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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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ASSISTANCE FOR THE ESTABLISHMENT OF A PILOT PESTICIDE FORMULATION PLANT IN ETHIOPIA

UC/ETH/85/214

ETHIOPIA

Technical report: Evaluation of offers for pesticide formulation plant in pilot scale*

Prepared for the Government of People's Democratic Republic of Ethiopia
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Kyu-Chin Hahn, expert in pesticide formulation technology

Backstopping officer: B. Sugavanam, Chemical Industries Branch

United Nations Industrial Development Organization
Vienna

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* The boundaries shown on the maps included in this report do not imply official endorsement or acceptance by the United Nations Industrial Development Organization. This document has not been edited.

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EXPLANATORY NOTES

- The monetary unit in Ethiopia is the "Birr"
- Exchange rate used in the report is 1 US Dollar = 2.07 Birr
- Reference to Dollars ($) are to United States Dollars

Abbreviations

ALSCO - Agricultural Inputs Supply Corporation
ARAD - Agricultural Research and Advisory Department

D - Dust
E.C. - Emulsifiable Concentrates
EIGS - Ethiopian Institute of Geological Survey
EMRDC - Ethiopian Mineral Resources Development Corporation
FC - Foreign Currency
G - Granular Formulation
Ha - Hactre
IAR - Institute of Agricultural Research
Kg - Kilogram
K.Lit - Kilo-litre
LC - Local Currency
MT - Miscellaneous Technique in CIPAC Hand book
NCC - National Chemical Corporation
ULV - Ultra Low Volume
UNDP - United Nations Development Program
UNIDO - United Nations Industrial Development Organization
W.P. - Wettable Powder

ABSTRACTS

Upon request by the UNIDO under the project entitled, "Evluation of Offers for Pesticide Formulation Plant in Pilot Scale" (UC/ETH/85/214/11-02) was conducted in 1989 to discuss previous studies, evaluate offers received, and recommend the best choice in terms of technical and financial acceptablity for the construction of a pesticide formulation plant in Ethiopia. Findings of this project are reported here.

This report presents recommendations on: (1) pesticide formulation design (2) specification of indigenous raw materials (3) testing methods for indigenous raw materials (4) pesticide packaging information (5) pesticide supply, storage, distribution and handling (6) occupational hygiene and industrial safety (7) selection of plant site. Also included in this report are (1) cost comparison of imported and locally formulated pesticides (2) list of equipment and machinery (3) list of references for pesticide formulators.

1. INTRODUCTION

Ethiopia is agrarian but the country is still not sufficient in food. In order to achieve self-sufficiency in food production modern agricultural technology must be practiced by farmers, including proper use of pesticides.

At present, all pest control products are imported from abroad even though many of the raw materials for formulating pesticides, such as solvents, dust diluents, and packing materials, are locally available. East German experts carried out a preliminary study in 1986 and recommended to establish a formulation plant for liquid pesticides in Ethiopia. Following this study the UNIDO was requested by the Ethiopian Government to conduct technical and economical feasibility studies for the establishment of a pesticide formulation plant.

Based on the positive results from the feasibility studies the Government decided to build a pesticide formulation plant and the tender documents for the construction were prepared and sent to several potential bidders. Upon further request from the Ethiopian Government the UNIDO assigned an expert in pesticide formulation to review all previous studies and evaluate all offers on the following aspects: (1) technical content and quality of know-how (2) effluent control and its suitability (3) cost effectiveness. The expert will recommend the best choice in terms of technical and financial acceptability and make suggestions on other aspects relevant to the construction and safe and economical operation of the formulation plant. The expert will also recommend the types of tests of local raw materials and come to UNIDO, Vienna, if necessary, with Senior Project Counterparts to discuss findings and recommendations.

This report is related with (1) "Financial And Economic Analysis" by the Industrial Project Service of Ethiopia (Project No. 008/47/79), (2) "Design of Pesticide Formulation Plant, Assistance for The Establishment of Pesticide Formulation Plant in Ethiopia (UC/ETH/85/214) and (3) The Preliminary Study conducted by the Experts of GDR.

According to the previous reports, it has been concluded that there is a definite need to establish a pesticide formulation plant with the capacity of producing 1.5 million litres of liquid insecticides per year for phase I. One of the proposed plant location was near Tendaho area where 70% of liquid insecticides are used.

The expert arrived in Addis Ababa, Ethiopia on 14th January 1989 and was assigned to the NCC. Mr. Makonnen Tessema, the Chemical Engineer, and Mr. Asrat Bulkula, the Project and Planning Manager of the NCC worked closely with the expert. The first discussion was held on 16th January 1989 at the NCC. Dr. Dembel Balcha, the Deputy General Manager, Mr. Makonnen Tessema, Mr. Asrat Bulbula and the expert were present at the meeting. Unlike the information given to the expert from the UNIDO the tender document was in fact not yet fully prepared and dispatched to the potential bidders. Therefore, at that meeting the NCC requested the expert (1) to add a dust formulation facility producing 1,500 tons per year to the tender documnet and to dispatch the document to the potential bidders; and (2) to evaluate all offers upon receipt of the bids. For these reasons the expert's assigment was extended by one month.

2. TYPE OF TEST ON LOCAL RAW MATERIALS

2.1. AVAILABILITY OF RAW MATERIALS

One of the most important factors for the economical management of a pesticide formulation plant is the availability of raw materials. Import from abroad of formulation materials such as solvents and carriers, and packaging materials such as containers, may seriously jeopardize the economical operation of the local formulation plant because freight cost, insurance and tariff increase the cost of production. Furthermore, long shipping lines create logistic problems and are not practical for seasonal production. Therefore, it is desirable that these materials are locally available. However, the locally available materials must be tested to ensure that they meet all specifactions required for formulation. The performance of formulations produced with these materials should be confirmed in the field.

2.2. Dust carriers and diluents

Inorganic raw materials such as kaolin, diatomite and bentonite are available in Ethiopia and these can be used as diluents or carriers for the formulation of pesticidal dust. According to the information obtained from the Ethiopian Mineral Resources Development Corporation (EMRDC), the above mentioned carriers occur in some of the regions of the country scattered at different areas. Kaolin deposits occur near Bomba Woha and Shakiso in Sidamo Region and diatomite in the vicinity of Adami Tulu and other locations in Showa Region. Bentonite reserves are found at Warsiso in Wollo as well as Gewane in Harrar Regions. According to the information from the Ministry of Mines & Energy, there will be a pilot plant, designed by GEOMINERALIA ITALIANA, to produce approximately 10,000 metric tons of micronized minerals containing 70% of calcium carbonate and 30% of

dolomite, bentonite, kaolinite, feldspar and quartz mixtures for 1991. Also, testing for the upgrade and classification of locally available non-metallic mineral will be conducted at pilot scale under the UNIDO project. The location and quantity of each mineral deposit are given in Figures 1-5 (Annex I).

TABLE 1

Industrial Minerals	Uses	PRESENT PRICES Birr/T*	Note	CONSUMPTIONS T/Y Present	CONSUMPTIONS T/Y Foreseen	COSTS BIRR/Y X 10^3 Present	COSTS BIRR/Y X 10^3 Foreseen
BENTONITE	Drilling Mud	1000	1	370	500-1000	370	500-1000
	Filter Aid	400-600	2	200	?	100	?
	Filler	100-150	3	50	1000-6000	7	100-600
CALCIUM CARBONATE	Filler	350-400	4	2600-2800	4600-5200	1000	1900
	Glass	150-180	5	1250	4600	200	760
DOLOMITE	Filler	450-500	4	600	1000 ?	280	470
	Glass	110-150	5	620	9870	80	1100
DIATOMITE	Filter Aid	500-700	2	25	?	15	?
	Filler	100-150	3	300	1000-6000	40	100-600
FELDSPAR	Glass+Ceramic	150-200	3	500-1000	2000-5000	130	250-620
	Filler	600-650	6	83	170	50	110
KAOLIN	Paper	600-650	6	130	6600-7000	810	4250
	Ceramic+Chem.	150-200	3	-	4200-9800	-	700-1700
SILICA	Glass	120-160	3	6100	9000-30000	500	600
	Ceramic	100-150	3	-	800-1000	-	100

N.B. All notes are given in the next page.

NOTES TO TABLE I

(1) Information supplied by the Water Resources Corporation.

(2) Information supplied by GEOMINERALIA ITALIANA.

(3) Approximate values based on current price for local use (excluding international transports).

(4) Information supplied by the NATIONAL CHEMICAL CORPORATION.

(5) Information supplied by Addis Glass Factory.

(6) Information supplied by the NATIONAL LEATHER AND SHOES CORPORATION and by PULP AND PAPER CO.

* Current price based on the values supplied by the consumers in Addis Ababa.

Comparison of Commercial and Local Samples of Industrial Minerals for Pesticide Dust Formulation

Types of Mineral	Analysis	Commercial	Local
BENTONITE	SO_2	60-65	61.93
	$Al_2 O_3$	15-25	11.06
	$Fe_2 O_3$	3-5	6.16
	$Ti O_2$	0.1-0.15	1.06
	Ca 0	0.4-1.5	1.03
	Mg 0	2.3-4.0	2.56
	K_2 0	0.15-0.5	1.27
	Na_2 0	0.2-2.6	1.68
	L.O.I.	5-7	
	Ph	8-9.5	
	Packed weight 53-55 LBS/ft^3		
	Fluffed weight 36-38 LBS/FT^3		
CALCIUM CARBONATE	Ca CO_3	90-98	48-99
	Mg CO_3	1-5	8-44
	$Al_2 O_3$	0.2-0.3	0.1-0.2
	$Fe_2 O_3$	0.1-0.2	0.1-1.1
	Si O_2	0.2-0.4	5-8
	H_2 0	0.1-0.2	14-46
	Ph	9-9.5	
	Packed weight 43 LBS/ft^3		
	Fluffed weight 30 LBS/ft^3		
DIATOMITE	Si O_2	80-85	82.56
	$Al_2 O_3$	4-7	3.97
	$Fe_2 O_3$	1.5-2.0	2.27
	Ti O_2		0.28
	CaO	0.8-1.6	0.91
	Mg 0	0.3-0.5	0.34
	K_2 0	N/A	1.32
	Na_2 0	N/A	2.93
	L.O.I.	4-6	5.42

Types of Mineral	Analysis	Commercial	Local
	PH.	5.5-8.3	
	Packed weight	23-25 LBS/ft^3	
	Flatted weight	9-10 LBS/ft^3	
KAOLIN	$Si\ 0_2$	44-46	45.5
	$Al_2\ 0^3$	38-40	37.4
	$Fe_2\ 0_3$	0.3-1.6	1.1
	$Ti\ 0_2$	0.8-1.6	0.05
	CaO	0.35	0.1
	MgO	N/A	0.015
	$K_2\ 0$	0.02	0.32
	$Na_2\ 0$	0.13	0.04
	L.O.I.	14-15	15.06
	Ph	4.5-6.8	
	Packed weight	35 LBS/ft^3	
	Flatted weight	19 LBS/ft^3	
SILICA	$Si\ 0_2$	98.5-99.5	96-97
	$Fe_2\ 0_3$	0.04-0.1	0.1-0.3
	$Al_2\ 0_3$	0.4-0.8	1.5-3.3
	MgO	Trace	0.1

3. COMPATIBILITY OF CARRIER/ACTIVE INGREDIENT

One of the most important properties to be considered when choosing an inert for formulating dry pesticidal product is the compatibility of the active ingredient with the carrier. Many of the technical grade pesticides available today are somehow unstable when exposed to long-term storage at elevated temperature that may normally encountered in the field. Even if the carrier were completely inactive chemically, merely spreading the toxicant over the large surface area of the carrier could increase the rate of inherent decomposition of the toxicant. The selection and requirement of deactivators for dust formulation pesticide products vary depending on the type of carrier and active ingredient. Therefore it is necessary and very important to do accerelated storage test and periodical analysis before being implemented to the production.

