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Industrial Dev. Officer

PRODUCTION OF SALT IN SIERRA LEONE

FROM SALINE SILT

REPORT PREPARED FOR THE GOVERNMENT OF

SIERRA LEONE

BY

K. L. SAHNI

(SALT EXPERT)

EXPERT OF THE UNITED NATIONS INDUSTRIAL DEVELOPMENT

ORGANIZATION AS EXECUTING AGENCY FOR THE

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(1) To be committed after clearance by the UNIDO

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I take the opportunity of expressing my deepest sense of gratitude to ,r. M. H. Kamali, Senior Industrial Development Field Adviser, Freetown and his staff there, Dr. J. G. M. Massaquoi, my counterpart there, Mr. M. Judt, Senior Industrial Development Officer, UNIDO Vienna, for their assistance in carrying out the assignment.

INTRODUCTION TO THE COUNTRY

Sierra Leone, covering an area of 27,925 sq miles (73326 sq kms) is situated on the West Coast of Africa. It is bordered on the North and North East by Guinea and on the South-East by Liberia. It is divided into four provinces - Eastern, Southern, Northern and Western area. It has 12 districts.

The Mende and Temne languages are widely spoken, but the majority of Sierra Leone speak Krio as lingua Franca. English is the official lanugage.

Freetown, the capital and principal city, has a population of about 500,000. The other Chief Town are Bo in the Southern province, Makeni in the Northern province and Kenema and Safadu in the Eastern province.

On 27.4.1961, Sierra Leone became an independent state. In SEptember 1961, Sierra Leone was admitted to the United Nation. On 19 April 1971, Sierra Leone became a Republic with the President as Head of State.

The map of the country is at annexure I. Sierra Leone is a predominantly agricultural country with over 65 % of its popuiation depending on farming and fishing. Rice is the basic crop as well as the staple food of the country. Other important crops for local consumption are cassava, maize, sweet potatoes, bananas, plantanes citrus and ground nuts. Coffee and palm kernels are the most important exports.

The currency of the country is Leones (Le.) One Le is equal to 100 cents. One US Dollar is equal to approximately 66 Le.

2. COMMON SALT PRODUCTION IN SIERRA LEONE.

(1) Common salt, or sodium chloride is a combination of two simple bodies- chlorine and sodium in the proportion of 35.5 parts by weight of the former with 23 parts of the latter. These figures represent the atomic weights or combining equivalents of chlorine and sodium respectively; so that 100 parts of salt will always be found to consist of 60.4 parts of chlorine with 39.6 parts of sodium. Salt does not resemble either of the elements of which it is composed. Chlorine is a yellow gas. Sodium is a metal of silvery lustre, capable of burning in the open air, and burning spontaneously in water. The chemical symbol of common salt is 'NACL' Na standing for natrium, the old name of sodium and CL for chlorine.

The specific gravity of common salt is taken 2 to 2.25. Its specific gravity is its relative weight, compared, at the same temperature and pressure, with the weight of an equal bulk of distilled water, taken as standard with the fixed value of 1.0. Owing to defective crystallization, it is hard to get two specimens of salt which will weigh alike.

Pratically in fact, however, it is twice as heavy as water.

Sodium chloride crystalizes in cubes, octahedrons, or intermediate forms. Manufactured salt has generally the appearance of an irregular, hollow, four sided pyramid.

Pure, anhydrous salt is colourless and transparent. Salt has sometimes pinkish or bluish tinge. These are from minerals or organic stains.

Its taste is saline- peculiar, conferring an agreeable flavour on all kinds of food.

There are many uses of common salt as will be seen from Annexure II.

(ii) PRODUCTION IN SIERRA LEONE

The total population of the country is 3.7 millions as per 1985 Census. Taking the requirements of salt 5 kilogramms per person per annum, the total demand of this essential commodity of daily use works out to 18500 tonnes annually. Against this, the production of salt in the country is approximately 4000 tonnes. The remaining need is being met by imports from countries like U. K., West Germany, the Netherlands, and mainly from Senegal.

3. RECOMMENDATIONS

3-1 In order to increase the production of salt by the existing process, the following UNIDO/UNDP assistance is recommended.

(a) To supply small diesel pumps to the salt manufacturers of MAKIMRA village (to begin with) to pump out rain water to commence manufacturing operations immediately after the rainy season is over. (para 4b-vi)

(b) To improve the method of transportation of brine from the main pit by pumping it into the storage tank for (i) filtration and (ii) to store brine for use in the rainy season. (para 4b-vi)

(c) To supply two evaporators to experiment in the months of February and March (para 6-i)

(d) To dig a pit about 5 metres deep in the silt area to examine if highly condensed brine could be had (para 6-ii)

3-2 UNIDO/UNDP may provide technical assistance in the form of a consultancy mission of three months (two of one and a half months each) for the above purpose.

3-3 Dr. J. G. M. Massaquoi be associated with the project and paid suitable renumeration/honorarium for supervising the execution of the above assistance. (para 7)

4. OBJECTIVE OF THE MISSION

Asses the extent of salt bearing silts and salt brine concentration at locations indicated by Sierra Leone authorities to have potential for industrial salt works and investigate the climatic conditions and soil characteristics at the site of the future salt works.

PERIOD OF MISSION

The short mission was from 18.12. 89 to 25.12.89.

