screening was applied upon intake of brine in this pond.Throughout the experiment about 25 kg (dry weight) of cysts were collected. By this time, the salinity has increased to 20.4 °Be. The water is crystal clear and Artemia densities are very low. The population consists mainly of juveniles, though a few adult males are also observed.

In the drainage canal (salinity 11.2 °Be; temperature 21 °C) a population of riding couples is actually observed. The adult animals are small (as compared to A. franciscana) which may indicate they are of A. tunisiana species. These observations, together with the finding that cysts from Bourg El Arab are of large size (260 µm) could indicate that the Artemia population at Bourg El Arab and El Mex as well, consists of a mixed population of bisexual and parthenogenetic Artemia. The former (most probably A. tunisiana) dominates during winter when temperatures are lower, while the latter previals during summer. Both species have a low productivity and poor temperature resistance as compared to bisexual A. franciscana strains and are producing cysts of larger size indeed.

- At this time previously reported infiltration problems in the crystallizers have become arrested due to deposists of gypsum on the bottom.

  By next year the salinity in the crystallizers will have increased to 24°Be (initiation of salt floor formation) rendering this area totally unsuitable for Artemia production.

B. Drawbacks for development of Artemia production in Bourg El Arab

- Shallow waterdepths and low salinity in the evaporator actually represent unsuitable conditions for Artemia. Optimal waterdepths (1 m) and a steady state salinity gradient from 3.5 to 24 °Be are but expected by the end of 1991. Even then, actual division of the evaporator area in an extremely large pond of 1360 ha and a small pond of 140 ha which under steady state conditions will contain brine with salinities of 3.5 to 17.5 °Be, resp. 17.5 to 24 °Be, will prevent proper management of the Artemia population. Division of the 1360 ha pond in 3 separate ponds with consecutive salinity gradients of 3.5 to 8.0, 8.0 to 14 and 17.5°Be will be required as to allow for controlled production of Artemia (e.g. control of predators, increase of food availability through fertilization, practising of salinity shocks as to induce cyst production etc.)

- Very low nutrient levels resulting in a poor food availability of *Artemia*. Fertilization will be required.

- Presence of fish at high salinities eliminating *Artemia* over the larger part of the evaporator. Screening of predators upon intake and eradication of remaining predators will be essential.

- Presence of a local population with low productivity and producing large cysts. Should be replaced by a more productive strain, also producing small cysts.

C. Recommendations

1. Immediately start screening of predators upon intake of seawater. Screens with gradually decreasing meshwidth (to 1 mm) and made of durable material are to be installed in supply canal. Regular cleaning as to prevent clogging of screens will be necessary.

2. Divide the 1360 ha evaporator area in 3 ponds in which the following consecutive salinities will be maintained : 3.5 - 8.0 °Be; 8.0-14.0 °Be; 14 - 17.5 °Be. In order to obtain this salinity gradient under steady state conditions, the successive ponds will have approximately the following area : pond 1 : 880 ha; pond 2: 350 ha; pond 3 : 130 ha. The dikes dividing the ponds should be equipped with gates to allow for control of waterlevels and salinities as well as additional screening of predators. As recognized by the management of ENSC, proposed divisions will also result in a much better evaporation efficiency and precipitation of salts with low salubility eventually leading to increased salt production outputs.

3. Eradication (preferably in winter when fish tend to concentrate around the gates) of remaining predators by local application of CaO and $(NH_4)_2$ SO_4 to a pH of 12.

4. Introduction of a new strain of Artemia demonstrating a higher productivity over a wide range of temperatures and producing small cysts as well. Instar I Artemia nauplii will be introduced in pond 2 and 3 in the spring of 1992 after steady state conditions are reached.

5. Management of the Artemia population and production will be basically the same as in Port Said and other salterns, i.e.
   a. regular monitoring of physico-chemical and biological parameters
   b. application of salinity shocks in pond 2 and 3 as to induce the population to cysts production.
   c. regular fertilization (weekly) of pond 1 and 2 as to maintain nutrient levels of 1 ppm N and 0.1 ppm P. Fertilizer is to be applied in the seawater supply canal when there is pumping (for better distribution and dissolving) and at outlet of gate separating pond 1 and 2 when there is active brine flow. Similar as to the other sites, fertilization should be further adjusted in function of transparancy, nutrients levels, etc.
   d. regular harvesting of Artemia biomass as to present collapse of the population (due to starvation) and to maintain and equillibrium between grazing rate and growth of phytoplankton.

