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The Analysis of Daily Rainfall Data for Agricultural Purposes

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Abstract: It is demonstrated that a comprehensive analysis of rainfall data to give useful agronomic results should use the daily measurements. Two methods of analysis are described and are illustrated using daily rainfall records for 56 years from Maradankadawala in the Anuradhapura district.

1. Introduction

Though rainfall measurements are recorded on a daily basis the daily data have seldom been made use of directly. A standard analysis of rainfall data for agricultural purposes involves first summarising the data to give monthly, or sometimes ten or seven day totals. These totals are then used as the basic units in all subsequent work. This approach has many inherent limitations. For example, it is not possible to obtain useful information on dry spells from this kind of analysis.

The main reason for totalling the daily data has been that the volume of data to be handled subsequently is greatly reduced. However, much larger volumes of data are now collected and analysed routinely in many other areas of study. Another reason for totalling the data was possibly the hope that the rainfall totals could then be assumed to be approximately normally distributed.[10] This assumption is however almost never appropriate for seven or ten day rainfall totals. Both these reasons for avoiding the analysis of the daily records are no longer valid. The relevant statistical methods for handling non-normal data, together with the associated computing facilities needed for handling the larger volumes of data, are now available in Sri Lanka.

Our first aim in writing this paper is to demonstrate that a comprehensive analysis of rainfall data for agricultural purposes should use the daily measurements. At least this level of detail is needed to study many characteristics, such as the risk of

long dry spells or the probability of the occurrence of erosive rainfalls. Daily rainfall records are available from more than 400 sites in Sri Lanka and 110 of these have records for 50 years or more.

The second aim is to compare two methods of analysing daily rainfall data. The two methods which are discussed in the next sections are described in more detail.[14,15] They are illustrated here using the daily rainfall records for 1923 to 1978 obtained from the meteorological station at Maradankadawala in the Anuradhapura District.

Our final objective is to contribute to the debate on ways in which climatic data in Sri Lanka should be analysed to be of maximum benefit to agriculture. The debate is far wider than the views expressed in this paper, because it relates to a range of other climatic variables besides rainfall, and also to available crop records. However, the dependence of crops on water necessitates the study of rainfall patterns, especially in tropical climates where droughts and crop failure are common. Thus, if it is accepted that much of the year to year variation in crop yields and in agricultural strategy (such as planting dates) may be caused by the variability in rainfall, then many important questions could be studied via a comprehensive analysis of the rainfall data. We would like to introduce such a system here.

2. The Direct Method of Analysis

The distinctive feature of what we have called the direct method of analysis is that, for any event or characteristic of interest, each year of data provides just one number. Thus if N years of data are available, and monthly totals are of interest, N observations would result for each month of the year. These observations are then treated as a simple random sample from a single population. Estimates of the probability of an event can then be obtained, either directly from the relative frequency of occurrence, or by fitting a suitable distribution to the sample values.

For example, if we are interested in total monthly rainfall amounts in November, percentage points can be estimated from a simple ordering of the N observations. Thus for Maradankadawala the 20th percentile for instance, can be estimated by noting that the total rainfall for November was less than 6.34 inches in 20% of the 56 years. The 20th percentile is therefore 6.34 inches and this means that the chance of receiving more than 6.34 inches rain in November is estimated as 0.8. The method is straightforward and makes no assumption about the distributional pattern of the observations. However, the estimates will not be very precise unless data are available for a very large number of years. This is generally true for all the methods described in this section.

An alternative approach is to fit a distribution to the 56 monthly totals for November. For periods of a month or longer, the rainfall totals are often found to be

approximately normally distributed. The histogram of totals for November shown in Figure 1 is approximately symmetrical with a mean of 11.4 inches and a standard deviation of 4.38 inches. So the assumption of a normal distribution for the totals may be reasonable and properties of the normal distribution then provide an estimate of the 20th percentile as 6.52 inches.