4 A ASSESS THE EXTENT OF SALT BEARING SILTS AND THEIR CONCENTRATION

In fact, a lot of study has already been done in this regard. The data collected shows that the total area suitable for deposit of salt - laden silts in the country is estimated as 2347 km2. The list of villages where such silt is found is given at annexure III. Out of these 20 villages 11 are main salt producing which are shown in the map at annexure IV. The process of manufacture is given in para 4 B (ii) below. According to the study conducted, this silt contains about 8 % salt. Such silts are found at many places in other countries also and salt is made more or less by the same process because the content of salt in the silt is too low.

4 B As the rainy season was over some weeks ago, the manufacture work had not yet been commenced at any of the units. My visit to the most important and presently the biggest unit (Makimba) was arranged This village is 28 kms away from Freetown. 22 kms is tarred road and the 6 kms remaining is untarred and about 2 to 3 kms we had to walk to reach the site. The Manufacture work had not yet started but they will start in january 1990. At this source about 400 persons are engaged during the season in the salt industry, out of which 75 % are women.

The various operations in the process were explained to me step by step and the examination carried out by me is explained below.

4 B (i) SOURCE OF BRINE

A stream called "YEGBET" flows during the rainy season, which ultimately flows into the sea. During high tide, there is inflow if sea water also in the area. The water of the stream covers an area of about 6 hectares around this village during the rainy season. After the rains are over, the silt there dries up with a white thin spongy layer over it, which is called locally the salt laden silt. Of this silt they scrap about 0.25" and use it for salt making by the process explained in para 4 B (ii) below. Some water of the stream remains in a few pockets (hereafter termed in the report as main pit) at the bed of the stream after the rains are over and that is used in manufacture of salt. The density of brine in the main pit at the time of my inspection was 0° Be. The soil of the area of silt was somewhat spongy but no white formation then existed. The density of brine in the small pit dug by the manufacturers in the area was 1° Be. Obviously the initial concentration of brine is low.

4 B (ii) PRESENT METHOD OF MANUFACTURE OF SALT

This type of method produces salt from salt-laden silts deposited at coastal estuaries of the river/stream. This method involves producing a highly concentrated brine from salt-laden silts which are collected from the tidal flats and creek beds. The salt is leached out from the silts by a percolation process. A filter funnel is packed with the silt and water from the main pit is poured upon it. As the brine filters through the silt, a greater part of the sodium chloride is carried away in solution and as the brine trickles down, it is caught in a wooden trough (locally known CALABASH) about 20 cms long 12 cms wide and made of wood of which normally boats are made. This process is repeated till the concentration of the filtrate is high. This condensed brine is very valuable for the manufacturer. It is then removed to their huts and boiled in a pan made of galvanized iron sheet on a specially designed stove (furnace) using wood as fuel. The brine is evaporated to dryness. Salt is formed which is then put in a perforated basket and water is sprayed over it and allowed to drain for a day or two and dried in the sun. The process of spraying salt with water is to remove magnesium chloride to the extent possible to improve the quality of salt chemically and also in appearance.

4 B (iii)

The percolation tank made locally consists of a funnel made with sticks and lined with wood leaves. The filter medium at the bottom is a collection of well placed rice straws resting on small sticks. The filter is usually placed over a wooden trough that collects the filtrate (see annexures V and VI) Leaching of salt can be a slow process in this method. But the obstacle can be hurdled with many more tanks been put to use simultaneously during the process.

4 B (iv) WOOD FIRE STOVE FOR BOILING CONCENTRATED BRINE

It consists of a pan 100 cms x 10 cms in size, made of galvanized iron sheet and placed on a specially designed wood fire stove, the platform of which is 150 cms x 75 cms x 30 cms made of stones and mud provide with a chimney.

4 B (v) CHEMICAL COMPOSITION OF SALT

Analysis reports of indigenous production compared with salt imported from Senegal are available which are tabulated below:

	salt produced at MOKIMBA village	imported salt from Senegal
CaSo4	1.061	0.247
MgSO4	1.331	0.034
MgCl2	0.347	0 320
KCL	0.071	0.139
NaCl	97.050	99. 64

The results show 97.50 % of sodium chloride in the locally made salt, which is fit for human consumption.

The salt seen by me however. showed that it was mostly powdery and contained plenty moisture. The appearance was white.

4 B (vi) SUGGESTIONS FOR IMPROVEMENTS

According to a rough estimate, at Mikimba a batch of two with the help of children, produces 3 to 4 tonnes of salt per season. This production per family can be increased by 50 % if the following facilities are provided to them:

Presently they bring water from the main pit or small pits in the area to the filtration unit by buckets etc. If one or two reinforced cement concrete tanks are provided near the filtration unit they can pump brine from the main brine pit to the tanks and utilize it for manufacture of salt.

The same tanks they can fill up with brine before the on set of the rainy season and use it for filtration and boiling even during the rainy season to make salt. Of course only those manufacturers who reside near the units will be able to avail of the use of this brine.

The same diesel pump they can use for sprinkling brine from the main pit over the silt area after a few scrapings in order to make the area more saline.

At present, the manufacturers start the manufacturing operations in the middle of January and at that time the density of brine in the main pit is hardly 1 Grad Be. If the rain water from this pit is pumped out immediately after the rains are over, during high tide sea water which has the density of about 3 Grad Be. will enter the main pit resulting availability of somewhat higher density brine even during December and January. This will result in prolongation of the period of manufacture and availability of higher density brine and hence more production.