D. Estimation of economics of Artemia production in Bourg El Arab

Provided accurate implementation of the above recommendations. The future (from 1992 onwards) outputs and inputs (possibly to be revised in function of the production results that will be obtained in Port Said next year) can be roughly estimated as follows :

OUTPUTS

cysts production (dry weight)

- 1992 (assuming a production season of 5 months)
  - pond 1 : -
  - pond 2 : 1,750 kg (a rato of 1 kg/ha/month)
  - pond 3 : 575 kg (a rato of 1.5 kg/ha/month)
  - pond 4 : 350 kg (a rato of 0.5 kg/ha/month)

  total : 3,075 kg
- from 1993 onwards (assuming a production season of 7 months and the same production rates as in the first year)
  total : 4,305 kg

The quality of cysts produced will possibly be similar to those that will be produced in Port Said.

biomass production (wet weight)

- 1992 (5 production months)
  - pond 1 : -
  - pond 2 : 26,250 kg (a rato of 15 kg/ha/month)
  - pond 3 : 4,875 kg (a rato of 7.5 kg/ha/month)
  - pond 4 : -

  total : 31,125 kg
- from 1993 onwards (7 production months)
  total : 43,575 kg

INPUTS

Chemicals to eradicate predators

CaO + $(NH_4)_2SO_4$ around gates in order to increase pH to 12. Total quantities required function of effectiveness and frequency of local application and to be extrapolated from experience gained in Port Said.

Cyst inoculation material

- 1993 : 120 kg x 60 US $ = 7,200 US $
- following years : 87.5 kg x 60 US $ = 5,250 US $

Fertilizer

- 1993 (assuming a weekly addition of 1 ppm N and 0.1 ppm P for 26 weeks)

. urea :	350 ton x 116 US $/ton =	40,600 US $
. superphosphate :	65 ton x 58 US $/ton =	3,770 US $
total		44,370 US $

- following years (the same as above but 30 production) total : 51,200 US $

III. CEBEKA

A. Observations/Findings

- Lay out/brine flow

Located near El Arish in the Sinai, this newly constructed salina occupies an area of about 2000 ha, and will produce 0.5 M ton of common salt per year.

The saltern basically consists of a large evaporator (total area about 1500 ha), 2 crystallizers of 68 and 70 ha and 2 drainage area's (located on both sides of the crystallisers) which will initially serve as bittern collectors. In a later stage one of these are's will be devided in 2 parts and used as crystallizers for the recovery of sulphates and magnesium.

Intake of seawater into the reservoir is accomplished by pumping (6 pumps with a total capacity of 7200 m^3/h) from Lake Zaranik which is connected to Bardawil Lake and the Mediterranean Sea. The larger part of the year the salinity from the intake is about 5°Be.

To feed the crystallizers, brine (24°Be) is relifted by 2 pumps (total capacity of 4000 m^3) from a small area which is separated from the 1500 ha evaporator by a dike made of boulders. Feeding of the crystallizers has already been initiated in order to establish a salt floor.

The large evaporator includes several sand dunes and is surrounded by a peripheral dike of about 3 m. These dikes are reportedly becomming gradually fixed as the water levels are increasing.

Plans to construct additional inner dikes in the large evaporator in order to improve the brine circulation and consequently the evaporation efficiency as well as gradual deposition of salts with low salubility have not yet been implemented because ENSC wants to include recommendations in order to obtain the most suitable configuration for Artemia production in addition to salt production.

At present no precise data are available on topography and area in between the sand dunes under steady state conditions. The latter condition in which the evaporator will have build up a salinity gradient from 5 to 24°Be at a waterlevel of about 1 m will be obtained by the end of 1991. By the end of 1994, waterlevels could possibly be increased to 1.5 m

- During our visit the waterlevels have reached about 30 to 50 cm. the actual salinity obtained at the crystallizer pump is about 15°Be. At this salinity no more fishes were observed.

- Although Artemia has reportedly been observed earlier in this area (prior to construction of the saltern), a natural population has not (yet) established in the saltern.

- The water at the intake and in the evaporation pond is very clear, indicating a very low natural productivity.

- Actual screening procedure using a large net (opening about 1 cm) and framed screens (plastic, opening about 2 mm) in seawater intake canal before the pump are not effective because smaller fish are still passing and growing on in the evaporator.

B. Major drawbacks for Artemia production in Cebeka

The actual situation in which the evaporator area consists of 1 large non-divided pond is totally unsuitable for Artemia production because it prevents appropriate control of predators and nutrient levels (through fertilization) as well as management procedures to induce cyst production (through salinity shocks). Another negative point of this saltern (similar to Bourg El Arab) are low nutrient levels. Therefor application of fertilizer in quantities relatively much larger than what is needed in Port Said, will be essential to sustain a commercially feasable

production of Artemia.
A minor positive point (as compared to the other salterns) is the absence of a local population of Artemia, which will facilitate the establishment of a selected strain producing cysts of small size. Also the area suitable for Artemia production (provided division of the evaporator, see further) will be relatively larger than in Bourg El Arab as a result of the higher salinity of the intake water. In addition, the waterlevels in Cebeka can be increased to an average 1.5 m resulting in a higher Artemia productivity per surface unit.