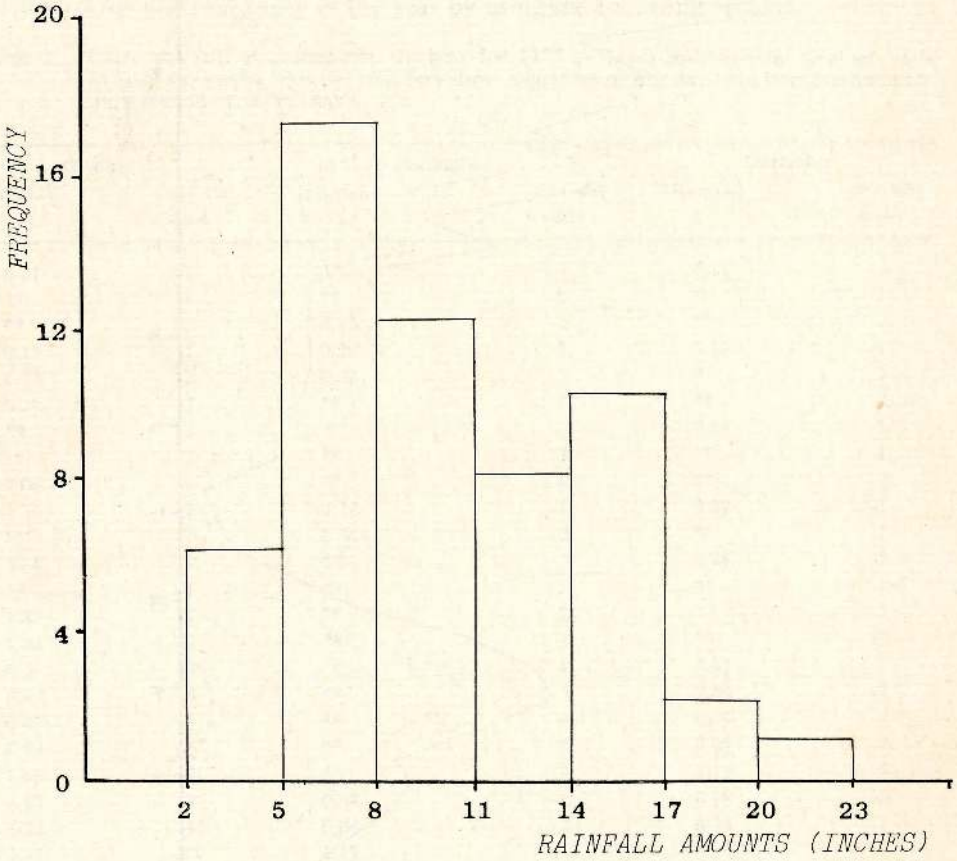

Figure 1. Histogram of total rainfall amounts in November (1923 - 1978) at Maradankadawala.

In the case when 10-day rather than monthly totals are of interest, the distribution-free approach can still be used as before, to estimate percentage points. Some results are shown in Figure 2. However, for 10-day totals, the assumption of normality is rarely appropriate. Transformations to normality can be used,[9] but