Notes: At the same village they have 4 units consisting of different groups of manufacturers. Therefore, facilities will have to be provided to all the four groups. To begin with providing facilities to this village may be considered. Approximately cost of the equipment proposed will be as under:

	NAME OF EQUIPMENT	NO.	COST US$
Item: 1.	PUMPS DIESEL 2 to 3 HP WITH EXTRA PIPES	5	5000
2.	RCC BRINE TANKS 5000 LITRES EACH	4	8000
3.	EVAPORATORS	2	1000
4.	DIGGING PIT	1	1500
5.	MISC. AND UNFORSEEN	L.S.	2500
	TRANSPORT FOR STAFF TO GO SITE		3000
		TOTAL	21000 US

5. STUDIES OF THE CLIMATIC CONDITIONS

For manufacture of salt by solar evaporation, it is necessary to make close observations of the meteorological data for that area based on which the period of the year suitable for salt production can be projected. It is mentioned that study in this regard has already been conducted:

The following tables are enclosed:

Monthly and annual rainfall		1980 - 1986		(annexure VII)
" do	- temperature	- do	-	(annexure VIII)
- do	- humidity	- do	-	(annexure IX)

Rainfall - It is the most important factor for consideration for setting up a solar salt work as one of the improved methods of salt production. The rain fall should be low and its distribution be restricted to only a few months leaving a long and dry weather for salt manufacture.

Relative Humidity - The lower the relative humidity, the greater is the rate of evaporation. Generally, humidity of 80 % or below is considered suitable for salt manufacture.

The annexures VII and IX will show that the rainfall and also the relative humidity in the area are very high and not suitable for setting up a solar salt work. A solar salt work was set up at Suen in this country in 1975 and had to be closed down after five years because making salt by solar evaporation in this country is not economically viable owing to unfavourable climatic conditions.

6. PROPOSED EXPERIMENTS

6 (i) The months of January to March are however some what dry months. RCC evaporators can therefore be tried on experimental basis to evaporate the condensed brine to make salt and save cost of wood used for boiling the condensed brine.

6 (ii) In the silt area a pit of about 5 metres deep be dug to ascertain if condensed brine is available at a lower strata. If available, the procution of salt at these places will increase in appreciable quantity. In fact, this is done in some areas to get condensed brine.

7. The following reports on salt production in this country were shown to me for studies:

1. Technology choice in the informal sector. The case of salt production in Sierra Leone (Dec 1987) by Dr. J. G. M.Massaquoi.

2. Small scale industrial salt production from salt laden silts (April 1989) written by Mr. Yonas Abera and supervised by Dr. Massaquoi.

3. Solar Evaporation of brine from salt laden silt by Alfred T. Gbakima and supervised by Dr. Massaquoi (1988 - 1989).

It will be observed from the above that Dr. J. G. M. Massaquoi has been taking keen interest in development of salt industry in this country and has sufficient knowledge about it. He needs to be associated with any assistance etc. to be given in this regard to these salt areas.