C. Recommendations

1* Installation of screens with gradually decreasing opening at intake both before (in intake canal from Lake Zaranik) and behind (in supply canal into the evaporation) the pumping station to prevent further incoming of predators

2* Determine topography of sand dunes and exact surface of area's under water in between sand dunes (air picture) when operating under steady state conditions (preferably at levels of 1.5 m) as to allow for accurate division of evaporator in separate ponds required for Artemia production.

3* Divide the evaporator area in 4 ponds of gradually decreasing size as to obtain the following salinity gradients: pond 1: 5-8°Be; pond 2: 8-14°Be; pond 3: 14-18°Be; pond 4: 18-24°Be. The respective area's occupied by these ponds will be about 27, 21, 9 and 7% of the total evaporation area under water. Assuming 1300 ha (to be verified) under water in steady state conditions with an average waterdepth of 1.5 m, the respective surfaces of the successive ponds will be 548, 426, 183 and 142 ha.
Dikes should be provided with gates (to allow practising of salinity shocks) and positioned to obtain the most optimal brine circulation at least cost (i.e. taking advantage of the sand

dunes) and to have ponds 2, 3 and possible 4 with then longest axis along the dominant wind direction to facilitate harvesting of cysts. When possible weak brine area's should not adjoin to heavy brine area's.

* for immediate action

4. Eradication of remaining fishes in winter prior to starting Artemia production by application of CaO + $(NH_4)_2$ SO_4 around gates where fish tend to concentrate.

5. Regular fertilization oi pond 1 and 2 to maintain nutrient levels of 1 ppm N and 0.1 ppm P by regylar application of urea and superphosphate. Fertilizers are to be distributed in supply canal (when there is pumping) and at outlet of gate between pond 1 and 2 when there is active brine flow.

6. Introduction of a selected strain of <u>Artemia</u>

7. Management of brine flow as to create sudden salinity shocks (rapid dilution of brine with 2 to 3°Be in pond 2 and 3.

8. Regular harvesting of biomass as to maintain maximum sustainable yields. Evaluate possibilities of local application of Artemia biomass.

D. Rough estimation of economics (possibly to be revised in function of production results obtained in Port Said)

OUTPUTS

Cyst production (dry weight)

- 1992 (assuming a total evaporation area of 1200 ha with air average depth of 1 m and production season 5 months)
  - . pond 1 : ----
  - . pond 2 : 393 ha x 5 m x 1.0 kg/ha/m = 1,965 kg
  - . pond 3 : 169 ha x 5 m x 1.5 kg/ha/m = 1,268 kg
  - . pond 4 : 131 ha x 5 m x 0.5 kg/ha/m = 328 kg
  - total : 3,561 kg

- from 1994 onwards (assuming an area of 1300 ha, an average waterdepth of 1.5 m and a production season of 6 m)

  total : $3{,}561 \times \frac{1300}{1200} \times \frac{7}{5} \times 1.25 = 6{,}750$ kg

  Cyst production in 1993 will be intermediate between the first year of production (1992) and the 1994 figure

Biomass production (wet weight)

- 1992 (5 production months)
  - . pond 1 :
  - . pond 2 : 393 ha x 5 m x 15 kg/ha/m = 29,500 kg
  - . pond 3 : 169 ha x 5 m x 7.5 kg/ha/m = 6,300 kg
  - . pond 4 :
  - total : 35,800 kg
- 1994 (7 production months)

  $35{,}800 \times \frac{1300}{1200} \times \frac{7}{5} \times 1{,}25 = 67{,}800$ kg

INPUTS

Cyst inoculation material

- 1992 : 84 kg
- following years : part of 1992 production can possibly be used

Chemicals for eradication of predators

$CaO + (NH_4)_2$: quantities to be extrapolated from Port Said.