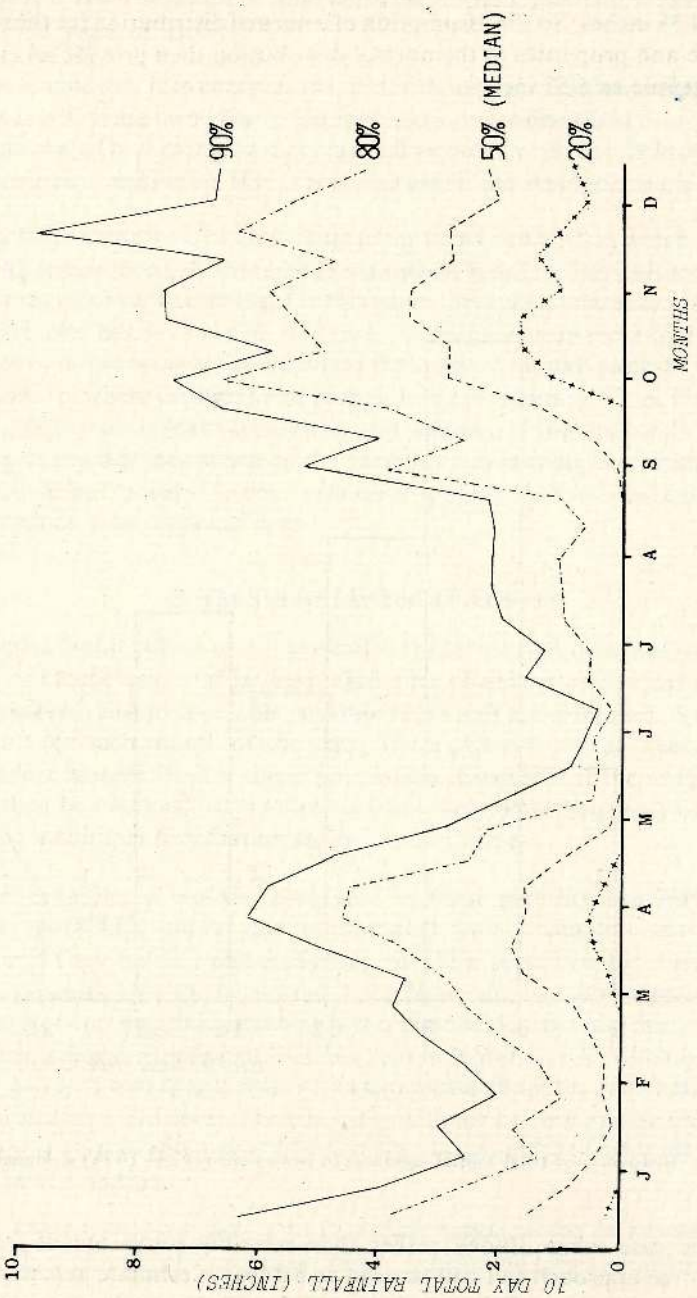

Figure 2. Percentiles for the 10 day total rainfall amounts at Maradankadawala (1923 - 1978) estimated from the raw data.

different transformations are usually needed for different periods of the year. A better approach is to fit a suitable alternative distribution. One possibility is to fit a gamma distribution.[11]

The type of analysis of amounts described above is useful and does provide valuable information, but is often all that is done. By making use of the daily data, many other characteristics of importance to agriculture can be studied. Here the risk of long dry spells is considered. This risk, defined as the "probability of a dry spell of greater than a specified number of days" within any period of interest, can be calculated for different times of the year by using the following method.

Table 1. Daily rainfall measurements (inches) for 1977 at Maradankadawala together with wet/dry sequences. Positive numbers show sequences of dry days and negative numbers show sequences of wet days.

October		November		December	
Rainfall	dry/wet state	Rainfall	dry/wet state	Rainfall	dry/wet state
0.11	-1	**	4	0.11	-1
**	1	**	5	**	1
**	2	0.85	-1	**	2
0.13	-1	0.29	-2	0.21	-1
1.12	-2	0.07	-3	**	1
0.29	-3	**	1	**	2
**	1	**	2	0.04	-1
**	2	**	3	**	1
2.06	-1	**	4	**	2
1.36	-2	0.72	-1	0.02	-1
**	1	0.34	-2	**	1
0.08	-1	5.31	-3	1.48	-1
**	1	**	1	**	1
1.82	-1	**	2	**	2
0.44	-2	**	3	**	3
0.16	-3	**	4	0.31	-1
2.02	-4	**	5	2.49	-2
0.42	-5	**	6	0.40	-3
0.29	-6	**	7	0.09	-4
1.65	-7	**	8	1.12	-5
2.07	-8	0.08	-1	0.18	-6
1.22	-9	0.06	-2	0.38	-7
0.45	-10	1.12	-3	0.30	-8
0.51	-11	0.10	-4	0.02	-9
**	1	0.13	-5	0.27	-10
**	2	0.19	-6	**	1
**	3	**	1	**	2
0.27	-1	**	2	**	3
**	1	**	3	**	4
**	2	**	4	**	5
**	3	–		**	6

First it is necessary to specify what is meant by a day being dry. A threshold value is chosen, and a day is classified as being dry if the amount of rain falling on that day is less than the threshold value. If not it is classified as being wet. The threshold can be chosen to be large enough to exclude days where the rainfall is so minimal as to be agriculturally insignificant. A threshold of 0.005 is often found acceptable although its choice would be dependent on the crop water requirements. The daily observations are then recorded as a sequence of dry and wet days. Table 1 shows the daily records from October to December in 1977, the positive numbers indicating a sequence of dry days and the negative numbers indicating a sequence of wet days.