The compatibility with active ingredients and carriers will be specified by the foreign supplier of the active ingredients. Deactivators for DDT, Endosulfan and Malathion dust formulations are mentioned below.

3.1. DDT

The decomposition of DDT when formulated with mineral carrier was already recognized when the product was stored at elevated temperature. In order to reduce or prevent the decomposition of the product, the use of deactivators have been suggested. Organic chemicals such as ethylene glycol, propylene glycol, or the combination of the different types of glycols have been found to have some effect in neutralizing the carrier.

3.2. Endosulfan

Endosulfan is slowly decomposed by the catalytic action of some clays and fillers. The kaolin type clays are especially active in this respect, but talc and calcium carbonate are relatively inert. Dipropylene glycol will deactivate the carriers to stabilize the finished product.

3.3. Malathion

It was found that malathion way slowly hydrolized under alkaline condition and that weak acids such as tall oil and rosin acids prevent the decomposition to a degree.

4. FACTORS TO BE CONSIDERED FOR DUST CARRIERS AND DILUENTS

4.1. Particle size

The particle size of dust carriers and diluents is not only important during production of dust pesticide formulation but also to the performance of products in the field. Most of dust carriers and diluents should be finer than 200 mesh, preferably 325 mesh (44 um).

4.2. Sorptivity

The most important property of dust carriers is sorptive capacity. The diluent must not only have the sorptive capacity to absorb the active ingredient during production, but also the ability to keep the product in a free-flowing condition during storage and use. Sorptivity of commonly used pesticide dust carriers and diluents is as follows.

Carrier		
Diatomite	:	Raw Linseed, S.G.: 0.928. Absorption: 150 kg. of oil
Attapulgite	:	Linseed 120 kg. of oil per 100 kg. of powder
Montmorillonite	:	Linseed 40 kg. of oil per 100 kg. of powder
Kaolinite	:	35 kg. of oil per 100 kg. of powder
Diluents		
Bentonite	:	40 kg. of linseed oil per 100 kg. of powder
Talc	:	N/A
Prophyllite	:	N/A
Calcium Carbonate (Lime stone)	:	N/A
Calcium Sulfate	:	N/A

4.3. Bulk Density

The factors affected by the bulk density of dust carriers and diluents are the degree of coverage of the finished product over an area, wind drift, penetration of plant leaves, ease of handling through production and application equipment, cost of packaging and shipping etc... The ideal bulk density of pesticide dust product is 30-40 pounds per cubic foot or 480-640 kilograms per cubic metre.

4.4. Flowability

The flowability of dust carriers and diluents is the rate of pouring, moving and displacing of material. The flowability of impregnated products can be damaged if the sorptive capacity of the inert is exceeded. During the formulation process, as flowability increases the power requirement for blending decreases. Flowability is

important for ease of handling and storage as a raw material, during formulation and for packaging of finished product. Flowability is also important during application, for example, flow of bags, field applicators, shaker canisters, etc. The flowability of dust diluents/carriers is as follows.

Attapulgite	100
Talc	112
Diatomite	8
Kaolinite	12
Prophyllite	89

The flowability of dust products can be adjusted, by mixing different types of carriers or diluents, to meet their requirement.

4.5. Dustability

Dustability is a characteristic of powdered diluents relating to the ability to be transported by the air currents within a limited area of application and stick to the surface of the crop plants after application.

5. PROPERTIES AND USE OF MINERALS FOR DUST FORMULATIONS

5.1. Diatomite

Diatomite skeletons and their fragments are very irregular shape and a highly porous nature. They are very small, being only a few microns in diameter. Since the porous internal structure is not lost in processing, a reduction in particle size does not greatly increase the total surface area. They have a low apparent density, a high percentage of voids or pore space, and consequently high sorptive capacity. In insecticide formulations, the diatomite is used as conditioning agents or as primary carriers for high concentration of insecticidal dusts and wettable powders.

5.2. Mica

Since internal porosity of a single particle is lacking and particle size of micas used as insecticide diluents is relatively large, these materials are low in sorptivity. When the toxicant is a liquid or an amorphous material, the percent of toxicant which can be taken up by the dust will be limited because of the low sorptive capacity. For these reasons, these materials will be more useful as diluents rather than as carriers for most insecticides.

5.3. Talc

In general, talc can be formulated with solid insecticides in any portion. However, when liquid or amorphous toxicants are used, the percentage of toxicant that can be incorporated in the formulation will be limited by the low sorptivity of these materials. Therefore, the use of these materials in insecticide formulation is limited to the role of diluents rather than the carriers of the toxicant.

5.4. Kaolin

In general, the particle size of the kaolin used as insecticide dust diluents and carriers is finer than that of micas and talcs. In formulation with liquid or amorphous toxicants, kaolins of finer particle size will take up a higher percentage of toxicant. Thus, higher percentage formulations can be made while retaining the desired properties of the powdered material. The agglomerates of the fines are readily dispersed in a water medium or by an air blast. Because of these properties, these products are most useful for wettable powder and dust concentrates formulaions.

5.5. Bentonite

The surface area of this group may be considered as being of two types - external and internal. The internal surface is accessible to polar substances, since such material can penetrate between the layers. It is not available to non-polar substances. Therefore, non-polar toxicants cannot penetrate between the layers. At present, most of the insecticides are non-polar. If polar-toxicants are found, the internaction of these with bentonite mineral should be considered. The large internal surface of this type of mineral gives it interesting possibilities for future use as a primary carrier for insecticides.

5.6. Attapulgite

It has a large capacity for taking up a liquid and still maintaining its flowability and non-caking characteristics. In the formulation of insecticides which are liquid or amorphous, this type of mineral can be used for high percentage mixes. Attapulgite group minerals are the most ideal dust carrier and diluent to adjust the

flowability of finished products. However, this mineral has not been found in this country.

6. COMPARISON OF PRICES BETWEEN IMPORTED AND LOCAL MINERALS

For the formulation of dust insecticides various types of minerals are used as diluents or carriers. As mentioned earlier, there are abundant deposit of minerals to be used for these purposes. Also, there are possibilities of processing the minerals for industrial purposes in cooperation with the Geomineralia Italiana. However, the estimated costs of the local minerals are not cheaper than the imported ones.

As of 6 February 1989, according to the Chemical Marketing Review, the world prices of the carriers and diluents that can be used for the formulation of dust pesticides are as follows.

Carriers/diluents	FOB price per ton (in US dollars)	Grade
Bentonite	30.50	
Calcium carbonate	90.00	325 mesh
Kaolin	64.00	General purpose filler
Silica	55.00	325 mesh
Talc	90.00	325 mesh

Additional costs on the top of the FOB prices are listed below:

Custom duty	10%
Surtax	5%
Transaction tax	18%
Municipality tax	1%
Port duty	0.25%
Freight	7.75% (approx.)
Total	42.0%

Therefore, the comparison of the costs between imported and the estimated value of the local diluents and carriers are as follows.

Carriers/diluents	Imported (in US dollars)	Imported (in Birr)	Local Materials (in Birr)
Bentonite	43.31	89.65	100-150
Calcium Carbonate	127.80	264.55	350-400
Kaolin	90.88	188.12	150-200
Silica	78.10	161.67	120-160
Talc	127.80	264.55	N/A

Although the prices of the local materials are not competitive against the imported ones, it is strongly recommended to use the locally available raw materials while suspending the imports of the minerals that are produced in this country, thus, encouraging the domestic industries to grow and saving the foreign currencies.

7. Solvent

In Ethiopia, according to the previous survey, Assab Oil Refinery produces a range of solvents including kerosene, white spirit and diesels, which may be used for liquid formulation of pesticide although their use appears to be limited due to low solvency, phytotoxicity etc.. Total requirement of solvents to produce 1,500 cubic metres of liquid insecticides is approximately 800 cubic metres of different types of solvents, and the breakdown is as follows.

320 cu.m. of aromatic hydrocarbons such as xylene and its mixtures.

160 cu.m. of alcohols.

160 cu.m. of ketones.

160 cu.m. of aliphatic solvents such as kerosene, white spirit etc.

When selecting a solvent for the formulation of liquid insecticide the following matters should be considered.

7.1. Solubility of active ingredients.

- Solubility to active ingredients increases as the aromatic content increases.

7.2. Phytotoxicity of the solvent.

- Alcohols and ketones are less phytotoxic than aromatic or aliphatic hydrocarbon solvents.
- Higher molecular weight solvent are more phytotoxic than lower ones.
- Hydrocarbon solvents are more phytotoxic than others.
- Higher boiling hydrocarbons are more phytotoxic than lower ones.

7.3. Chemical compatibility with active ingredients.

- The higher the boiling point is the better

killing efficiency of insects.

. Solvents, depending on its type, may increase the insecticidal efficacy of active ingredients, e.g. kerosene with DDT.

7.4. Flammability

7.5. Volatility

. Low volatile solvent in E.C. may increase the residual effect of active ingredients.

7.6. Miscibility with water.

. Water content in a solvent may decompose active ingredients.

. To make emulsifiable concentrates, it is important to choose the solvents which are immiscible with water.

. Aromatic and Aliphatic hydrocarbon solvents are immiscible with water.

. As the polarity of solvents increase, the miscibility of water also increases.

7.7. Toxicology

7.8. Cost

As aromatic content increases the cost also increases.

It is essential to ascertain that all the characteristics of local solvents should be equivalent to imported ones. The distillation range, aromatic content, solvency, flash point, water miscibility, water content, phytotoxicity should be checked and compared with imported solvents before switching to local ones. Also, the emulsifier balance with local solvents, in formulating emulsifiable concentrates, should be thoroughly studied and tested before making any change. Chemical and physical properties of local solvents are listed below.

Chemical and Physical Properties of Local Solvents

(Supplied by Assab Oil Refinery)

Fractional distillation	Light Naphtha 28-50	Heavy Naphtha 50-160	Light Kerosene 160-200	Heavy Kerosene 200-240
1. Unsaturated Hydrocarbon	1.2	9.6	18.5	26.6
Aromatic % VOL.OLEFIN	NIL	NIL	1.08	1.4
2. Acid				
TAN. Mg KOH/G	0.007	0.009	0.011	0.016
SAN. " "	NIL	NIL	NIL	NIL
3. ASH. % Mass	0.024	0.036	0.031	0.020
4. Sulphur Total	0.039	0.07	0.22	0.66
5. Kinetic Viscosity at 15°C.CST	0.45	0.76		
" " 20°C			1.65	3.9
6. Flash pt.°C.	Below 0°C	Below0°C	32°C	87°C
7. Peroxide No.	NIL	NIL	NIL	NIL
8. ASTM Distillation Range				
IBP °C	26	59	128	208
10% Evaporated D.C.	36	92	174	238
50% " "	53	119	200	256
90% " "	86	154	224	280
E.B.P. D.C.	138	179	238	296

TAN = Total Acid No

SAN = Strong Acid No.

8. Phytotoxicity Test of Solvents and Emulsifiers in Insecticide Formulations

The phytotoxicity of insecticidal formulations has been a constant problem for farmers and formulators from the first time of using pesticides to the present days. Dust formulations are generally non-phytotoxic, but emulsion type sprays often cause considerable burning of treated plants and are frequently replaced by wettable powders for use in sprays even though emulsions offer more effective insect control.

8.1. Method of phytotoxicity test

All the plants are grown in individual pots greenhouse conditions that produced very tender foliage. The plants are approximately 10 cm high when tested. The plants are treated by quickly dipping the foliage into solutions of emulsifiers or emulsion of the solvents. The solvents are tested at 5% and 0.5% on a volume to volume basis. In testing the solvents, it is necessary to formulate them with an emulsifier.