Fertilizer (assuming a required weekly addition of 1 ppm N and 0.1 ppm P to pond 1 and 2 and a price of fertilizer 2 US$/ton higher than in Port Said and other sites)

- 1992 (26 production weeks, average depth of 1.0 m, total evaporation area 1200 ha)

. urea :

. $899.10^7 \times \frac{1}{10^9} \times \frac{100}{36} \times 26$ ton x 118 US$/ton = 76,600 US$

. superphosphate :

$899.10^7 \times \frac{0.1}{10^9} \times \frac{100}{19} \times 26$ ton x 60 US$/ton = 7,400 US$

total : 84,000 US$

- 1994 (30 production weeks, average depth of 1.5 m, total evaporation area of 1300 ha)

. urea :

$974,10^7 \times \frac{1}{10^9} \times \frac{100}{36} \times 30 \times \frac{150}{100}$ ton x 118 US$/ton = 143,600 US$

. superphosphate :

$974,10^7 \times \frac{0.1}{10^9} \times 30 \times \frac{150}{100} \times \frac{100}{19}$ ton x 60 US$/ton = 13,800 US$

total : 157,400 US$

IV. EL MEX

A. Observations/Findings

- Lay out/brine flow

The saltwork of El Mex is located west of Alexandria in the former Mariut salt lake and occupies an area of about 3000 ha. It consists of 2300 ha of evaporation ponds (300 ha preconcentrator, 2000 ha concentrator) and 700 ha of cystallizers.

Seawater is supplied from 2 sources, i.e. from the cooling system of the Alexandria Petroleum Company discharging 4 to 5° Be brine into a 300 ha preconcentrator which drains into to the large concentrator at its south east side, and from the Mediterranean Sea (3.5° Be) pumped directly into the north east side of the concentrator.

At the east side of the concentrator in between the 2 sources of feeding, brine is relifted into a canal serving the cystallizers. Bitterns from the crystallizers are drained into a bittern collector adjoining the seawater supply canal from the Petroleum Company.

In the concentrator an inner bund located in east-west direction is being constructed in order to improve the brine circulation and evaporation efficiency. Furthermore, the 300 ha preconcentrator has recently been divided in 4 separate ponds. Two ponds will serve as additional bittern collectors (from next year onwards?) while the other 2 will be used in a later phase for the extraction of magnesium and sulphates (effective by 1996). By next year the construction of a new seawater supply canal in between the crystallizers and the 2000 ha concentrator will be finished. Through this canal, seawater from the Mediterranean will join the outlet of the 40 ha supply canal from the Petroleum Company resulting in a discharge of 4 to 5° Be at the south east side of the concentrator.

- During our visit pumping of seawater had stopped and salt is still being harvested from the cystallizers. The bitterns are being pumped into the already completely filled up collector. In addition, the dike separating the latter pond from the Petroleum Company seawater supply is in bad conditions resulting in both overflow and seepage of bittem into the seawater supply canal and eventually recirculation of magnesium rich bittern over the entire sytem. Actual salinity in the supply canal is 28° Be (should normally be less than 5°Be) illustrating the extent of bittern infiltration indeed. As indicated in the report of Mr. Hector Teruel, this procedure of bittern recirculation puts a serious burden on the production of salt e.g. reduced evaporation and formation of small salt crystals through a higher viscosity of the brine as a result of magnesium enrichment, premature preciptation of sodium chloride in the concentrator, etc.

- Furthermore, these high concentration of magnesium create toxicity problems both for algae and Artemia. Bioassay tests performed earlier (1988) by the Artemia Reference Center, using 192 ppt brine form the preconcentrator, indicated that this brine is highly toxic to Artemia. Prevailing high concentration of magnesium are probably also toxic to other biological communities including algae. Bioassay tests performed by Dr. Sameh T. from the Alexandria University revealed that algae could not be induced to bloom in El Mex brine even after addition of nutrients. Blooms of algae (Dunaliella) are reportly only occuring during spring in the supply canal and preconcentrator when pumping is initiated and magnesium rich brine is diluted.

- This visit no Artemia have been observed. Artemia is reportly occuring in the Petroleum Company supply canal and the preconcentrator only during spring and disappears again during summer as bitterns are again being drained from the crystallizers. The population presumably consists of a mixture of Artemia tunisiana (dominating during early spring) and A. parthenogenica (domminating in late spring). Cysts produced are large with an average diameter of 264 µm.

B. Major drawbacks to Artemia production

- Brines of El Mex containing high concentrations of magnesium are toxic to Artemia. This may possibly be alleviated already next year when new bittern collectors are being used and when further enrichment of magnesium is arrested. Nevertheless, it may still take a few years to wash out the remaining magnesium completely. The extent of the toxity to Artemia and algae of gradually decreasing concentrations of magnesium should be verified in bioassay tests.

- The evaporation area consists of one large pond preventing controlled production of Artemia.

- The saltern is located in an industrial area near the population center of Alexandria. Presence of possible contamination in Artemia cysts and biomass should be verified.

- The local population has a low productivity and is producing cysts of large size.

A positive point of the El Mex saltern is that, compared to Bourg El Arabs and Cebeka, it is likely to contain higher levels of nutrients (to be verified) as a result of gradual accumulation/concentration of nutrients over the years.

C. Recommendations

1. Renovate/heigthen the dikes of the bittern collectors in order to arrest mixing of bittern with seawater from the Petroleum company supply canal.