Having specified what a "dry" day is, we can now define a dry spell. An n-day dry spell is a period of n successive dry days preceded and followed by a wet day. We also say that the period of interest will include an n day dry spell if at least n consecutive dry days are included within the period. It is then simple to calculate the proportion of years which have a dry spell of n or more days within that period.

Some results are given in Figure 3. This shows for example that there was a dry spell of 10 days or more in 96% of years in June compared with 16% in November. This simple analysis can often give useful information which complements the results from an analysis of total amounts. It is also clear that such information could not have been obtained without using the daily data.

Daily rainfall measurements can also be used to obtain results on the distribution of the start and length of rains[14]. An event to mark the start of the rains can be defined in different ways depending on the ultimate aims of the analysis. For instance, if 25 mm of rain in one day is needed for planting a particular crop, and if planting before 1st September is never done, the start of the rains from the farmers' viewpoint will coincide with the first day with 25 mm or more after 1st September. Stern[13] gives a more general definition which specifies an earliest possible starting date D and a potential start date coinciding with the first occurrence of at least y mm totalled over n days. They also consider the potential start as a false start if a dry spell of t or more days occurs in the next m days. Values for D, y, n, t and m are set by considering the purpose for which the start of the rains becomes important.

The end of the rains can also be defined on the basis of rainfall amounts or by using in addition, information on soil water storage. When the start and end of the rains have been satisfactorily established, the length of the rains can be calculated by subtraction and its distributional pattern investigated. This can provide a guide to the selection of crop varieties.

The direct method of analysis described in this section is very straightforward and only few assumptions are needed about the underlying structure of the data. However, the cost that is incurred for this simplicity is that the method can only really be used for long records and even then the estimates obtained have large standard errors. A further problem arising from the lack of precision is that the comparison of