The formulations are made to contain 10% emulsifer and 90% solvent. The tap water used in the tests had PH of 7 and a hardness of 30-45 ppm of combined calcium and magnesium salts. After treatments, all plants are held in

a constant temperature room at 32°C and relative humidity of 75% for seven days. During this time, the pots of the test plants are held in trays containing 1.3cm of water. Flourescent lights are provided sufficient light to prevent chlorosis.

At the end of the holding period, the plants are rated for injury, using the following values: 0 = non-visible sign of injury. 1 = very slight injury. 2 = moderate injury, 3 = heavy injury and 4 = severe injury, usually a dead plant. The readings of the three replicates are averaged for the rating of the material. In nearly all cases, there should be a very close agreement among the three replicates.

8.2. Phytotoxicity of Emulsifiers

The effective emulsifiers, are generally more phytotoxic due to the ability of penetration. The better the emulsifiers are the more penetration to the leaf tissue than the less effective ones.

The 1% concentration used in testing the emulsifiers was about 10 times greater than the highest concentration normally encountered in agricultural sprays. Thus, the fact that a material showed considerable injury at the 1% level does not prohibit its agricultural use, but it does mean that some phytotoxicity may result if the material is used above the recommended rates. Those materials that showed injury greater than a rating of 0.1 at 0.1% concentration should be considered hazardous for agricultural use.

8.3. Phytotoxicity of Solvents

The petroleum distillates are more phytotoxic than the other types of solvents. The acetates, alcohols, ketones and ethers are generally non-phytotoxic until four or more units are in the carbon chain. The butyl radical

units are in the carbon chain. The butyl radical seems to be more phytotoxic. The addition of chlorine or phosphorous to the molecule also increase the phytotoxicity. The more water soluble the solvent, the less it is to cause plant injury: and those materials that are water insoluble are highly phytotoxic. The addition of an insecticide to the formulation may alter the intensity of the phytotoxicity of the solvent.

The solvents as a group are less phytotoxic than the emulsifiers. In general, five times the concentration of solvent was required to give the same average injury as with the emulsifiers. Much of the phytotoxicity caused by agricultural spray is more due to the emulsifier than the solvent. The phytotoxicity of both solvent and emulsifiers should be considered when selecting materials to use in insecticide formulations.

9. RECOMMENDATION OF EMULSON-TYPE FLOWABLE FORMULATION

The flowable formulation is water-based dispersion of active ingredients and has various good characteristics. There are several flowable formulations that have been developed and commercialized. In most cases, technical active ingredients used are solid.

The research work has been carried out to develop emulsion type flowable formulations, which contain liquid technical active ingredients, such as fenitrothion or fenvalerate, that are widely used in Ethiopia. This formulations do not contain organic solvents which this country has to import from foreign countries by spending huge amount of foreign currencies.

These flowable formulations are formulated by dispersing liquid technical active ingredients in water in the presence of proper dispersing agents under vigorous stirring. In order to stabilize the dispersions thickening agents such as xanthan gum, sodium carboxymethyl cellulose and polyacrylic polymers can be added.

Biological efficacy is almost same or better. Application by conventional sprayer is very easy. These formulations show good chemical and physical stability.

As water, not organic solvents, was used as carrier or diluent acute oral toxicity is decreased very much. Also, no eye irritation was found in this formulations. It was also found that spray mist of these formulations contain less amount of fine particles than that of E.C. in case of ULV application.

It is very essential to develop, for safety, better efficacy and for saving foreign currency for the importation of organic solvents, water based emulsion type formulations containing liquid technical active ingredients,

malathion, diazinon, cypermethrin, etc., that are very commonly used in this country.

10. TYPE OF TEST ON LOCAL RAW MATERIALS

Before designing recipes for the formulation of pesticides by using locally available raw materials, it is essential to test each items to find out the characteristics of the materials and formulated products, and to compare the imported products with local ones. The standard procedures of testing methods are available from CIPAC (Collaborative International Pesticides Analytical Council) Hand Book, A.O.A.C., EPA Manual, ASTM, etc. However, CIPAC Handbook is considered to be the most informative and the testing methods are very simple and suitable to this country. Therefore, it is suggested to follow the methods described in this publication.

Accelerated storage tests	MT 46.1-46.4
Dustability	MT 34
Flowability of powders	MT 44
Free acidity and Alkalinity	MT 31
Sieve Tests	MT 59.1-59.3
Bulk density	MT 3
Tap density	MT 33
Active Ingredient Extractions	MT 37.1-37.3
Flash points	MT 12.1-12.3
Soluble Alkalinity	MT 81
Emulsifiable concentrates	
Dispersibility	
Cold stability	MT 39.1
Dilute emulsion stability	MT 20 and 36
Freezing point	MT 1
Melting point determination	MT 2
Mercaprans determination	MT 78
Mineral oil for diluting insecticide formulations	RE 36.1

Miscibility of non-aqueous solution with hydrocarbon oils	MT 23
Neutrality of solvents	
Neutral oil	
Distillation range	MT 61
Unsulphonated residue	MT 57
Volatility	MT 56
Material in soluble in oil	MT 35
Petroleum distillation	MT 70.2
Petroleum oil products data	P. 582
Neutral oil in petroleum	P. 583
Phenol in petroleum	P. 586
Residue on evaporation of low boiling products	MT 80.1
Specification of kerosene	RE 73
Solubility of materials	
Insoluble in acetone	MT 27
kerosene	MT 8
oil	MT 35
water	MT 10
xylene	MT 11
Soluble in acetone	MT 5
benzene	MT 4
water	MT 9
toluene	MT 90
	MT 60
Rate of solution	
Specific gravity	MT 3.1 and 3.2
Wetting of leaves evaluation	MT 53 - 53.2
Viscosity	MT 22.1,22.2 & 22.3
Volatile substances	MT 17

The analytical methods of active ingredients and formulated products are also available from CIPAC Hand book, EPA suppliers' manuals.

11. LOCAL FORMULATIONS BY USING LOCAL MATERIALS

11.1. Liquids

There is an oil refinery in Asab, Ethiopia, producing several varieties of oil, mainly aliphatic solvents. Due to the unavailability of phytotoxicity data with these solvents, however, it is not recommended to use the solvents for the formulation of pest control products until these experimentations have been done and the results are found to be satisfactory. Other tests, such as solubility of active ingredients in the solvent, compatibility with active ingredients, volatility, etc., should be carried out. It is suggested to try the solvents for the formulation of insecticides for structural uses, household pest control by adding masking agents.

11.2. Solids

Malathion 25% dust concentrate can be produced with required amount of active ingredients and a mixture of diatomite and kaolin in acidic condition at the rate of 1 to 3 or 1 to 2 ratio. As the formulated product will be stored at elevated temperatures, excess amount, preferably 2%, of the active ingredient is required.

Malathion 50% dust concentration, due to the high content of the liquid active ingredient, requires highly sorptive carrier such as calcium silicate which will be available in this country.

To make malathion 5% dust, these concentrates can be diluted down to the strength by mixing with the required amount of kaolin or talc.

Endosulfan 50% dust concentrate and 5% dust can not be formulated with locally available diluents due to the sensitivity of the technical ingredient to diatomite and

kaolin.

As dipropylene glycol deactivates the diluents, however, it is recommended to spray the deactivator to diatomite then, add the active ingredient to the carrier/diluent. Bentonite and Talc are safe and inert in the formulation of endosulfan dust. It is suggested to use a mixture of diatomite and bentonite or talc with the deactivator. However, it is not recommended to use kaolin for endosulfan formulation as it is too sensitive to the active ingredients.

DDT 5% and 10% dust can be produced by diluting down DDT 75% dust concentrate, which can be manufactured with silicon dioxide and technical DDT. Depending on the PH of the diluent used, it is necessary to adjust the PH of the surfaces of diluents by adding glycols or ethanolamines. DDT is, however, stable under the mentral conditions.

Cost of Formulated Products by Using Local Raw Material(s)

	ENDOSULFAN				FENITROTHION				MALATHION			
	35% E.C.		25% ULV		50% E.C.		95% ULV		50% WP		50% E.C.	
	Kg.	Birr	Kg.	Birr	Kg.	Birr	Kg.	Birr	Kg.	Birr	Kg.	Birr
Active Ingredient	370	4070	264	2989	.510	8400	970	15976	540	4525	540	4525
Aromatic Solvent	570	765	726	973	440	590	30	40			410	550
Emulsifier	50	369			50	369					50	369
Cyclohexanone Epichloro Hydrin	10	56	10	56								
Diproylene Glycol												
Diatomite												
Kaolin												
Silica												
Calcium Silicate									430	195		
Talc												
Dispersant									30	30		
Vegetable oil												
Antioxidant												
Specific Gravity	1.095		1.015		1.03		1.03				1.07	
Volume	913		985		970		770				935	
Total Cost		5260		4018		9359		16016		4750		5444
Unit Cost		5.76/L		4.08/L		9.65/L		20.80/L		4.75/kg		5.83/L

Cost of Formulated Products by Using Local Raw Materials

	D.D.T.		DIAZINON				DIMETHOATE			
	10% D		25% E.C.		60% E.C.		60% ULV		40% E.C.		40% ULV	
	Kg.	Birr	Kg.	Birr	Kg.	Birr	Kg.	Birr	Kg.	Birr	Kg.	Birr
Active Ingredient	100	824	250	2060	640	9632	640	9632	425	7897	425	7897
Aromatic Solvent			700	939	290	390			400	538	300	402
Emulsifier			50	369	60	443			75	554		
Cyclohexanone									100	453	275	1245
Epichlorohydrin					10	56						
Kaolin	800	480										
Silica	100	16										
Vegetable Oil							340	1108				
Antioxidant							20	520				
Specific Gravity			1.03		1.02		1.03		1.05		1,04	
Volume			970L		982L		970L		952L		963L	
Total Cost	1320		3268		10521		11260		9442		9544	
Unit Price	1.32/Kg		3.37/L		10.71/L		11.60/L		9.92/L		9.91/L	

COMPARISON OF THE COST BETWEEN IMPORTED AND LOCALLY FORMULATED PRODUCTS(IN BR.)

PRODUCTS	IMPORTED PRODUCTS PRICE	Land	Factory Gate	Locally Formulated		
D.D.T.	(C & F Aseb)	Cost	Price	Products	Savings	Remarks
95% Tech.	5.80/kg	2.44	8.24	N/A	N/A	
25% E.C.	4.35/L	1.83	6.18	3.37	2.81	
25% W.P.	4.35/Kg	1.83	6.18	4.75	1.43	
10% Dust	2.70/Kg	1.14	3.84	1.32	2.52	
DIAZINON						
95% Tech.	10.60/Kg	4.45	15.05	N/A	N/A	
60% E.C.	9.22/L	3.88	13.10	10.67	2.43	
60% ULV	9.22/L	3.88	13.10	11.60	1.50	
DIMETHOATE						
95% Tech.	13.08/Kg	5.50	18.58	N/A	N/A	
40% E.C.	9.84/L	4.13	13.97	9.92	4.05	
40% ULV	9.84/L	4.13	13.97	9.91	4.06	
ENDOSULFAN						
95% Tech.	7.97/Kg	3.35	11.32	N/A	N/A	
35% E.C.	7.74/L	3.26	11.00	5.66	5.34	
35% ULV	7.74/L	3.26	11.00			
25% ULV	17.08/L	7.17	24.25	4.08	20.17	Specially formulated for Ethio-State Farm Development only
MALATHION						
95% Tech.	5.90/Kg	2.48	8.38	N/A	N/A	
50% E.C.	4.29/L	1.80	6.09	5.83	0.26	
50% ULV	4.29/L	1.80	6.09			
50% WP	4.18/Kg	1.76	5.94	4.75	1.19	
FENITROTHION						
48% Tech.	11.60/Kg	4.87	16.47	N/A	N/A	
50% E.C.	7.22/L	3.03	10.25	9.65	0.60	
95% ULV	10.25/L	4.30	14.55	20.80	(6.25)	

NOTES:

1. These tables are guidelines only, as the prices and land cost fluctuate time to time.

2. All the liquid products are supplied in 200L lined metal drums. However, the cost of the drum, which is approx. 100 Birr each, is not included in the cost of product.