2. Reduce the water level in the bittern collector by gravity draining of bittern (via the bittern canal) to the new collectors.

3. Divide the 2000 ha concentrator in 4 separate ponds which will contain brine of the following salinities in a steady state condition: pond 1: 4-5 - 10° Be; pond 2: 10-14°Be; pond 3: 14-18°Be; pond 4: 18-24°Be. The respective area's required to obtain this salinity gradient are, among others, function of the evaporation as well as precicipation of salts with low solubility along the salinity gradient, but also of the amount of salts dissolved from the saltbed of the concentrator, the latter determined by the velocity and salinity of the upper brine layer. Consequently, the area of respective ponds need to be calculated on a material basis, rather than on a volume basis. The dikes should be positioned to obtain the least cost configuration (i.e. making use of the existing separating bund) but also taking into account that pond 2 and 3 are oriented to have their longest axis along the dominant wind direction in order to facilitate accumulation and harvesting of cysts.

4. The respective ponds should be connected through gates (instead of openings in the dike) to allow for a better control of salinity and waterlevels and to allow practising of salinity shocks in order to induce cyst production in pond 2 and especially pond 3.

5. Prevent income of predators as a early as possible in the brine circuit by screening the main intake and the gate between pond 1 and 2. If necessary, eradicate remaining predators by local application of CaO and $(NH_4)2\ SO_4$ to pH 12 at places were fish are accumulting during winter, e.g. gates.

6. Perform comparative bioassay tests as to evaluate the toxicity effect of magnesium remaining in the brine and of possible pollution originating from surrounding industries to Artemia and phytoplankton. Have analysis performed on the presence of contaminants (heavy metals, pesticids) in Artemia cysts from El Mex.

7. As soon as the previous recommandations have been succesfully implemented and excess magnesium has been washed out entirely, the local population should be replaced by introduction of a new Artemia strain showing an optimal productivity under local ecological conditions and producing small cysts.

8. Perform regular monitoring of physico-chemical and biological parameters including nutrient levels and population dynamics of algae and Artemia.

9. Improve the food availability and consequently the production of Artemia by regular fertilization of pond 1 and 2. The rates of fertilizer to be applied will be function of the nutrient levels and the transparancy of the water. As a rule of thumb a minimum concentration of 1 ppm of N and 0.1 ppm of P should be maintained by application urea and superphosphate in small doses but on a frequent basis. It is advised to predissolve the fertilizer and to apply it at places where there is an active flow of water (f.i. at intake of water in pond 1 and 2) in order to ensure an optimal distribution.

10. Perform regular harvesting of biomass in order to maintain an equilibrium between grazing rate of Artemia and availability of food.

D. Economics of Artemia production in El Mex

Provided magnesium toxicity problems are solved, no pollution inhibiting growth of phytoplankton and accurate implementation of the other recommendations including division of the concentrator in 4 separate ponds, the production of Artemia in El Mex per surface unit of area available between 8 and 24°Be is estimated to be in between the production rate given for Port Said and the other salterns of Bourg El Arab and Cebeka. An estimation of total production of Artemia and quantities of fertilizer required can only given in the natural nutrient levels, the respective area's of the evaporation ponds and production figures from the Port said are known. Provided no traces of contamination, the quality and consequently prices of Artemia will be similar to the quality obtained from the other salterns.

V. GENERAL CONCLUSIONS

Commercial production of Artemia at the coastal salterns of ENSC discussed in this repot is not obvious and will require accurate follow up of the technical recommendations made in Chapter I to IV.

A major problem to the development of Artemia production in all salterns discussed, is the persistance of fishes at very high salinities, eliminating Artemia over the larger part of the evaporation ponds. Unlike most other coastal salterns where predators already dissappear at salinities of 8 to 10°Be, these salterns are indeed inhabited by extremely hardy fish (such as Aphanius) which tolerate salinities up to 18° Be. Above these salinities, Artemia production is limited because of the restricted area leftover and increasing stress conditions to Artemia (higher energy requirements for osmoregulation, poor food availability) resulting in poor growth and reproduction. Furthermore, at these high salinities the nutritional value of Artemia produced is very low owing to the poor nutritional value of the food available.

As a consequence, the first condition to Artemia production involves accurate screening/eradication of predators as to keep the evaporation ponds entirely free from fish from about 8°Be onwards. Unlike Port Said, which consists of separate evaporation) ponds, the new salines of Cebeka and Bourg El Arab will require major infrastructural works (division of the large evaporator in separate ponds) allowing for controlled production of Artemia. It has to be noted however that aside from Artemia production, also the saltproduction will largely benefit from the infrastructural modifications proposed as a result of improved brine circulation and deposition of salt with low solubility.