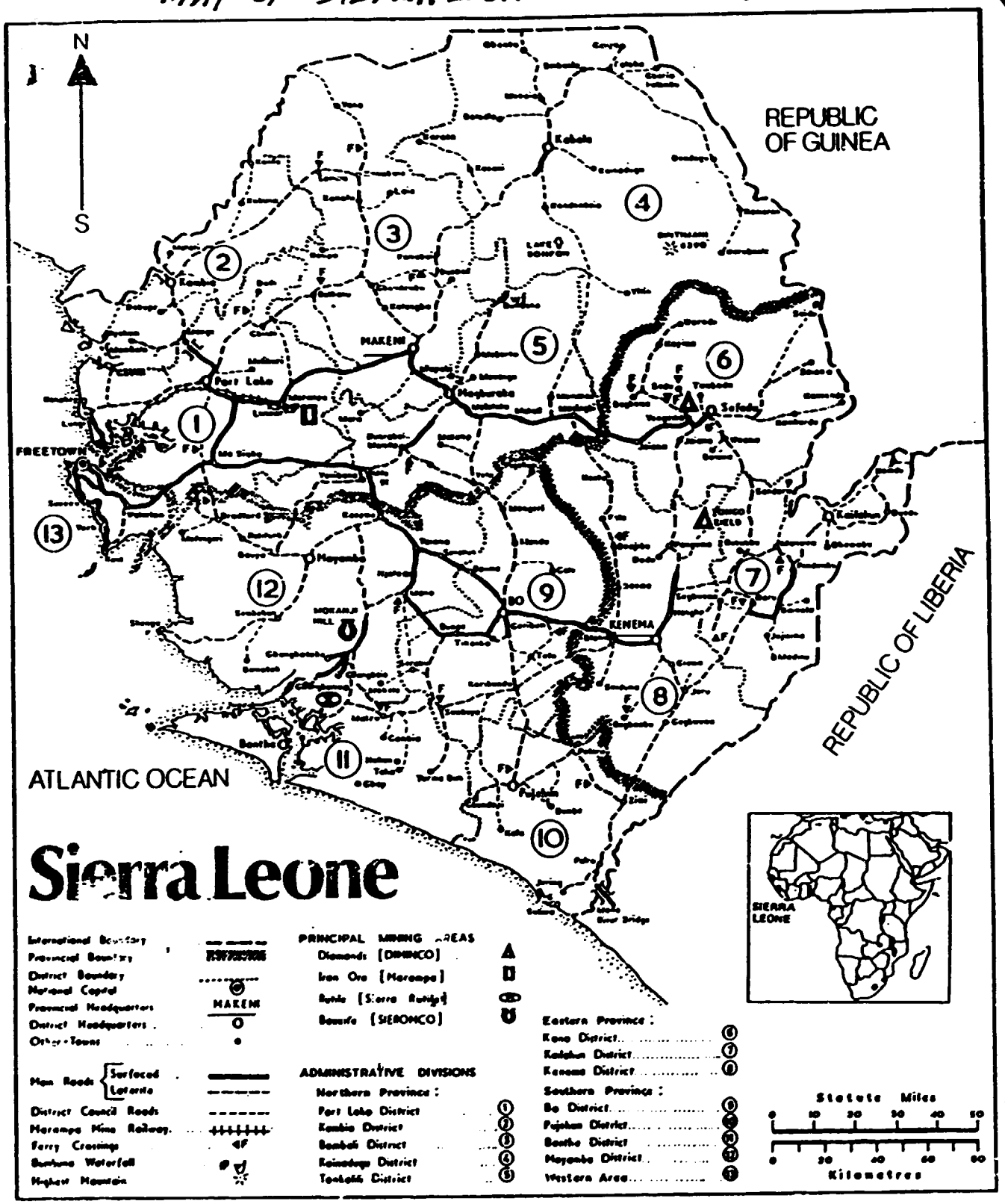
8. FINDINGS

The climatic conditions in the country are not suitable to set up an economic unit of solar salt work.

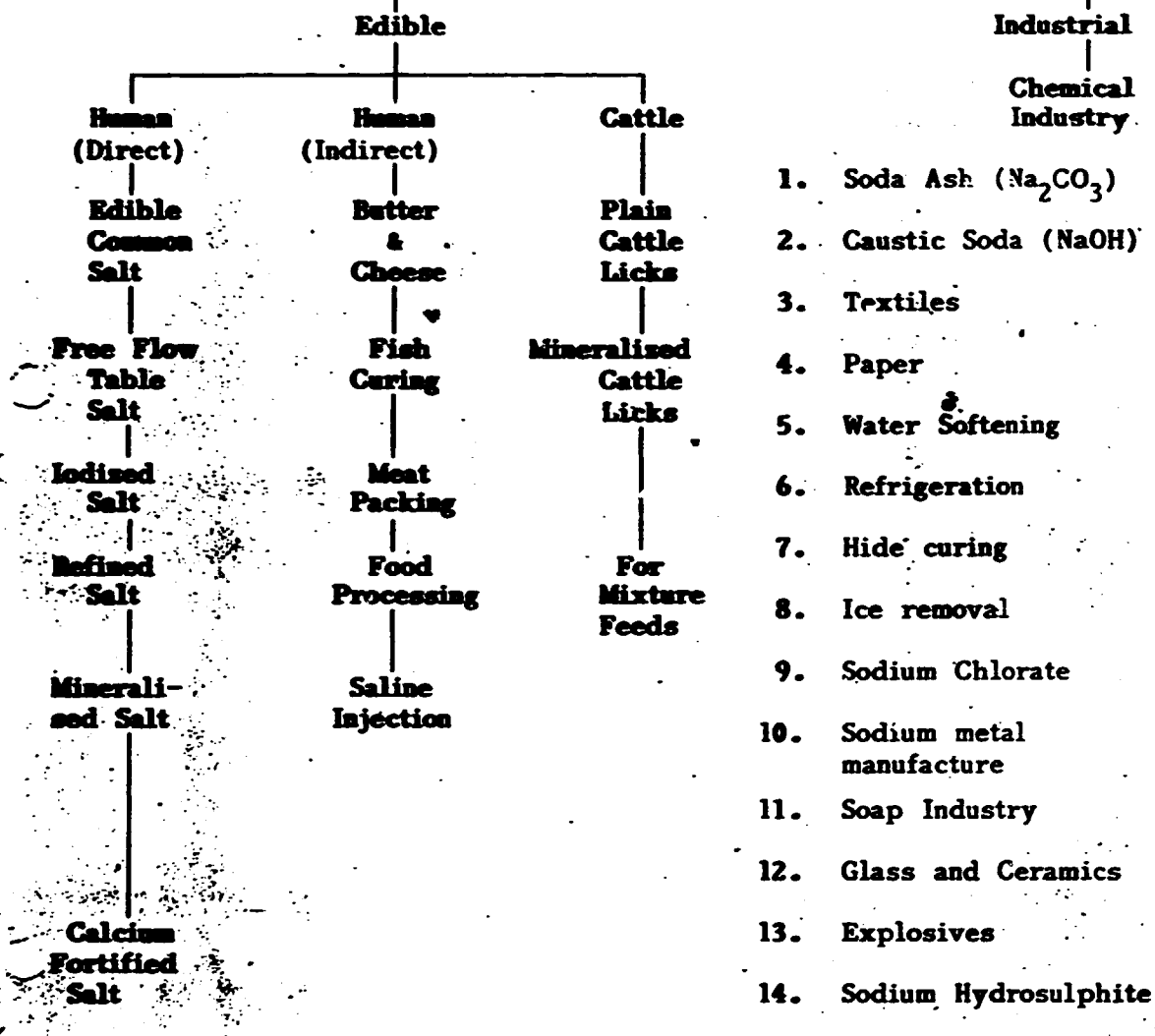
The sodium chloride contents in the silt and also the initial density of brine available in silt areas are too low to take up production of salt from the salines silt in a large scale manner.