3. Land cost is approximately 42% of C & F Aseb price as explained on page 20 .

4. In order to avoid confusion and to standardize all the prices are obtained from same supplier.

5. Factory Gate price is C & F Aseb + Land Cost.

6. Country of origin of all the pesticides is India.

7. Country of origin of adjuvant, emulsifier, co-solvent, etc. is the United States of America, and the costs are F.O.B. U.S. Port.

8. Prices of the dust diluents are based on the information from GEOMINERALIA ITALIANA who has been involved in the development of industrial minerals in Ethiopia.

9. The cost of products by using local raw materials does not include the cost of labor, container, overhead and transportation.

12. Recommendations for local formulations

12.1. As the costs of malathion 50 E.C. ULV, Fenitrothion 50 E.C. ULV and Diazinon 60 ULV are not profitable or competitive against that of imported products, it is recommended to switch to other products such as cypermethrin 5% E.C. and 2.4% ULV.

12.2. If possible, cypermethin 1% Dust and Granite can be good profitable products to be included in the production programme.

12.3. For soil insect control for small farmers, it is recommended to formulate Diazinon 5% Granule by using ground maize cob as a carrier.

12.4. As the active ingredient in the formulated product increases the profit decreases, it is recommended to formulate the products containing low percentage of active ingredient.

12.5. New formulation technology by using locally available raw materials is strongly recommended.

12.6. If profitable and the active ingredients are available formulate the more required products, such as chloropyrifos and profensfos than less required such as fenitrothion.

13. PESTICIDE PACKAGING

There is no standard policy to distribute pesticide in small package for small farmers, public health and household pest controls. At present, most of the pesticides are dispensed from drums into any types of containers such as plastic or glass bottles for liquid and polyethylene, paper bags, or sacks for solid products.

The end-users bring those bottles or bags whichever is available or suitable for them. There is no label information such as directions for use, toxicological information, pre-harvest intervals for food crops, name of the product, warning symbol, etc.. It is strongly recommended that the small pack pesticides, for both liquids and solids, should be packaged with proper labels with complete information for safety and economy of using various types of pesticides for small farmers, household and public health uses.

13.1. AVAILABILITY OF LOCAL PACKAGING MATERIALS

13.1.1. Plastic Containers

At present, there are two plastic container manufacturers, Ethiofoam and Ethioplastics, in Addis Ababa. Ethiofoam is equipped with a blow-moulder and four injection machines. They use styrene polymer, high impact styrene, polypropylene and both high and low density polyethylene to make various types of pipes, housewares and containers. As the mould cannot be made in the country, they depend it on imports from abroad. However, small repairs and renovations are being done in Ethiopia. In the plant, 5-20 L rectangular cubiform HDPE containers with handle and 38mm-44mm neck are being manufactured for diesel, motor and vegetable oils. As HDPE may hold kerosene type solvents, it will be wise to try the 5L container for kerosene based

insecticides. These containers can also be used for water based formulations, such as flowables and low solvent containing products such as ULV formulations. However, it is required to do compatibility and storage tests before making a decision to use it.

Ethioplastic is equipped with only one blow moulder to make plastic bottles. The moulder is being operated to produce 500 ml and 1 litre yellow bottles for bleach, liquid detergents, etc.. The same blow moulder is also producing 800-100 ml light density polyethylene bottles for potable water for military forces. These bottles can be used for kerosene based liquid insecticides or water based products for household, public health or institutional pest control. As the factory is not equipped with silk screen devices, it is recommended to print the label informations on plastic or cellophane film in sleeve shape and put the printed sleeve outside of the bottle. Due to the limited production capacity, it is strongly recommended to install at least one more blow moulder to increase the productiy. According to the information provided by the general manager of the factory, unlike the information from another plastic factory, mould can be made by water pump factory, spare part factory or Kotebe Metal Factory which are under the management of the Ethiopian Metal Corporation. However, it was found that the precision level in mould production is not perfect yet. As mentioned earlier, any plastic bags, sheets, liners, etc. are made and printed at this factory in accordance with the International Standard and Specifications. In order to prevent the leakage of toxic substances such as pesticides, it should be perfectly precise to make non-leaking container and caps. Also, it is required to do all the necessary testings in accordance with the ASTM and CIPAC handbook.

If the neck is re-designed so as to put sifter or perforated caps for dust or granular application, it will be ideal for small pack solid products for household and small farmers.

13.1.2. Metal Containers

The package should be designed and manufactured so that the contents can be poured and measured with minimum hazard and loss. Unlike plastic bags or glass bottles, there are possibilities of spillage or stock accumulation resulting in possible deterioration. Therefore, it must be safe enough to carry the product for substantial periods, particularly if the contents are highly concentrated. Also it is very important to check the compatibility of the products with metallic substances in the containers. Usually phenolic or epoxy lined metal containers are recommended for packing liquid pesticides. In Assab, there is a 200L metal drum manufacturing facility for asphalt products. The steel sheets are being imported from abroad. By using lined or coating the metal sheets it may be able to produce lined drums for pesticides and other chemical or food products. It is strongly recommended to produce metal containers, such as 5L oblong cans, 20L pails and 200L drums according to the specifications described in ASTM. These sizes are very popular and can be used for other products as well. Importation of empty containers from abroad is not really economical or practical due to the volume of transportation. Shell Oil Company near Addis Ababa is going to manufacture 200 L metal drums for oil products.

Specifications required in the purchase of pesticides containers are shown on the Annex 2. These specifications are not only applicable for the purchase but also for manufacturing. More detailed data is also available in ASTM as mentioned earlier.

13.1.3. Glass Containers

There is SAVA glass in Asmara 1080 km North of Addis Ababa. The factory manufactures a large range of products:

bottles, tumblers, jars, ash trays, and in general, any kind of hallow articles for every use. Hand blown articles are also manufactured. Both flint and amber glass are used. Main raw materials are silica and calcium carbonate from local sources and soda ash from Kenya. A glass bottle manufacturer in Addis Ababa is producing 350-750 ml amber and clear glass bottles for the requirement of drinks such as beer, wine, mineral water, etc. Due to the unavailability of mould, however, the threaded neck 250-500ml glass bottles with screw caps to be used for pesticides are not being manufactured. However, 900ml threaded neck bottles are manufactured in the plant for alcohols. The screw caps can be made locally if the mould becomes available. Usually 28-32mm x 410 plastic caps with aluminum foil liner are ideal for 250 ml - 1 litre glass bottles which are required for small peasant farmers and household or public health pesticidal products. If possible, small sizes aluminum container production may be amalgamated with other metal containers, such as 5L oblong cans or 20 L pails which are also required for other products. For safety, aluminum bottles are superior to glass ones, but the cost is much higher in aluminum.

Due to the blockage of road to and from Asmara, the supply of glass bottles from SAVA glass is neither practical or possible.

Addis Glass Factory is equipped with two machines, one for tumbler production and the other for bottles. They have approximately 150 full time production workers and 150-200 part-timers producing 40,000 beer bottles per day through 24 hours of cperation. As a lack of skilled workers

the productivity is very low and damage or loss during the production is as high as 20 percent. The mould is designed by an Italian company and built by an English, and that costs over 40,000 U.S. dollars. 2.5 million bottles can be produced with one set of mould. It is strongly recommended that UNDIO should arrange the on-the-job training for mould making for both plastic and glass bottles, thus they do not have to spend huge amount of foreign currencies to import the moulds from overseas.

By printing small amber peroxide glass bottles this can be used for packaging liquid pesticides for small farmers. At present, 350 ml beer bottle cost approximately 0.6 Birr in retail stores.

13.1.4. Paper Products

Paper products such as bags and cartons, are locally manufactured. It will be possible to produce paper bags in accordance with the specifications provided by the ASTM. Bags should be made with more than one ply of material. The inner ply will usually be polyethylene film which provides an excellent moisture barrier and is resistant to attack by most chemicals. The thickness of the film should not be less than 0.02mm and the thicker film upto 0.08mm may be used for better leak-proof. These plastic films, liner, etc. can be manufactured by Ethio-plastic in Addis Ababa in accordance with the International Standard specifications. However, it is required to carry out all the testings according to the CIPAC Handbook and the ASTM before making decision to use them. Ethiopian Pulp and Paper Factory in Wonji is manufacturing cartons. The material used to manufacture carton products is corrugated cardboard composed of 3 layers of paper, the inner one being corrugated. Raw material for corrugated cardboard manufacturing is mainly:

Kraft paper of 150 g/m^2

Semi-chemical paper (to be corrugated) of 127 g/m^2

Test liner of 170 g/m^2

The last one is manufactured in the country by Ethiopian Pulp and Paper Factory in Wonji and all other items are imported. Considering that upto 9 different types of cartons are manufactured, the imported paper rolls have to be of suitable. For gluing purpose, neutral silicate solutions are used.

13.1.5. Closures

For packaging, one of the most important factors is closure, capping, etc. There are many different ways for closing such as sealing, capping, folding, twisting, etc..

For liquid products, screw caps are the most popular, practical and safe. The selection of materials for the caps and liners are also important, the range of size should be 24mm to 38mm depending on the size of the bottles and viscosity of the product in the bottle. To check the tightness of capping, torque tester is required, and for the leaking test leave the bottle with the contents upside down for 24 hours. All other test should be followed by the ASTM. Childproof caps are also recommended for further protection.

For solid products, heat sealing on twister for plastic bags, hot glue or sawing for paper bags and screw or snap on caps for jars, bottles or canisters. For small sizes, such as 500 grams, 1 kg. or 2 kg., perforated plastic or metal caps are recommended for easy and safe application of dust or granular products for household, small farmer and public health purposes. For drums, selection of proper gasket is very important for the prevention of leakage of liquid products. The seal or gasket should stand and be compatible with the contents. It may be stated that without

the proper supply of packaging materials and availability of technology, the establishment of a pesticide formulation plant should be reconsidered.

For standardization and quality control of packaging materials, the following references can be used as guidelines.

ASTM D 15.9	Paper packaging
ASTM D 15.02	Glass containers
ASTM D 14.02	Durability of non-metallic materials.

14. INDUSTRIAL SAFETY AND OCCUPATIONAL HYGIENE

Safety requirement in pesticide formulation plant is very important. There are possible risks happening at several stages in different ways. Besides the risk from machinery and equipment during its operation, plant workers may be exposed to toxicant in the form of liquids, vapours and dusts. Other hazards come from working with processing equipment, and fire and explosion hazards come from dust or vapour-filled environment.

For the operational safety, the equipment purchased should comply with national or international standard specifications such as ASTM, ILO and IOS.

Climatic conditions affects standards, in tropical zone it is better to assure the best plant design and construction to avoid excessive dependence on individual workers by the use of uncomfortable protective clothing.

Safety regulations must be established in the plant. The inherent toxicity of pesticides needs a sound commitment to achieve high safety standards at all levels of workers.

14.1. SAFE OPERATION OF EQUIPMENT

The equipment and machinery for pesticide formulation and processing are not complicated. However, all the processes should be fully and properly documented for the safety of operators. The operator should be thoroughly familiar with the equipment and machinery which he is working with. Operating procedure for each equipment should be placed near the equipment so that the operator is able to read it whenever needed.

Formulation should not be started without a written formulation procedure. The procedure should be incorporated with danger and precautions to be taken. Material Safety Data Sheet (MSDS) on all chemicals involved should be available or attached to the procedure.