The salterns evaluated are of large size, more difficult to manage than small or medium size systems. In addition, the ponds of these salterns represent fairly stable conditions (limited salinity variations, long water retention times, no extreme seasonal temperature variations) as a result of which nauplii production will be favored over cyst production. If significant quantities of cysts are to be produced, application of salinity shocks as to induce the population to cyst production will be essential.

Aside from Cebeka, the other salterns contain an endemic population of Artemia with a poor productivity and producing large cysts (to be verified for Port Said) less suitable for the feeding of early larval stages of marine fish and other predators. It is however expected that introduction of a new strain with a higher productivity over a wide range of temperatures and producing small cysts will result in a gradual disappearance of the local strain. Basically, the strain to be inoculated will be of San Francisco Bay type, however to be confirmed by the results obtained from the introduction (performed by the SCU) in the saltern of the Egyptian Salt and Mineral Company near Fayoum.

Another drawback limiting commercial production of Artemia at least in Bourg El Arab and Cebeka (El Mex to be verified) are extremely low nutrient levels resulting in a very poor natural phytoplankton production and food availability for Artemia, through which massive application of inorganic fertilizer will be essential. Port Said has definitely a much higher natural productivity, hence requiring relatively much lower application rates of fertilizer. It is however to be verified if present blooms of algae in evaporator 1 are a suitable food for Artemia. If this algae prove to be poorly digested by Artemia, bioassay fertilization tests (applying different ratio's of N to P, or N only) should be performed as to evaluate the possibility to alther the species of algae present in Port Said.

Application of fertilizer will not negatively interfere with the salt production. Applied to the first 2 ponds, fertilization will result in blooming of algae which will improve evaporation owing to better coloration and heat absorption of the brine. Moreover, fertilization (again, special care should be given to Port Said as to promote algae which are of good digestability to Artemia) will sustain a healthy population of Artemia which will completely clear the brine of all suspended solids prior to entering the crystallizers and which provides a substrate for the development of Halobacterium in the crystalliser ponds. These red halophylic bacteria ensure an increased heat absorption as well as a reduction of dissolved organic material resulting in a higher output and quality of salt produced. Hydrobiological management, including maintenance of a healthy population of Artemia in the evaporation ponds as to control proliferation of algae and organic material may indeed be very important for Port Said.

In comparing the coastal salterns of ENSC, priority is given to Port Said. Unlike the other salterns, this site contains higher nutrient levels and is furthermore readely available (does not require major infrastructural works) for development of commercial production of Artemia. Cebeka may have a slightly better potential than Bourg El Arab because of its relatively larger area available for Artemia production (as a result of a higher salinity of the intake brine and because it can be operated at higher waterdepths. On the other hand the Cebeka site is quite remote (slightly higher prices of fertilizer, local use of Artemia biomass is not evident, monitoring and analysis of samples requires permanent local expertise, etc.) and will possibly require a higher investment for dike construction as well.

Al Mex could possible become a suitable site provided high magnesium concentrations in the brine are washed out and provided inplementation of the infrastructural modifications proposed.

The author does not agree with the pilot production plant (for processing of _Artemia_ biomass) and laboratory proposed by the previous UNIDO expert Mr. H. Teruel. Such an installation is presently not justified and can only be considered after next year when Port Said has proven to produce commercially feasable quantities of Artemia. Again, the latter can only be garanteed if predators are completely eliminated from the evaporation ponds.

GENERAL RECOMMENDATIONS

- *Artemia* production in the salterns of ENSC will be developed on a step by step basis. Therefor ENSC is recommended to give full priority next year (following the recommendations) to verify the technical feasability of *Artemia* production in Port Said. The decision to develop the other sites will be made by the end of next year and will be largely based on the results obtained in Port Said.

- ENSC is recommended to evaluate the local market for *Artemia* cysts and biomass. First priority should be given to supplying this local market, prior to considering export of *Artemia*.

- ENSC company will require additional expertise with regard to all aspects concerning *Artemia* production. This expertise is available at the *Artemia* project of the Suez Canal University (coordinators : Mr. P. Baert, Dr. Samir Ghoneim).
  Rather then sending local technicians to foreign countries for training in *Artemia* production, it is recommended that these be trained "on site" under the supervision of the SCU. The *Artemia* Reference Center of the State University of Ghent, coordinating this *Artemia* project at the Suez Canal University will make the necessary arrangements allowing for a cooperation agreement between ENSC and SCU.

- UNIDO is recommended to field on *Artemia* expert to Egypt in September 1990 for a period of about 3 weeks. This expert will assess the results obtained in Port Said and give the necessary recommendations for further development of *Artemia* production at the ENSC salterns.