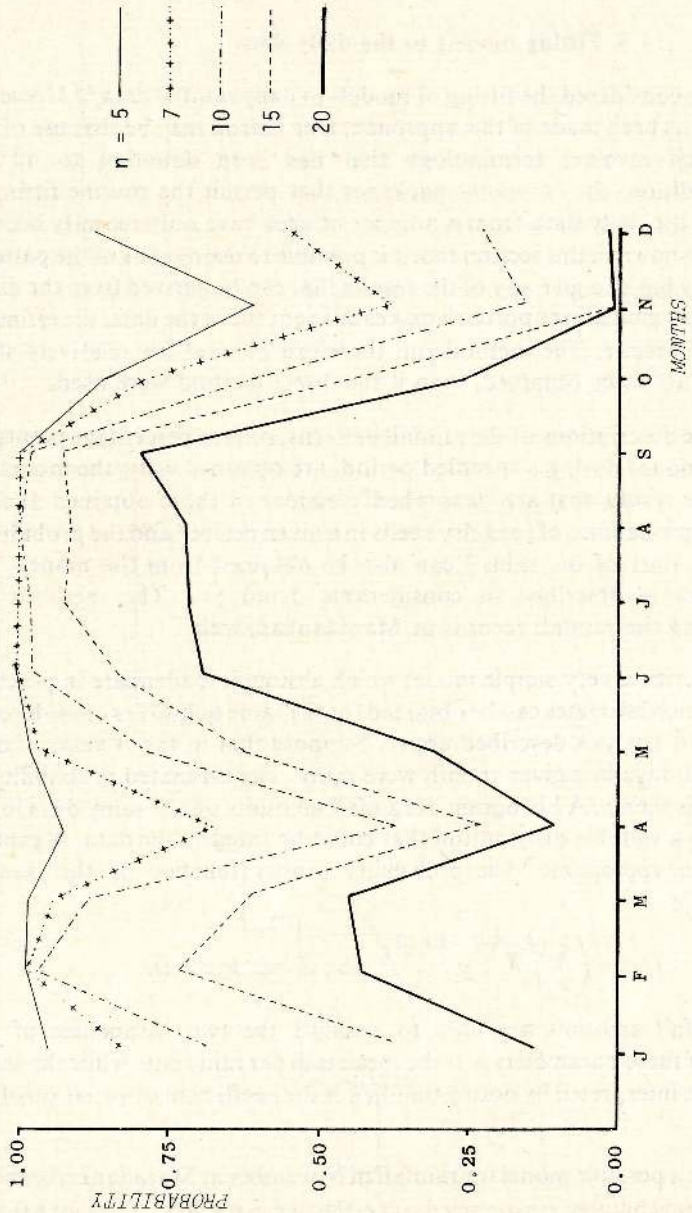

Figure 3. Probability of a dry spell of length $\geq n$ days, for n = 5, 7, 10, 15, 20, in each month, estimated using the raw data from 1923-1978 at Maradankadawala.

rainfall from different sites is difficult. Because of the limitation of the direct method, an alternative approach, which involves the fitting of models to the daily rainfall records, is discussed in the next section.

3. Fitting models to the daily data

Many authors have considered the fitting of models to daily rainfall data.[2,7] However, little practical use has been made of this approach. One reason may be that use of this modelling approach involves terminology that has been daunting to all but statisticians. In addition, the computer packages that permit the routine fitting of suitable models to the daily data from a number of sites have only recently become available. It will be shown in this section that it is possible to use models of the patterns of rainfall on a daily basis to give any of the results that can be derived from the direct analysis. Because this modelling approach makes efficient use of the data, the estimates obtained are more precise. The method can therefore be used for relatively short records, and more accuracy obtained, than if the direct method were used.

When simple descriptions of the rainfall patterns, such as percentage points for the total rainfall amount during a specified period, are obtained using the modelling approach, they give results that are "smoothed" versions of those obtained directly from the data. The probability of long dry spells in a given period[5] and the probability distribution of the start of the rains[13] can also be obtained from the model. The modelling approach is described in considerable detail.[4,15] The methods are illustrated here using the rainfall records at Maradankadawala.

We first describe a very simple model which although inadequate in practice, shows the way in which estimates can be obtained for the same quantities considered in the direct method of analysis described above. Suppose that in the N years of data available, $100p\%$ of days in a given month were rainy. The estimated probability of rain in that month is then p. A histogram of rainfall amounts on the rainy days in the month will indicate a suitable distribution that could be fitted to the data. A gamma distribution is often appropriate.[3] The probability density function of the gamma distribution is given by

$$f(x) = \left(\frac{k}{\mu}\right)^k X^{k-1} e^{-kx/\mu} \Big/ \Gamma(k),\ X > 0,\ k,\ \mu > 0.$$

The observed rainfall amounts are used to estimate the two parameters of this distribution. One of these parameters μ, is the mean rain per rainy day, while the shape parameter, k, can be interpreted by noting that $1/\sqrt{k}$ is the coefficient of variation of the distribution.

For example a possible model for rainfall in November at Maradankadawala is the following. The probability of rain on any day is estimated as $p = 968 / (30 \times 56) = 0.576$,