14.2. VENTILATION

A risk from inhalation of toxic dust and vapours should be prevented. A proper ventilation system such as exhaust fans should be installed. To be efficient, exhaust ventilation should be located as close as possible to the point where dusts, fumes or other contaminations generate. The ventilation should provide an air current with a face velocity of 0.5 - 1.0 m/second across the opening and discharging points.

14.3. INTOXICATION

Intoxication can be caused by absorption through the skin, inhalation of fumes or dust, or actual ingestion of pesticides. Skin contact is one of the most common causes of poisoning. Many liquid or dust pesticides can penetrate skin into blood stream. Inhalation is one of the quickest way of being poisoned as the fumes and vapors pass directly into the blood stream from the lungs. Ingestion is the least cause of accidental poisioning.

14.4. ENTERING A MIXING EQUIPMENT

A permit must be obtained before entering mixing equipment such as mixing vessel or any other one which is contaminated with toxic substance. The contamination in the equipment should be completely removed and the electric power to the equipment should be disconnected. The conditions of entry must be specified and the equipment shouldn't be started until the authority gives permit to operate.

14.5. FILLING EQUIPMENT

There are automatic, semi-automatic and manual filling equipment for both liquid and dry forms of pesticide formulation.

Depending on the nature of the equipment used and the product filled, precautions are required against splashing, over-flow and contamination of operators. It is necessary to adjust the equipment for each formulation to ensure the correct quantity and speed of filling. Operators must wear protective clothing such goggles, gloves and coveralls during the operation. Sufficient ventilation must be provided at the filling point and, for dust filling, dust exhaustion systems should be installed.

14.6. DUST COLLECTION

Dust formulation sites may cause atmospheric contamination due to dust. Because of static electricity, dust clouds or dust particles fires or explosions may occur. Dry formulation plant, in addition to the exhaust fans, must be provided with dust collecting and explosion proof equipment. It is essential to prevent dust dispersing in the plant as it can cause serious maintenance problems.

14.7. MEDICAL SUPERVISION

It is essential to arrange medical supervision because toxic chemicals such as malathion, diazinon, dimethoate, DDT, endosulfan, etc. will be used in the pesticide formulation plant. Pre-employment medical examinations are recommended for both full and part-time workers. As organophosphates will be handled, pre-exposure base-line blood cholinesterase activity level should be checked. All the plant workers, including warehouse crews, handling pesticides must have their cholinesterase checked regularly. Detailed records of the results should be kept and be explained by a physician.

In the case of suspected or acute intoxication, immediate assistance of the doctor should be sought. The doctor must be fully informed of the chemicals handled and

should keep the necessary antidotes. The plant should have its own first-aid center and certified nurse. A manual on the first-aid and antidotes should be available for nurses and doctor at any time.

14.8. PROTECTIVE CLOTHING

To prevent the accident, it is necessary to wear proper protective clothing in the plant.

For head protection hard hats or cloth caps should be worn. To protect eyes, non-breakable goggles or even a face shield must be worn. A water proof apron is needed when handling liquids. Hands should be protected by the use of rubber or plastic gloves. For comfort in the hot climates a disposable thin cotton glove may be worn inside the rubber gloves. To protect the respiratory tract, dust masks or a respirator should be worn. Filter cartridges should be changed every day or more often if pesticide odour is noticeable through the mask. Use of self-contained air supply respirator should be worn when working inside blender, tanks or dust hoppers during cleaning and repair operations.

15. INVITATION TO TENDER

The expert provided the NCC with the names of companies who are manufacturing pesticidal active ingredients to be used for the formulation of liquid and dust pesticide in this country. Among these names, the NCC sent the documnet "Invitation To Tender" to the following six companies on January 25, 1989 and the closing date was set for February 28th, 1989.

No. 1. Sumitomo Chemicals of Japan.
No. 2. Garbato Impianti Chimi of Italy.
No. 3. Hindustan Insecticides of India.
No. 4. Bayer of FRG.
No. 5. Endeco of Italy.
No. 6. Agrimec Barral of Italy.

Out of above six companies two of them No. 1 and 2 have withdrawn, No. 3 and 4 submitted financial offers only and the other two No. 5 and 6 complete offers.

15.1. EVALUATION OF OFFERS

As a result of interim evaluation by the evaluation committee No. 5 and 6 were considered to be lack of technical back ground in the field of pesticide formulation technology which is one of the important parts in this project. Therefore, the committee requested the companies to bring technical partner to support the project and improve the facilities to meet the requirement of industrial hygiene, safety features and effluent control for the plant operation, and the deadline was set for March 27th 1989. They have improved the layout according to the committee's request, but the participation of technical partner was not

confirmed until the expert's departure from the duty station.

While waiting for the responses from the No. 5 and 6 for their improvement, the evaluation committee opened the financial offers from the companies NO. 3 and 4, who have technical background in the field of pesticide formulation technology, and it was found that the offer from company No. 3 was lower than even No. 5 or 6.

The expert recommended as follows. If the No. 5 and 6 are not able to find qualified technical partner, the expert suggested that the NCC to request the company No. 3 to provide technical offer and complete information to meet the tender requirement, such as specificaitons of machinary and equipment, design and layout of the plant. If technical offer provided by No. 3 does not meet the requirement, the NCC may give the company a chance for the improvement, then compare it with the offers from No. 5 and 6.

For the implementation of the project, the winner of the bidding will be requested to complete the document in the attachment "A Winner of the Bidding" (page 68).

16. PLANT SITE

According to the previous studies Tendaho was recommended as a proposed site for a liquid formulation plant because 70% of liquid pesticides are used in this area, and the raw materials will be in imported through the port of Assab. However, the NCC recommends Adami Tulu area as a proposed site because of the availability of water, electric power, manpower, housing and dust diluents in the area.

If the plant is established in Tendaho area, housing has to be provided for all the employees, 40% extra salary to be paid, and water and electric power are not readily available. Also, the plant has to be airconditioned due to the high humidity and temperature.

16.1. Proposed Plant Site

The proposed plant location for the pesticide formulation project is Adami Tulu, 170 km south of Addis Ababa, and the following matters were investigated by the NCC for the implementation of the proj t.

16.1.1. All weather paved highway links to the town of Adami Tulu, and motor tracks are also available. There is a railway, which starts from Addis Ababa, connecting to Mojo, Nazareth and Dire Dawa. Its terminal station is the port of Djibouti.

16.1.2. There are three power plants. They are located at Awash River about 100 km south of Addis Ababa and supplying electric power to the central, southern and eastern zones of this country. The current rate for manufacturing is 0.223 Birr per Kilowatt hour, and the power is supplied at 380 volts 3-phases and 220 volts single phase.

16.1.3. The water for processing, cleaning and sanitary services is available from Lake Ziway near the town. Water for drinking and laboratory use will be available either from local water supply or ground well. The rate for municipal water is 0.5 Birr per cubic meter.

16.1.4. Distances from the proposed plant site to the consumer areas and to the port of Assab are some of the factors to be considered. Distance from proposed plant location to Tendaho, the major liquid consumer area, is 572 km and to the port of Assab 880 km. However, main consumer areas of dust products are located in the central, southern and western area of the country.

16.1.5. Other aspect of factors are labor and social amendities. There are adequate labor and facilities to meet the requirements.

16.2. Site Survey

A trip to Adami Tulu and Ziway areas was made on February 9th, 1989 for the site survey.

16.2.1 The Site Information

Station	:	Adami Tulu	Ziway town
Latitude	:	N: 7°55'	N: 8°00'
Longitude	:	E: 38°45'	E: 38°45'
Elevation	:	1650m	1640m

16.2.2. The area has a wet season from July to September a dry season from October to January and a season of highly variable rainfall from February to June. The monthly average rainfall never exceeds evaporation. The climate data are available from NCC.

16.2.3. Monthly rainfall data for selected sections are available from NCC. The mean annual rainfall at Adami Tulu (1914-40 and 1956-69) is 602mm, maximum daily rainfall in Adami Tulu (dated 14/3/70) is 81.1mm.

16.2.4. Mean annual evaporation around Lake Ziway is about 2000 to 2200mm compared with a rainfall of 300-750mm. Evaporation exceeds rainfall in every month of the year. The measurements of evaporation are undertaken at Ziway town with a Pichi instrument and a class 'A' evaporation pan.

16.2.5. The mean daily temperature at Ziway is 19.3°C. The highest temperatures occurs between March and June prior to the start of the main rains. While frost has not been recorded at Ziway, the minimum temperature in the dry season falls below 10°C and sometimes to 4°C.

16.2.6. Humidity is highest in the wet season, and lowest in February and March. Throughout the dry season and generally between 1200 and 1500 hours, relative humidity is below 50%.

16.2.7. Strong and persistent daytime winds are significant feature of the Lake Ziway area. During the afternoon the dry season, the prevailing N/E winds are reinforced to the west and the south of the lake by a local on-shore air flow. The mean wind speed is relatively high, averaging 1.19m/m throughout the year. The windiest periods are November-January.

16.2.8. As evaporation rate exceeds the precipitation in the area in every month of the year, the evaporation pond may be constructed, if required in the future, to minimize the contamination of nearby water and food supplies, and for

the disposal of waste water.

16.2.9. Concrete reinforced with steel and laid in thickness of approximately 0.1mm may be used for construction of the pond in the area. For roofing the pond, fibre glass sheets may be used.

16.2.10. Solid will gradually be accumulated on the floor of the pond and required periodical removal. These solids can be disposed of in a secure landfill by putting in impermeable soils or liners to prevent leaching from entering ground water.

16.2.11. Well should be installed around the land fill and checked periodically to detect ground water contamination.

16.3. Comments On The Plant Site Visited

(1) The location has access to main road (highway).
(2) The area is accessible to the source of labour.
(3) The space for extension, if required, is available.
(4) The area is already zoned for industrial purpose.
(5) Soil survey had been done and the data is also available.
(6) The cost for the road pavement from main road to the site (highway) can be saved.
(7) As the site is close to the Caustic Soda Plant (under construction) the cost for the installation of electric power lines and water supply will be tremendously saved.
(8) Canteen, medical facilities, office building, maintenance shop, laundry facility can be shared with the Caustic Soda Plant if agreed.

(9) There will be huge saving in manpower and staff such as safety officer, security guards, mechanics, cleaners, etc. if they are consolidated to a certain degree.

(10) Due to the climate condition, such as low humidity, precipitation and temperature in comparison to other areas, work environment will be ideal for plant workers handling toxic substances.

(11) The location is accessible to the source of Diatomite, one of the important dust carriers, when it's developed.

(12) A large quantity of dust pesticides are used in this area, specially small farmers who require ready-to-use dust products.

(13) As the mean temperature is not too high on lower than the other areas, the cost of energy to maintain the warehouse temperature (approximately 30°C) will be economical.

16.4. Summary

As a result of analysis and investigation, the site in Ziway is considered to be one of the ideal locations for pesticide formulation plant.

17. PESTICIDE FORMULATION DESIGN

Currently all pesticides in Ethiopia are imported from abroad at the expense of limited foreign currency. To maximize the economic return only some selected pesticides would be formulated locally. The following aspects should be considered in selection: (1) type of pests involved (2) type of pesticide (3) type of formulation (4) method of application (5) efficacy (6) phytotoxicity (7) persistance (8) impact on wildlife and environment (9) pest resistance (10) availability of raw materials (11) climatic conditions (12) cost and benefit.

Since the Government has decided to produce ULV, E.C and dust formulations, this report describes only these formulations.

17.1. Ultra Low Volume (ULV) Formulation

ULV formulation is an oil concentrate containing high percentage of active ingredient and widely used in this country. It is usually used undiluted for aerial application but may be diluted to a ready-to-use formulation with inexpensive diluent. Aromatic hydrocarbons are generally used as solvents. If solubility of the active ingredient is limited in aromatic hydrocarbons stronger solvents such as cyclohexanone, isopropanol, can be added as co-solvents. Vegetable oils which are readily available in Ethiopia can be used as diluents.