ANNEX I

LIST OF SENIOR COUNTERPART STAFF

- Mr. Hosny M. Ismail, Chairman, Mining and Refactory Industries Corporation (MARIC)
- Mr. Abdalla Darwish, Head of Technical Sectors, MARIC
- Mrs. Souheer Sabra, Technical Director, MARIC
- Mr. Salah M. Dawoud, Chairman, El Nasr Salinies Company (ENSC)
- Mr. M. Fayez A. Mokthar, Sector Director, ENSC
- Mr. Ibrahim Abd El Dayem, R&D Director, ENSC
- Mr. Badea Audrous, Head El Mex Salines Sector, ENSC
- Mr. Hossni Abd El Samee, Head Bourg El Arab Salines Sector, ENSC
- Mr. Moustafa El Kassas, Head Cebeka Salinies Sector, ENSC
- Dr. M. Sameh T., Professor of Plant Physiology, Alexandria University

ANNEX II

CYST PROCESSING

The various steps involved in cyst processing are as follows :

1. Size cleaning with brine

Harvested cysts should undergo a first on site cleaning by washing/spraying the harvested product with saturated brine or water from the pond from which cysts are harvested over a set of 3 sieves with meshwidths of 800, 500 resp. 150 µm and a surface of about 1 m^2 in order to remove debris larger and smaller than the cysts. Different sets of screens will allow for simultaneous harvesting of cysts from various production spots/ponds.

2. Storage in brine

Cysts collected from the bottom screen are stored in woven bags in a plastic or fibreglass flatbottom container of about 500 l filled with saturated brine and provided with a cover. Storage of crude cysts under these conditions should not take longer than 1 month.

3. Density separation in brine

For further removal of small debris in the same size range as the cysts, the crude cysts are transferred to a 300 l cylindroconical fibreglass tank provided with a drainage valve and filled with saturated brine. After a few hours a heavy aeration from the bottom (as to disagregate clumps of cysts and debris) the aeration is removed as to allow separation of full cysts, empty cysts and light debris (to surface) from heavy debris (to bottom). Upon full separation the tank is drained. Debris from the bottom and brine are discarded. The cyst paste is collected (drained/washed down with brine) in a bag of about 30 l made of 150 µm nylon screen.

4. Washing in freshwater

For further processing cysts in the bag are thoroughly washed with freshwater in order to remove all salts. This step should not take longer than 5 minutes.

5. Density separation in freshwater

Cysts are again transferred to a 300 l cylindroconical fibreglass container (provided with a drainage valve). Clumps of cysts are disaggregated by providing slight aeration just below the watersurface for 5 minutes. When the aeration is removed full cysts will sink while light debris and empty cysts will float. The whole freshwater separation procedure should not take longer than 20 minutes. Full cysts will be drained from the bottom of the cone in the 150 µm cyst bag. Excess water can be removed by firm squeezing or by placing the bag in a domestic spinner (e.g. a laundry centrifuge).

6. Drying

After the treatment in freshwater, the cysts should be dehydrated as soon as possible. For this cysts will be dried in a fluidized bed dryer. A schematic outline of a prototype dryer with a capacity to produce about 3 kg of dry cysts over a period of 3 hours is presented in Fig. 1. The fluidized bed dryer will be placed in a well ventilated thermostatic at 35 °C.
Although temperature readings of incoming and outgoing air may give a rough estimation of the drying rate of the cysts, it is

advisable to perform regular analysis of the moisture content of the cysts after different time intervals in order to standardize the time of drying. The quantity of cysts to be dried per batch should be adjusted in order to obtain a cyst moisture content of less than 5 % in 3 hours. Standardization of the drying procedure should preferably be performed in cooperation with the Artemia project of the SCU. It is also advised that regular quality control of the cysts produced will be performed at SCU and/or the Artemia Reference Center in Ghent, Belgium.

7. Storage and packaging of dry cysts

Dried cysts will be packed in scaled plastic bags. For better storage it is advised to replace the air in the bag by flushing the cysts with H_2O-free nitrogen gas from a bottle. Closed bags should be stored in a dark dry cool place.

Proposed procedures for cyst processing involve relatively simple methods and low cost equipment. The set up of a more sophisticated cysts processing plant with a larger capacity and including canning of cysts and a laboratory for quality control can only be considered when Port Said has proven to produce commercially feasable quantities of cysts and when other salterns of ENSC are being modified for the development of Artemia production.