The production by the existing process is to continue by the existing agency. To increase further the production of salt, the number of units need to be enhanced by persuasion/providing facilities to the manufacturers and for the purpose is understood to be available.

MAP OF SIERRA LEONE



USES OF SALT

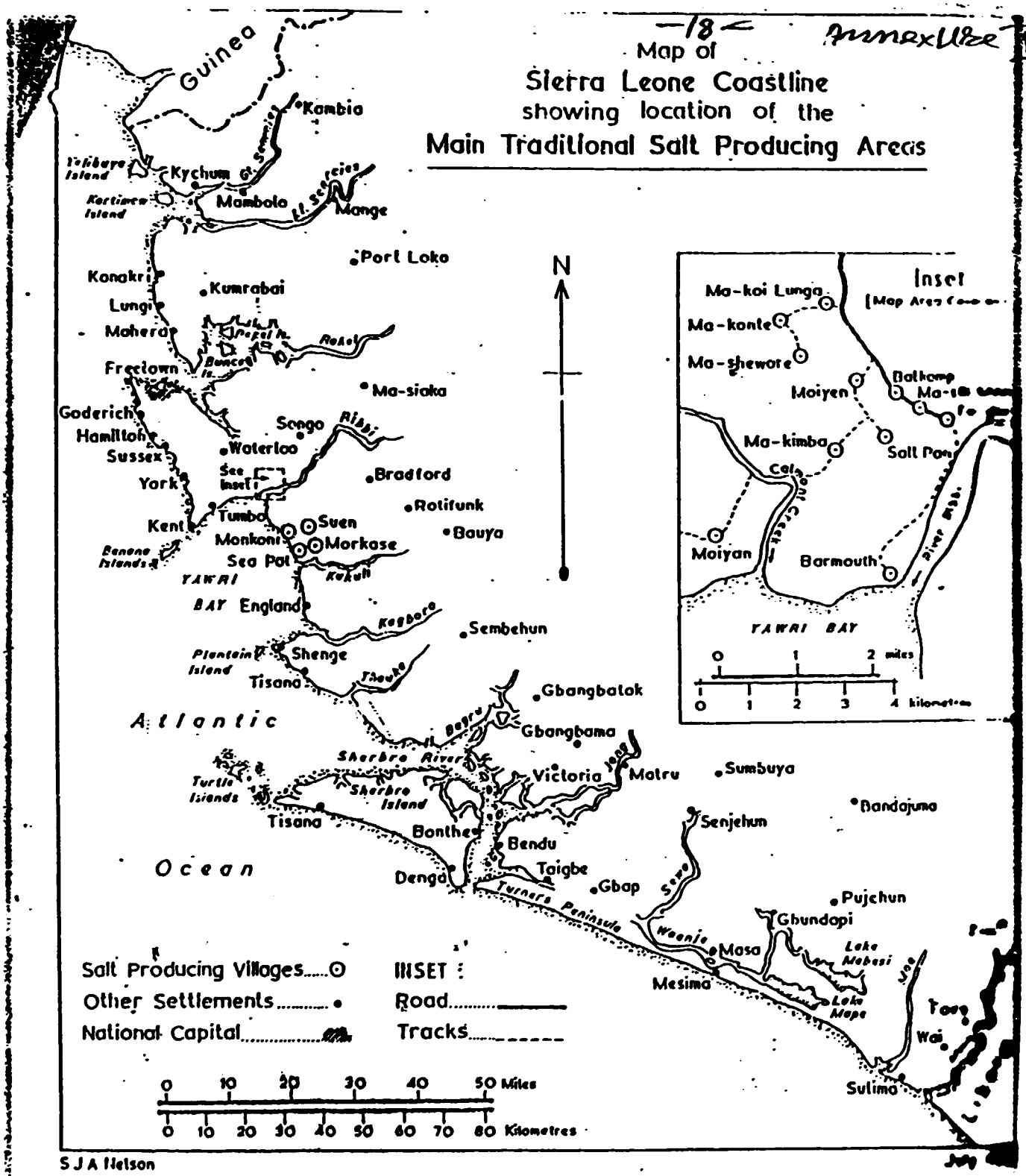

Edible
Industrial
Human (Direct)
Human (Indirect)
Cattle
Chemical Industry
Edible Common Salt
Free Flow Table Salt
Iodised Salt
Refined Salt
Mineralised Salt
Calcium Fortified Salt
Butter & Cheese
Fish Curing
Meat Packing
Food Processing
Saline Injection
Plain Cattle Licks
Mineralised Cattle Licks
For Mixture Feeds
1. Soda Ash (Na_2CO_3)
2. Caustic Soda (NaOH)
3. Textiles
4. Paper
5. Water Softening
6. Refrigeration
7. Hide curing
8. Ice removal
9. Sodium Chlorate
10. Sodium metal manufacture
11. Soap Industry
12. Glass and Ceramics
13. Explosives
14. Sodium Hydrosulphite

Number of households, persons and sex distribution - major salt producing villages

(Source: Provisional figures of 1985 national census)