When designing ULV formulations, volatility of solvents, viscosity, phytotoxicity and surface tension of the finished product should be considered. Generally, a solvent with moderate viscosity would be ideal. If the viscosity is too low the spray droplets would be too fine.

As the viscosity increases the droplet size will increase. The least volitile solvent should be used to minimize loss through volatilization. To increase the efficacy of the product addition of spreader-stickers is recommended.

17.2. Emulsifiable Concentrates (EC)

The main components of emulsifiable concentrate (E.C.) are active ingredient, solvent and emulsifier. Stabilizer such as epichlorohydrin can be added for certain formulations. For best results, the solvent must be able to dissolve the active ingredient to form a stable formulation under storage but should not be miscible with water. The widely used solvents are xylene and heavy aromatic naphtha, and kerosene is also used for this purpose but to a lesser extent. EC must be diluted with water to disperse uniformly with gentle agitation and remain stable throughout the spraying period. Therefore, this formulation is not really useful in the area where water is not available.

The physical properties of the mixture of the active ingredient and the solvent will determine the emulsifier to be used. Information on the solubility of active ingredient in various solvent is usually provided by the manufacture or supplier of the active ingredient.

Representative samples of different formulations containing the same active ingredient should be prepared in the laboratory to test their emulsification and stability. Impurities in the active ingredient affect the solubility and stability of the formulated products. However, selecting a proper emulsifier can be a difficult task. It is therefore advisable to use the one recommended by the manufacturer of the active ingredient.

17.3. Dusts

Dusts are finely powdered dry products containing active ingredients and diluents such as talc and kaolin. The active ingredients are usually less than 10% because they are applied directly to the field without further dilution. This formulation is ideal for the area where water is not available or scarce. Ethiopia has abundant resources of minerals that can be used as diluent or carrier for dust formulations of pesticides.

When dust formulations are prepared directly from solid active ingredients, a solvent must be used to dissolve the active ingredients to ensure even distribution on the carrier. High sorptivity carriers such as kaolin or diatomite should be used as carriers to prepare dust formulations with liquid active ingredients. Talc is the most common diluent used to dilute dust concentrates but is not available in this country. However, kaolin or diatomite can be used to replace talc and both kaolin and diatomite are available in this country. Because of the chemical reaction between the diluent and active ingredient it is necessary to add deactivator, such as dipropylene glycol, or to the diluent before adding the active ingredient. Particle size of the finished products should be 325 mesh. All finished products should be tested to ensure flowability, dustability and stability under storage.

18. EQUIPMENT AND MACHINERY

The equipment and machinery for the pesticide dust formulation plant are listed in Annex 3.

19. TECHNICAL REFERENCES ON PESTICIDES

Due to the limited availability of foreign currencies, it is not easy to purchase foreign technical publications, such as text books, journals, periodicals, hand books, etc. It is strongly suggested that the below listed publications should be purchased and stocked in library.

19.1. Periodicals and Journals

Economic Entomology.
Farm chemicals.
Pest Control.
Plant Protection Bulletin.
Journal of Agricultural & Food Chemistry
Crop Protection.
Weed Science.
Journal of Pesticide Science.
Journal of AOAC.
Pesticide Abstracts.
Journal of Science of Food & Agriculture.
Farm Chemicals Hand Book.

19.2. Books

Industrial Production and Formulation of Pesticides in Developing Countries Vol. 1 & 2.
FAO Specification of Pest Control Products.
WHO Specification of Pesticides used in Public Health.
WHO Guidelines to the use of the WHO Recommended.
Classification of Pesticides by Hazard.
UN Transportation of Dangerous Goods.
FAO Guide to Codex Maximum Limits for Pesticide Residues.

FAO & WHO Guidelines for Legislation
Concerning the Registration and Rebutting of
Pesticides.
Education and Handling in Pesticide Application.
Recognition and Management of Pesticide Poisoning.
Guidelines for Safe Handling of Pesticides During
Their Formulation, Packing and Storage and Transport.
Analytical Methods Pesticide Plant Growth Regulators
Pesticide Manual.
Guide to Chemicals Used in Crop Protection.

Herbicide Hand Book of Weed Science Society of
America.
CIPAC Hand Book. Including Annexe(s)
Proceedings for International Congress of Pesticide
Chemistry.
Pesticide Formulation Technology by J.W. Van
Valkenberg.
Pest Control Hand Book.
Pesticide Disposal Research.
Safety and Accident Prevention in Chemical
Operations.
EPA, Manual of Chemical Methods for Pesticides and
Devices.
Manuals for Prevention of Cross-Contamination of
Pesticide Chemicals.
McCutcheon's Surfactant and Emulsifier Manual
A World Compendium 15 BN 0-901436-77-1
Pesticide Manual by British Crop Protection Council

20. FINDINGS AND RECOMMENDATIONS

In addition to the recommendations under each section, the following matters should be considered.

(1) All the raw materials for the formulation of pest control products should be tariff free.

(2) Once a finished product become available from the formulation plant, the importation of the similar or same product should be suspended or phased out.

(3) The packaging material, such as cans, drums, bottles, caps, bags should be locally produced and available.

(4) The diluents, carriers and solvents should be thoroughly tested in accordance with the manuals and specifications prior to use.

(5) In order to save the cost of organic solvents, a research to develop water based formulation of pesticide products is also recommended.

(6) For small farmers, public health and household pest control, the small packages of both liquid and solid products should be produced.

(7) The packaging standard, including proper labelling, should be established and enforced.

(8) Pesticide storage in the field should be improved to protect both personnel and the products i.e. installation of exhaust fans and temperature control in the warehouse.

(9) Material handling equipment and protective clothing should be provided and used for the safe handling of pesticides.

(10) Sufficient technical literature and information should be available for pesticide formulators and users.

(11) Empty container disposal system should be established and enforced.

(12) For the selection of plant site, not only the distance to and from the transportation and distribution of raw material and finished products, but also the security and environmental factors should be considered.

(13) Distribution of small pack for peasant and small farmer should be improved for the availability of pest control products when required.

(14) To maximize the productivity and to minimize the complication, keep the variety of the products to be formulated in the plant as less as possible.

(15) Very strong technical partner, who is able to provide on-the-job training, formulation technology, quality control procedure, plant operation, product management, stock control, industrial hygine, etc., is required.

(16) It is suggested to look for relief fund or aids for the contruction of the plant, procurement of equipment and machinery, and for initial training of key personnels.

(17) It is strongly recommended to start the formulation plant in pilot scale. When they become fully acquainted with the operation and technology they may expand the facility to the commercial scale.

(18) In order to suffice the requirement of plastic bottles, caps, glass bottles and closures for pesticide packing it is recommended to increase the moulds and blow moulders in the existing factories. UNIDO's accistance in the training of skilled worker to make moulds is also recommended.

(19) Production programme of the pesticide formulation should be decided in cooperation with the MSFD, MOA/AISCO and the Ministry of Health.

21. LIST OF ORGANIZATIONS CONTACTED

(1) Ethiopian Plastic Factory, Addis Ababa
(2) Ethifoam Factory, Addis Ababa
(3) Ethiopian Glass Factory, Addis Ababa
(4) Hoechst Ethiopia Ltd., Addis Ababa
(5) Mineral Resources Development Corporation, Addis Ababa
(6) Addis Exporters Ltd., (HIL Agent in Ethiopia) Addis Ababa
(7) Ministry of Industry, Addis Ababa
(8) Ministry of State Farm Development, Addis Ababa
(9) Mojo peasant Association, Mojo
(10) United Nations Development Programme, Addis Ababa
(11) Sidamo Agricultural Development Enterprise, Sidamo
(12) World Health Organization, Representative Office, Addis Ababa
(13) Ethiopian Petroleum Corporation, Addis Ababa
(14) National Chemical Corporation, Addis Ababa

A Winner of the bidding should provide the following:

1. Scope of Supply and Services by Contractor

a) Supply know-how and basic engineering

b) Supply civil design and detailed technological design engineering

c) Establish and supply list of equipment and spare parts

d) Supply the list of suggested vendors

e) Supply all equipment and materials

f) Inspection of equipment during fabrication

g) Supply test certificates for equipment

h) Ensure seaworthy packing of the equipment

i) Transport the equipment

j) Take care of inspection of equipment

k) Supervise storage of equipment

l) Supply equipment for "pert plan" net work planning system

m) Guidelines, direct and supervise the erection of all equipment

n) Guide, direct and supervise all erection tests preparation of equipment for mechanical start-up

o) Guide and supervise the commissioning of plant until the performance of plant garantee tests begin

p) Supervise the operation of the plant from the start-up until the performance of guarantee tests

q) Prepare programmes for training

r) Train plant manager, formulation chemist, quality control chemist, batch makers, etc.

s) Basic and detailed design of the waste control system occupational hygiene, basic design for drainage systems, basic data for communication system and basic data for civil and electrical systems

t) Supply of structures for civil works and process doors, windows and glasses

2. - Specification of the Equipment

3. - Scope of Supply and Services by N.C.C.

a) Transport of equipment for F.O.B. Italy port to the site
b) All the insurance coverage
c) Development of the project site
d) The construction of the civil works
e) The construction of the plant internal roads
f) The supply of the drinkable water
g) The supply of the electric power
h) The final painting of the steel structure
i) The temporary housing facilities
j) The sewarage
k) The supply of all utilities
l) The supply of raw materials for the start-up of the plant
m) Local personnel participating in the erection work, trial tests and commissioning under suppliers guidance and supervision
n) Supply of process water upto the fence
o) Supply of electric feeding lines
p) Supply rain
q) Construction of sanitary water system
r) Basic and detailed design of telecommunication network
s) Basic and detailed design of office building, canteens, fence, etc.
t) Detailed design of road and drainage system
u) The supply of erection equipment
v) Delivery of expendable items such as fuel oil, laboratory reagents, raw materials and utilities.

4 - Project design data and criteria
5 - Scope and delivery of project design
6 - Parameters of the raw and auxiliary materials
7 - Conditions for erection and commissioning of the plant
8 - Main analysis of raw materials and finished products
9 - Performance guarantee tests
10 - Training of N.C.C. personnels
11 - Price breakdown (Itemization)
12 - Standards and Regulations
13 - Conditions for reputations of supplier and technical partner
14 - Implementation schedule