ANNEX III

LIST OF EQUIPMENT/MATERIALS FOR HATCHING AND PROCESSING OF CYSTS

ITEM	SPECIFICATION	QUANTITY
air blower	Rotron of similar, 150 m^3/h	1
cylindroconical tank	volume 300 l, diameter 80 cm, cone bottom, outlet of 4 cm wide + outlet valve, fibreglass opaque, + cradle support	6
flatbottom tank	500 l, rectangular + cover, plastic or fibreglass	1
TL lamps	25 watts, 60 cm, daylight	24
TL lampholders	watertight, 2 x 25 watts	12
air tubing	polyethylene, inner diameter 6 mm, outer diameter 8 mm	25 m
tubing clamps	roll clamp, polyester, fit tubing of 8 mm	25
heater	air heater + build in fan, 2000 watts	1
thermostat	+ themosensor, adjustable from 15 to 45 °C	1
screen	type Monodur or similar, polyamide	
	meshwidth 150 µm	10 m^2
	500 µm	5 m^2
	800 µm	10 m^2
fluidized bed dryer	see Fig. 1	1

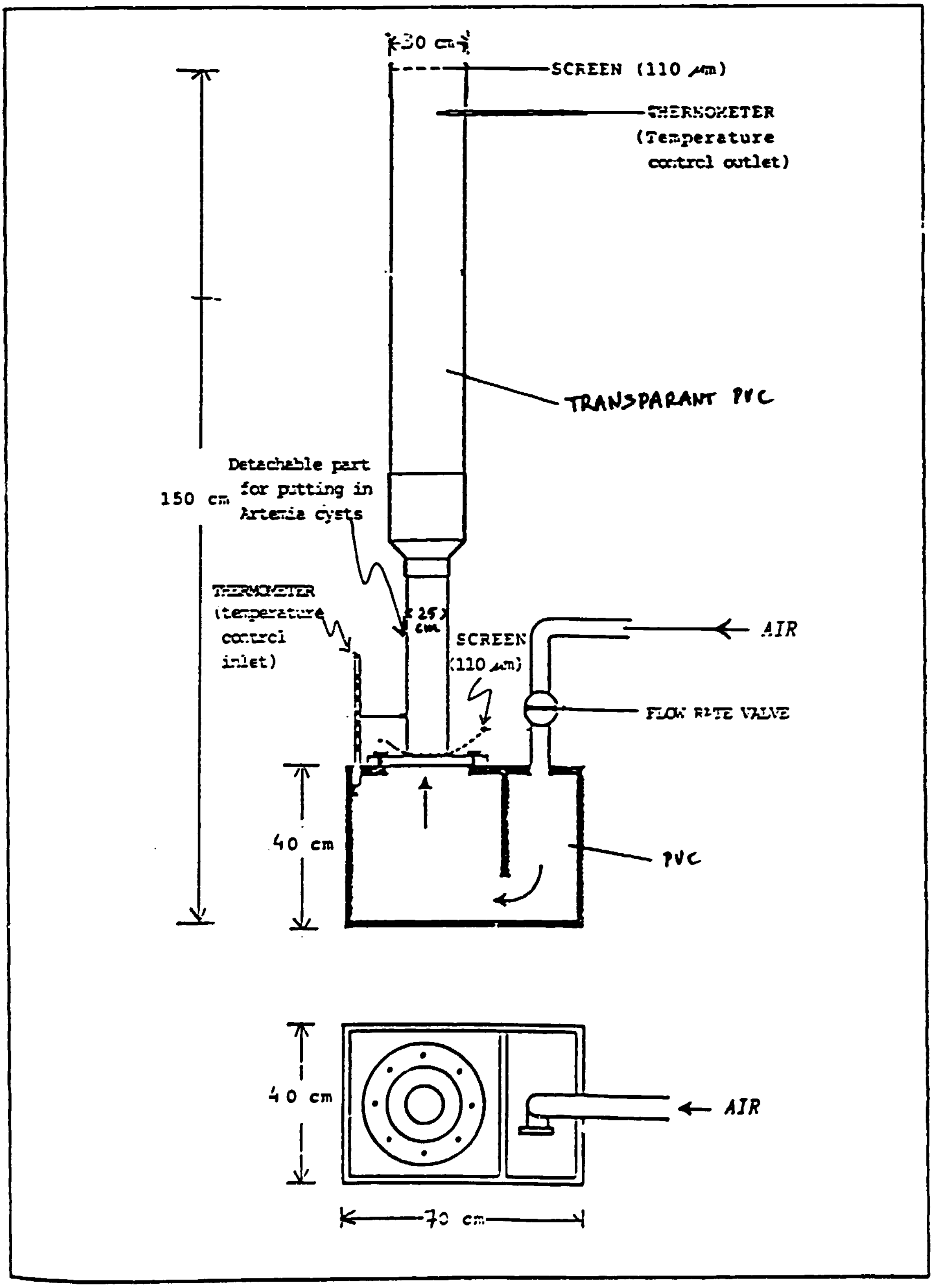

Figure 1. Prototype Fluidized Bed Dryer.