Name of village	Administrative region in which located	Number of households	Number of persons	Male	Female
SUEN	Ribbi chiefdom Moyamba dist.	145	921	448	473
MORKASO I+II	" "	20	181	85	96
SEA PORT	" "	13	98	40	58
MANONI	" "	6	40	21	19
BANGA GROUND	Bumpe Chiefdom Moyamba dist.	67	434	221	213
MOIA	" "	73	476	222	254
TASSO ISLAND	East III, Western Rural Area	580	3672	1952	1720
MAOMBI	York, " "	9	63	37	26
MOIYON	Koya, " "	34	268	131	137
MA-KOI LUNGA	" " "	19	112	53	59
BAIKOMP	" " "	15	162	86	76
MASILI MANI	" " "	28	172	78	94
MAKONKOBO	York Western Rural district	5	29	18	11
BANGA GROUND	" " "	3	13	9	4
FOLGOO	Koya Western Rural District	75	547	292	255
MAKONTE	" " "	9	67	31	36
MASHOWORE	" " "	7	40	20	20
BARMOUTH	" " "	13	85	43	45
MAKIMBA	" " "	20	160	82	78
ROKAI/SALT PAN	" " "	16	102	49	53
TOTAL		1157			

Annex Ulze IV



S J A Nelson

Annexure V

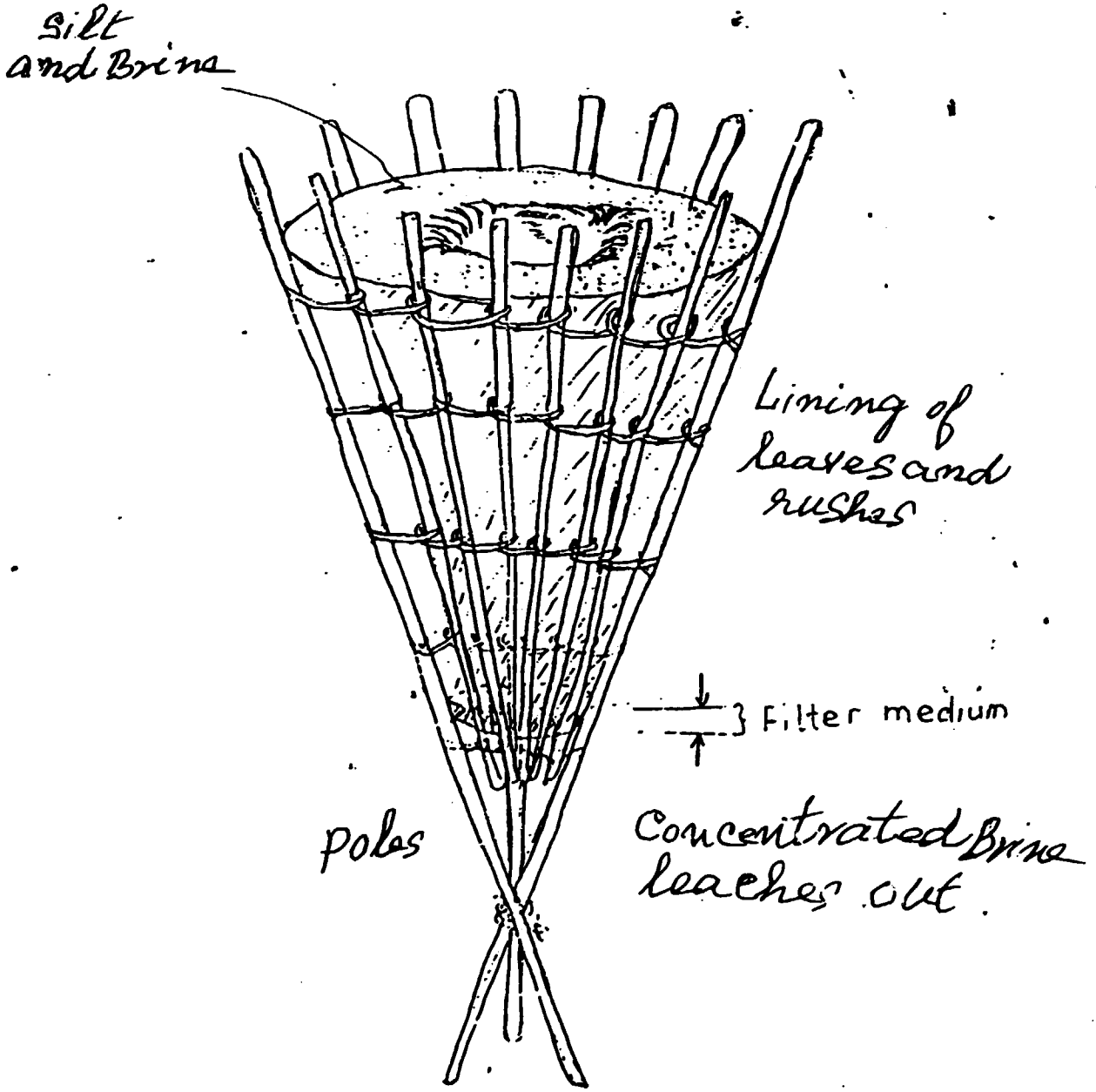


Fig. 2a Traditional Filtration Unit used by salt processors.