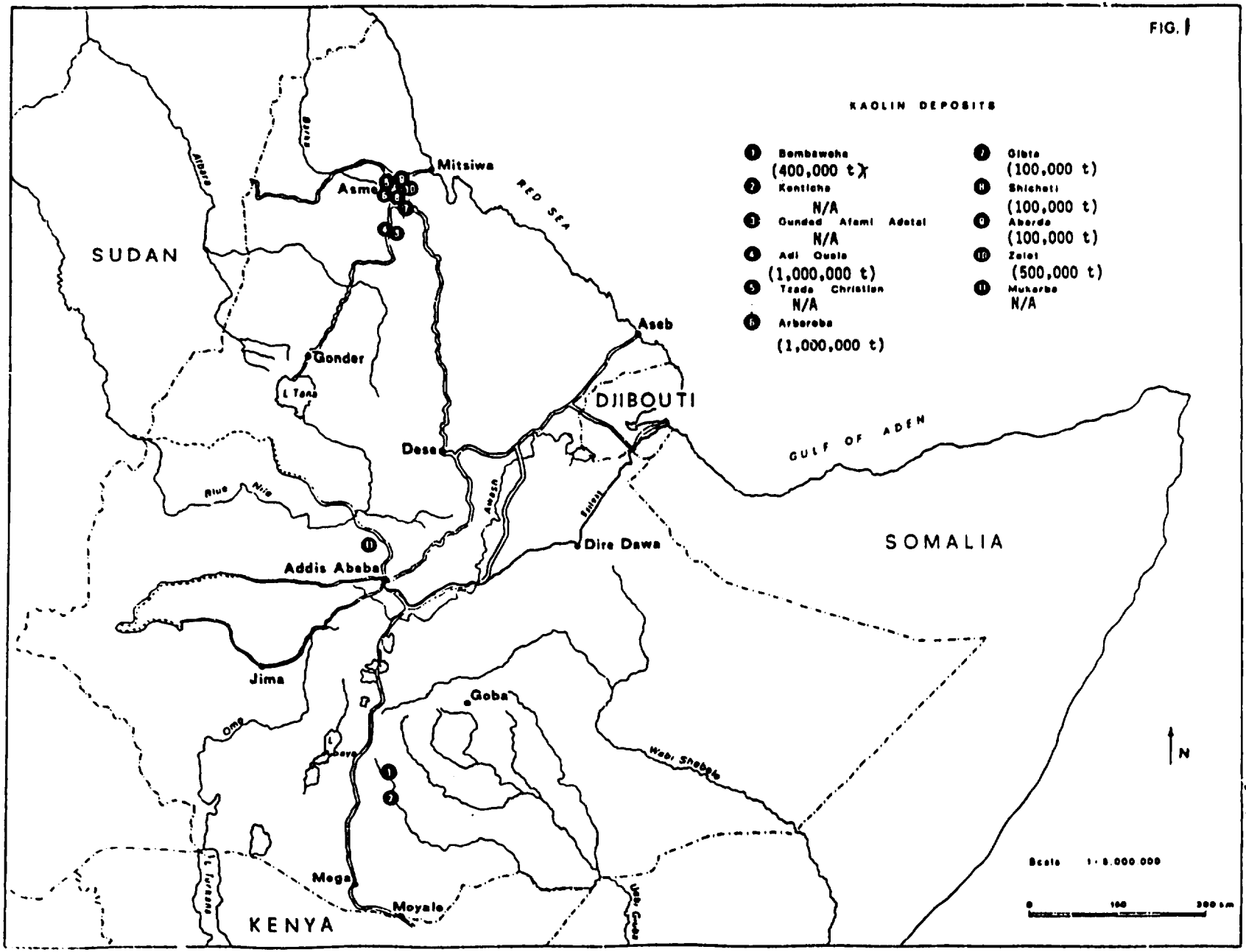
FIG. 1
KAOLIN DEPOSITS
1 Bombaweha (400,000 t)
2 Kentiche N/A
3 Gundad Afami Adetal N/A
4 Adi Ouela (1,000,000 t)
5 Tzada Christian N/A
6 Arboroba (1,000,000 t)
7 Gibta (100,000 t)
8 Shichati (100,000 t)
9 Aberde (100,000 t)
10 Zalet (500,000 t)
11 Mukerbe N/A
SUDAN
KENYA
SOMALIA
DJIBOUTI
Mitsiwa
Asmara
Aseb
Gonder
L. Tana
Dese
Addis Abeba
Dire Dawa
Jima
Goba
Mega
Moyale
RED SEA
GULF OF ADEN
Blue Nile
Awash
Baro
Omo
L. Rudolf
Wabi Shebele
Ganale Doria
L. Turkana
Scale 1 : 5.000.000
0 100 300 km
N

Annex 1
Fig. 1.

FIG. 2

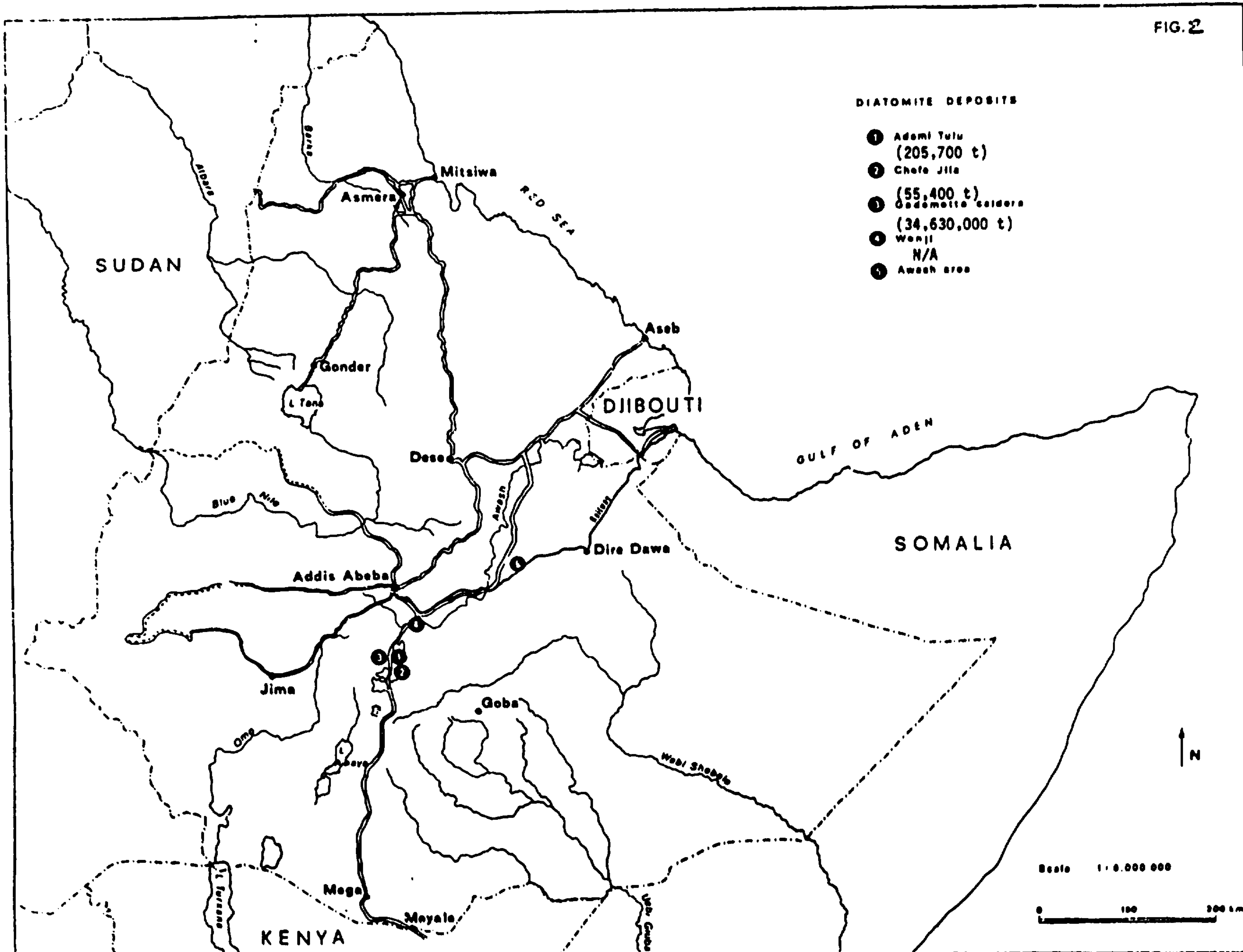
DIATOMITE DEPOSITS
1 Adami Tulu (205,700 t)
2 Chefe Jila (55,400 t)
3 Gademotta caldera (34,630,000 t)
4 Wenji N/A
5 Awash area
SUDAN
Mitsiwa
Asmera
RED SEA
Aseb
Gonder
L. Tana
DJIBOUTI
GULF OF ADEN
Desse
Blue Nile
Awash
Dire Dawa
SOMALIA
Addis Abeba
Jima
Goba
Omo
Webi Shebele
N
Mega
Moyale
KENYA
L. Turkana
0 100 200 km

FIG. 2.

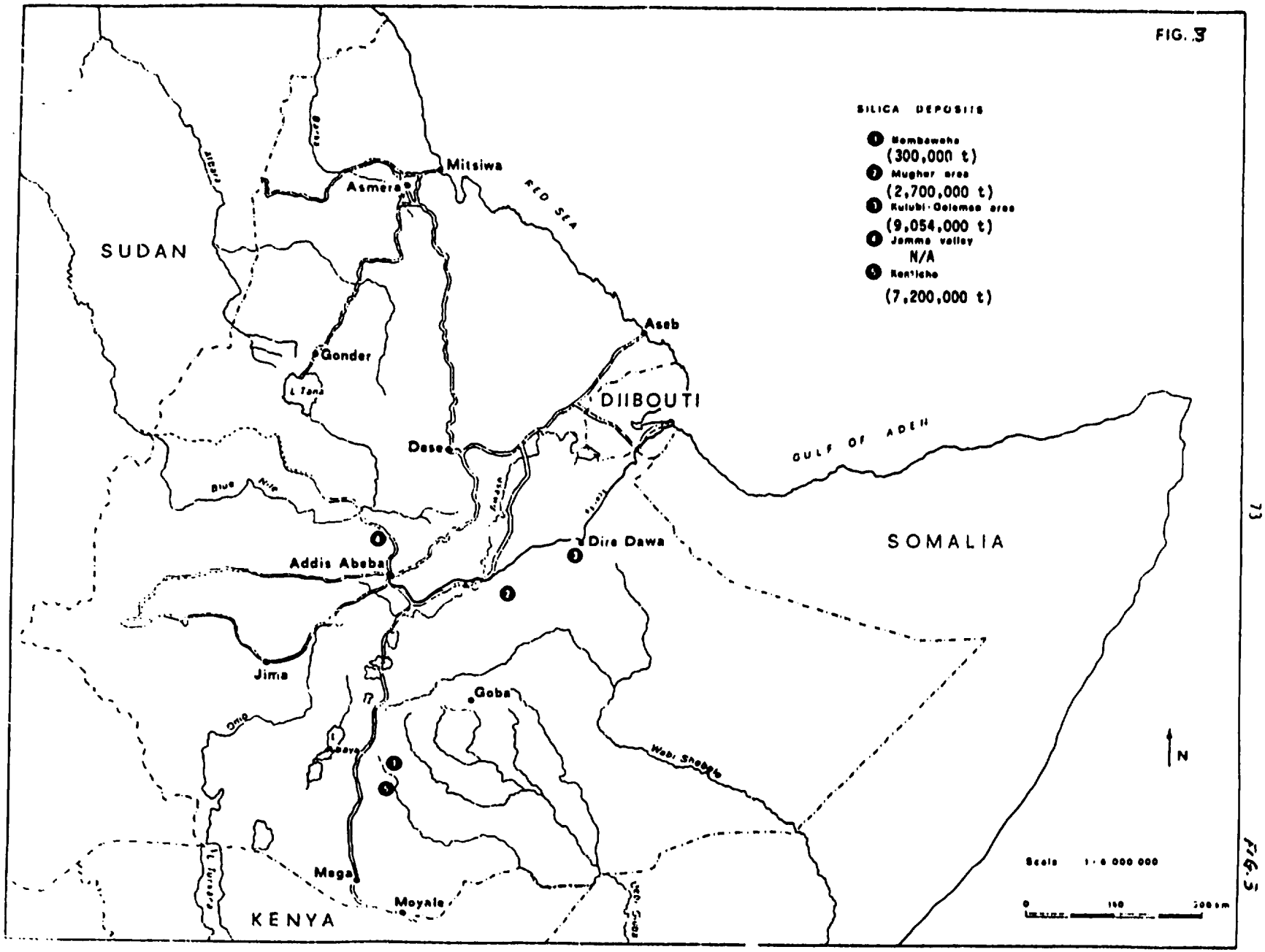
FIG. 3
SILICA DEPOSITS
1 Bombaweha (300,000 t)
2 Mugher area (2,700,000 t)
3 Kulubi-Golemso area (9,054,000 t)
4 Jamma valley N/A
5 Rantcho (7,200,000 t)
SUDAN
Asmera
Mitsiwa
RED SEA
Aseb
Gonder
L. Tana
DJIBOUTI
Desee
GULF OF ADEN
Blue Nile
Awash
Dire Dawa
SOMALIA
Addis Abeba
Jima
Goba
Omo
L. Abaya
Wabi Shebelle
Mega
Moyale
KENYA
N
Scale 1 : 6 000 000
0 150 300 km