Annexure VI

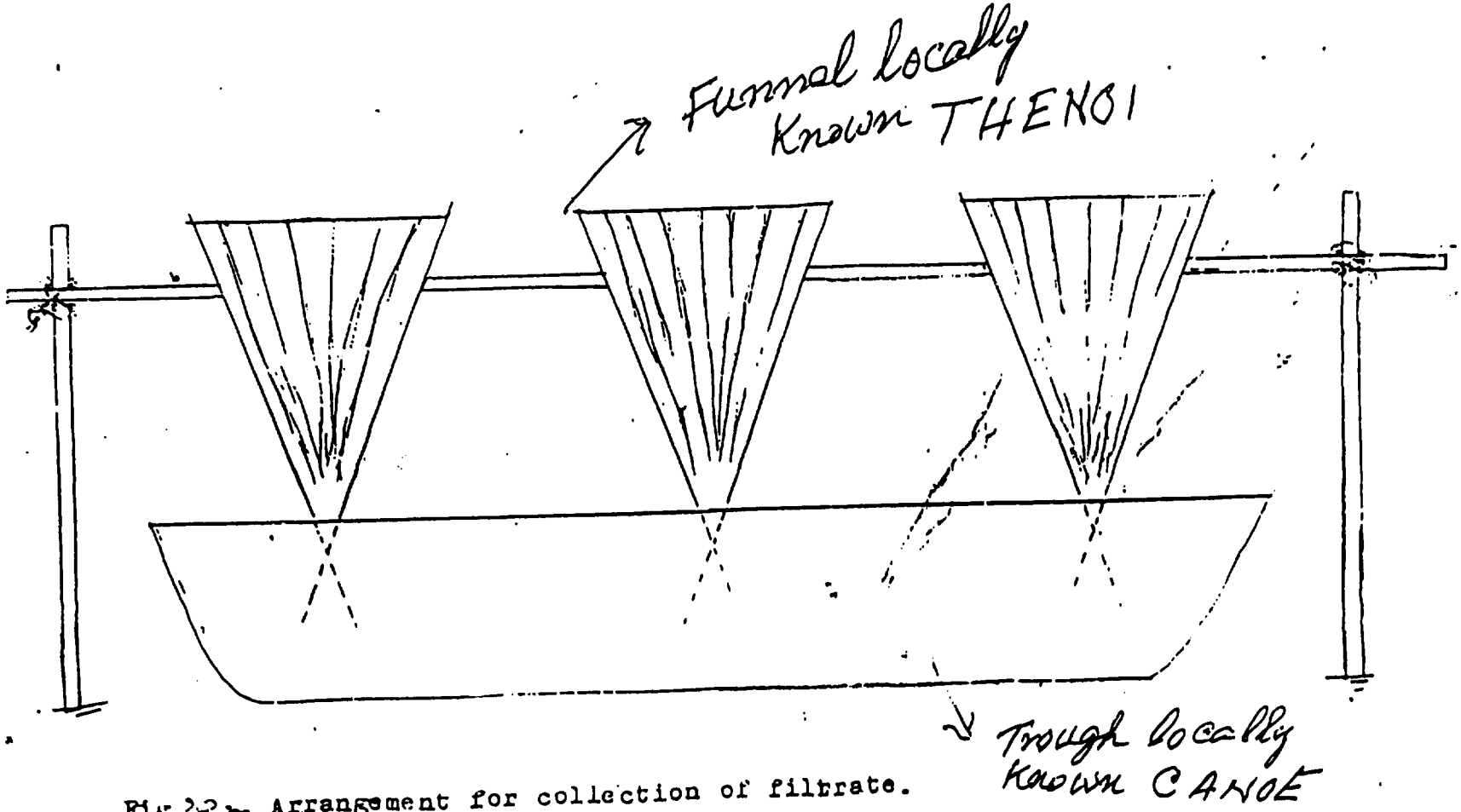


Fig. 2.2b Arrangement for collection of filtrate.

Annexure VII

Monthly and Annual Rainfall By Meteorological Station, 1980 - 1986

(In mm)

Station	Month Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Bonthe	1980	1	25	29	113	466	628	1601	1387	554	388	124	120	5436
	1981	0	12	18	114	254	420	1058	618	359	221	133	54	3261
	1982	0	0	8	88	283	798	965	974	454	384	147	0	4101
	1983	0	Trace	0	106	308	688	1154	1256	677	247	221	8	4665
	1984	0	3	26	218	580	371	699	705	434	362	120	0	3518
	1985*	-	-	-	-	-	-	-	-	-	-	-	-	-
	1986*	-	-	-	-	-	-	-	-	-	-	-	-	-
Freetown	1980	18	21	Trace	70	207	447	861	1144	414	189	98	8	4377
	1981	Trace	15	76	33	275	397	993	599	430	293	32	24	3167
	1982	0	Trace	Trace	32	246	440	581	1170	310	217	75	0	3070
	1983	0	10	3	76	133	405	500	705	298	246	32	14	2422
	1984	0	0	0	80	223	321	532	324	318	250	92	1	2141
	1985	0	30	Trace	0	70	222	853	722	384	188	126	12	2606
	1986	0	Trace	24	6	199	182	530	685	435	314	70	0	1731
Lungi	1980	6	31	Trace	78	269	380	802	767	379	176	173	32	3093
	1981	Trace	21	14	109	284	311	1086	514	402	311	75	26	3153
	1982	0	0	0	74	196	498	656	1041	336	309	99	0	3203
	1983	0	13	7	8	160	470	526	760	314	288	83	36	2665
	1984	0	0	4	69	266	412	463	431	356	189	115	0	2305
	1985	0	24	5	Trace	153	310	555	614	304	329	137	3	2135
	1986	0	Trace	3	15	220	270	564	687	447	272	49	Trace	2527

Sources: Meteorological Headquarters, Freetown.