Fig. 3

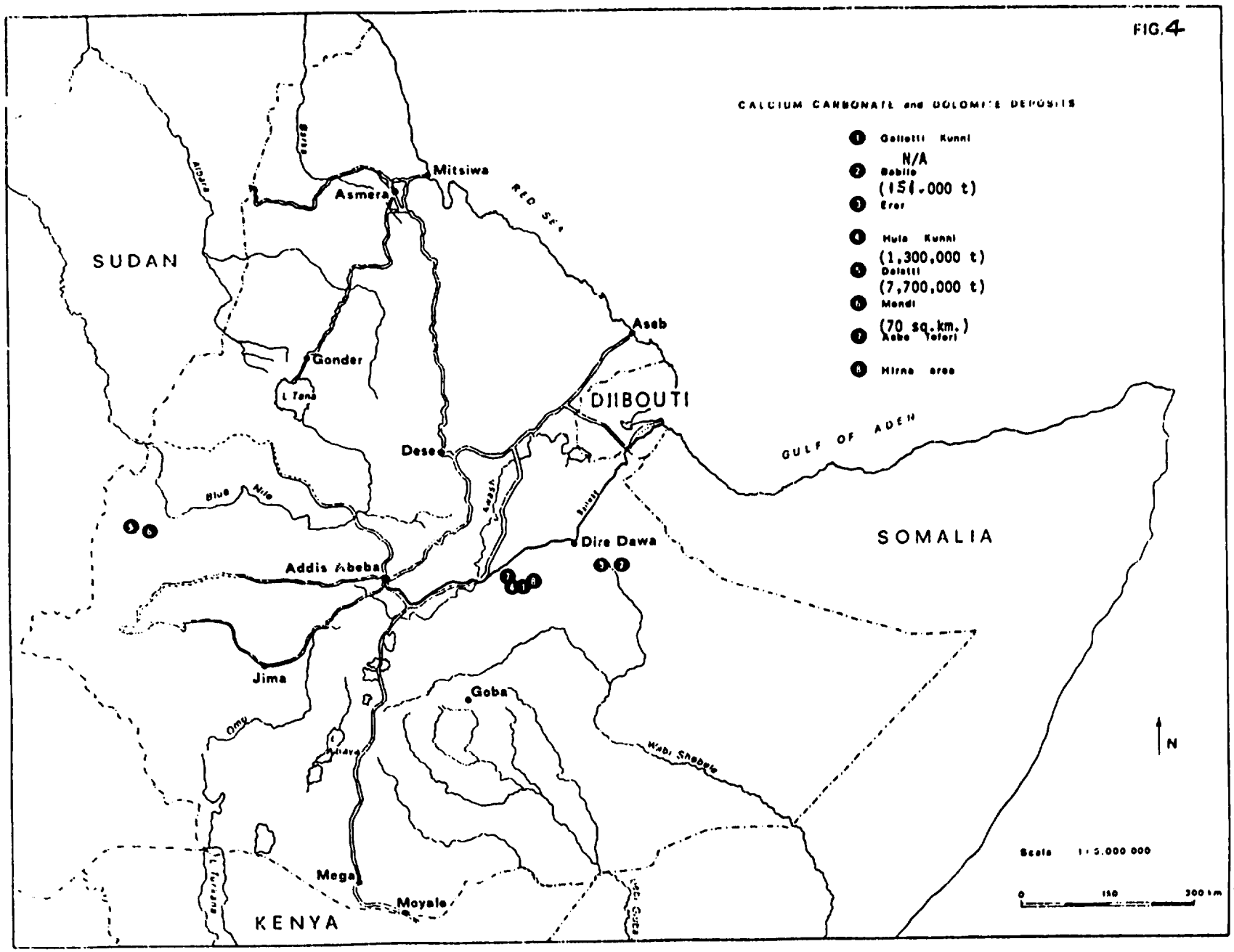
FIG. 4
CALCIUM CARBONATE and DOLOMITE DEPOSITS
1 Gelletti Kunni
N/A
2 Babile
(151,000 t)
3 Erer
4 Hula Kunni
(1,300,000 t)
5 Delatti
(7,700,000 t)
6 Mendi
(70 sq.km.)
7 Abbe Teferi
8 Hirna area
SUDAN
Mitsiwa
Asmera
RED SEA
Aseb
Gonder
L. Tana
DJIBOUTI
Desee
GULF OF ADEN
Blue Nile
Awash
Dire Dawa
SOMALIA
Addis Abeba
Jima
Goba
Omo
L. Abaya
Mega
Moyale
L. Turkana
KENYA
N
Scale 1:5,000,000
0 150 300 km

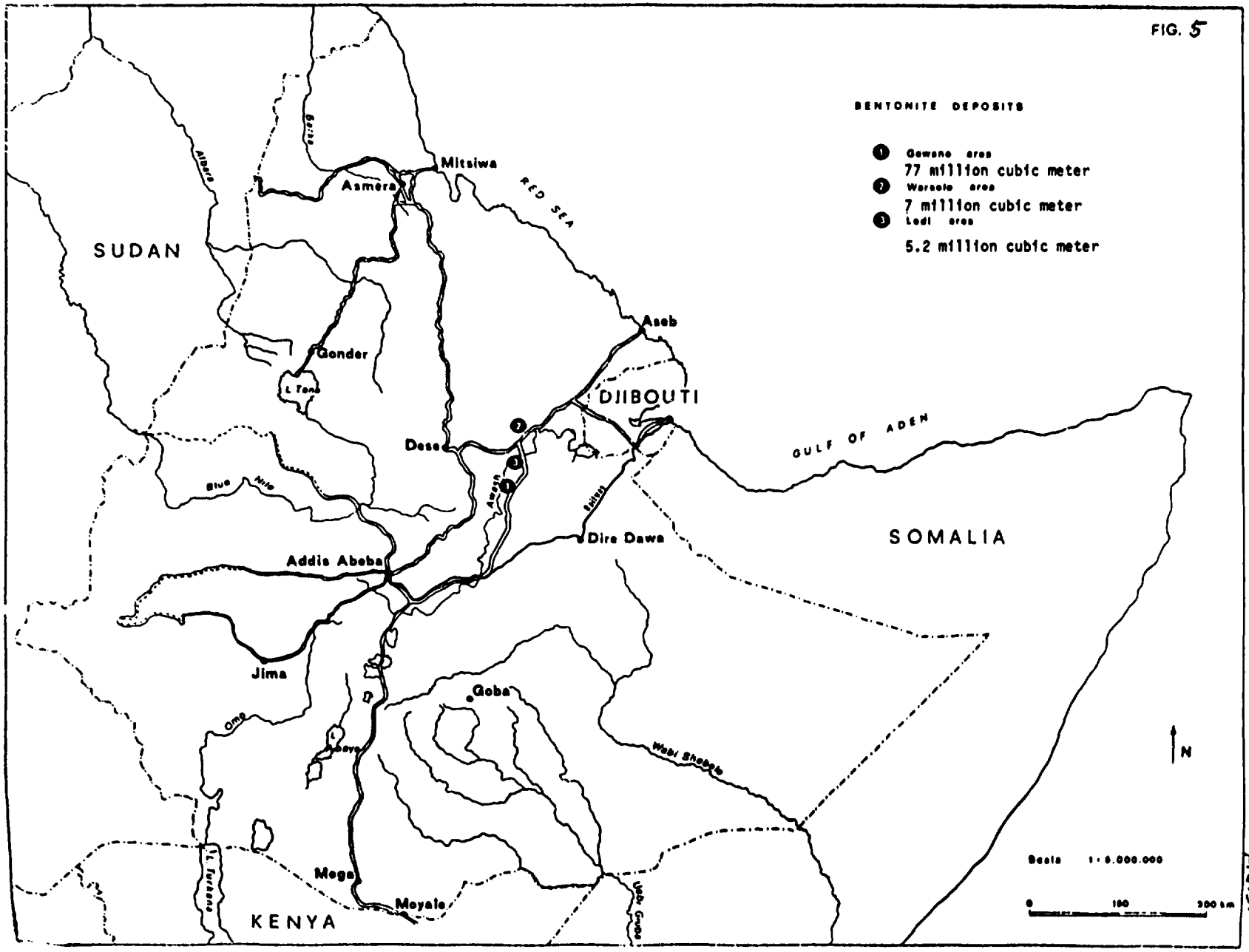
FIG. 5
BENTONITE DEPOSITS
1 Gewane area
77 million cubic meter
2 Werasole area
7 million cubic meter
3 Ledi area
5.2 million cubic meter
SUDAN
KENYA
SOMALIA
DJIBOUTI
RED SEA
GULF OF ADEN
Mitsiwa
Asmera
Aseb
Gonder
L. Tana
Dese
Blue Nile
Awash
Dire Dawa
Addis Abeba
Jima
Goba
Omo
L. Abaya
L. Turkana
Mega
Moyale
Wabi Shebele
Ueb Ganale
N
Scale 1 : 5.000.000
0 100 200 km

Fig. 5.

SPECIFICATIONS REQUIRED IN THE PURCHASE AND MANUFACTURE OF PESTICIDE CONTAINERS

Specification item	Packaging item																
	Bags	*Sacks*	*Pouches*	*Polyethylene bags*	*Adhesives*	*Pallets*	*Fibre drums*	*Polyethylene drums*	*Steel drums*	*Steel pails*	*Tin cans*	*Polyethylene jugs*	*Labels*	*Closures*	*Boxes*	*Booklets*
1. Outside length or height	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
2. Outside width or diameter	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
3. Outside depth	X	X		X		X					X	X			X	
4. Inside length															X	
5. Inside width															X	
6. Inside depth															X	
7. Nominal capacity				X			X	X	X	X	X	X				
8. Actual capacity							X	X	X	X	X	X				
9. Number of pages																X
10. Flute															X	
11. Thickness	X	X	X	X			X	X	X	X	X	X	X			
12. Minimum average weight	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
13. Coatings							X		X	X	X					
14. Yield (m^2/kg)																
15. Substance weight (g/m^2)	X	X	X	X									X		X	X
16. Opening								X	X	X	X	X		X		
17. International Maritime Organization class							X	X								
18. Valve description		X														
19. Catalogue numbers				X	X		X	X	X	X	X	X		X		
20. Drawing numbers						X	X	X	X	X	X	X		X	X	
21. Materials of construction	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
22. Test values	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
23. Assembly			X	X											X	
24. Special features			X				X	X				X				
25. Outside decoration			X				X		X	X	X			X		
26. Printing	X	X	X	X			X	X	X	X	X	X	X		X	X
27. National freight designation	X	X	X	X			X	X	X	X	X	X			X	

A. Dust Formulation Plant

Capacity to produce- 1500 metric tons per annum. 1-8 hour shift operation per day. 250 operating days a year.

Item	Denomination and Broad Specifications	No. of
1.01	Ribbon blenders, stainless steel inside, 2	
1.02	capacity 2 000L each unit with approximately 16 HP motor and drive. Approximate dimension 12′ long, 3.5′ wide and 3.5′deep with round bottom. The motor and drive should be completely covered.	
1.03	Micropulverizer 325 s/s mesh screen (grate) and explosion suppression device.	1
1.04	s/s Kettle double well with heating coils. Capacity 200 L with spraying system.	
1.05	Air Compressor with explosion proof 1/2 HP1 motor.	
1.06	Exhaust Hood at feeding unit	1
1.07	Bucket Elevator. Height is approximately 110 meters.	1
1.08	Val e packer St. Regis type or Du Bell to weigh upto 25 kilograms.	1