Rainfall

Monthly rainfall is the monthly total of the daily amounts.

Daily amount of rainfall is the measure of rain fallen in the 24 hours from 9 a.m. to 9 a.m. the following day.

[redacted]

annexure VIII

Monthly and Annual Temperature By Meteorological Stations, 1980 - 1986

Degrees centigrade (°C)

Station	Month Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Average
Bonthe	1980	27.2	27.6	27.8	28.9	27.7	26.7	26.1	25.3	26.5	27.0	26.9	26.5	27.0
	1981	25.7	26.2	27.3	27.6	26.7	26.5	24.7	25.1	25.6	26.7	26.8	26.8	26.3
	1982	27.1	27.5	27.7	28.4	27.5	27.0	25.3	25.7	27.0	27.2	27.5	27.1	27.1
	1983	26.8	27.8	28.5	28.3	27.7	26.5	25.7	25.9	26.7	27.3	27.4	27.5	27.1
	1984	26.8	27.7	28.2	28.0	27.5	27.3	26.6	26.4	27.2	27.6	28.3	27.8	27.4
	1985*	-	-	-	-	-	-	-	-	-	-	-	-	-
	1986*	-	-	-	-	-	-	-	-	-	-	-	-	-
Freetown	1980	27.7	27.0	27.9	28.5	28.3	26.4	26.4	26.2	26.5	27.0	27.1	26.8	27.2
	1981	27.0	27.0	28.1	28.5	27.6	27.2	25.5	25.7	26.2	26.9	27.9	27.3	27.1
	1982	26.4	27.4	27.7	28.5	27.8	27.2	26.2	25.6	25.9	26.6	27.3	26.8	27.0
	1983	26.8	27.9	28.5	28.3	28.3	27.1	26.7	26.2	26.7	26.8	27.8	27.2	27.4
	1984	26.9	27.1	28.1	27.9	27.6	27.1	26.3	26.7	26.5	26.9	-	26.2	27.0
	1985	26.0	26.6	27.3	27.8	27.6	26.8	29.1	25.0	25.8	26.9	27.0	25.9	26.8
	1986	25.9	11.3	11.5	11.9	27.9	26.7	25.6	20.8	25.9	-	-		15.6
Lungi	1980	27.1	27.0	27.6	28.7	27.7	25.9	25.9	25.8	26.4	26.8	26.8	26.3	26.8
	1981	27.7	26.6	27.5	28.0	27.0	26.7	25.1	25.4	25.7	26.0	27.3	26.2	26.4
	1982	26.4	27.3	27.9	28.5	27.5	26.7	25.5	22.7	26.1	26.2	26.9	26.1	26.5
	1983	26.2	27.7	28.6	28.5	28.4	26.4	26.1	25.4	26.0	26.7	27.7	27.0	27.7
	1984	26.4	27.5	28.0	28.2	27.2	26.2	25.4	25.6	25.9	26.2	-	26.0	26.6
	1985	26.1	26.6	27.4	27.3	27.3	25.6	24.6	24.9	25.7	25.7	26.7	-	24.0
	1986	25.5	26.5	26.1	27.4	27.1	25.4	24.8	24.9	25.4	25.7	26.0	25.8	25.8

Source: Meteorological Headquarters, Freetown

* Station non-functional in 1985 and 1986

Temperatures

The monthly temperature is the average daily temperature measured for the month. Average daily temperature is the mean of the maximum and minimum temperature observed for the day. The yearly average temperature is the mean of the 12 monthly average temperature.

Annexure IX

Monthly Relative Humidity (%) Meteorological Station, 1980-1986

Station	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bonthe	1980	85	80	82	88	89	90	93	91	89	89	89	86
	1981	81	84	82	83	89	89	93	91	90	87	86	87
	1982	93	91	88	86	87	90	91	92	92	91	90	92
	1983	88	89	86	85	87	91	93	94	90	89	89	89
	1984	85	80	82	84	86	87	90	91	87	86	83	83
	1985*	-	-	-	-	-	-	-	-	-	-	-	-
	1986*	-	-	-	-	-	-	-	-	-	-	-	-
Freetown	1980	77	74	75	77	80	81	85	87	84	81	80	74
	1981	68	75	76	79	86	84	90	89	88	85	84	83
	1982	82	80	80	82	86	89	92	89	86	89	84	84
	1983	68	79	79	78	82	86	89	93	87	84	84	87
	1984	74	72	74	77	79	83	85	85	84	83	-	71
	1985	70	73	74	74	77	80	86	87	84	81	81	66
	1986	62	72	67	67	73	76	83	85	83	-	75	64
Lungi	1980	74	71	71	71	78	83	86	86	84	81	81	72
	1981	73	76	77	79	84	84	89	88	87	85	83	85
	1982	90	85	80	79	83	89	92	91	92	89	88	90
	1983	81	82	78	74	84	89	89	93	90	88	87	89
	1984	76	74	73	76	80	84	86	87	85	85	-	69
	1985	73	75	76	73	76	86	87	88	85	85	82	-
	1986	64	72	68	70	76	82	87	88	85	83	78	64

Source: Meteorological Headquarters, Freetown.

Humidity

The daily relative humidity is average relative humidity of the synoptic hours i.e. every three hours starting from 0000 to 2100 GMT. Average relative humidity for the month is the total daily relative humidity for the month divided by the number of days in the month.