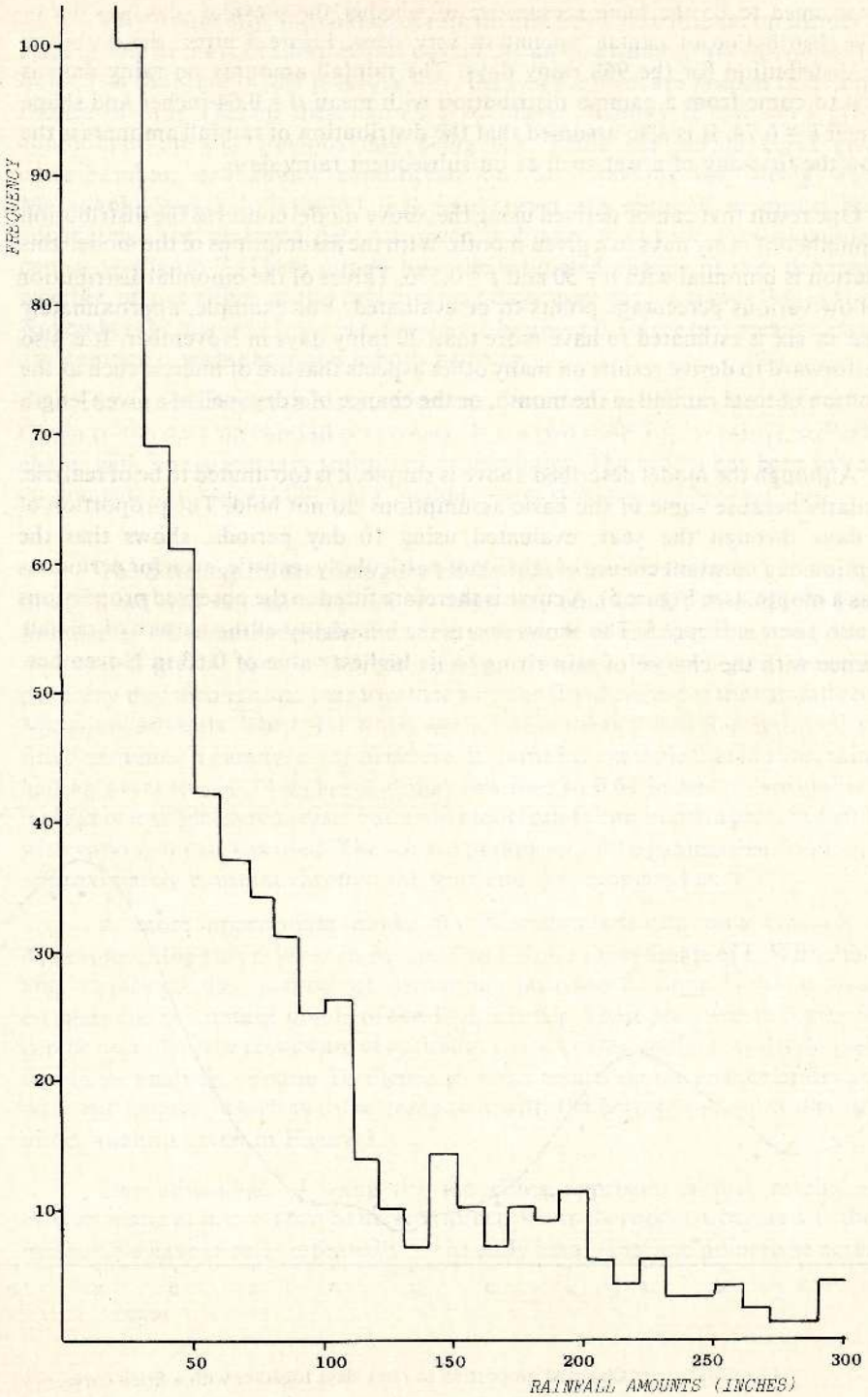

Figure 4. Histogram of daily rainfall amounts in November (1923 - 1978) at Maradankadawala.

This is assumed to be the same irrespective of whether the previous day was dry or wet. The distribution of rainfall amounts is very skew. Figure 4 gives the histogram of this distribution for the 968 rainy days. The rainfall amounts on rainy days is assumed to come from a gamma distribution with mean $\mu = 0.64$ inches and shape parameter $k = 0.74$. It is also assumed that the distribution of rainfall amounts is the same on the first day of a wet spell as on subsequent rainy days.

One result that can be derived using the above model concerns the distribution of the number of rainy days in a given month. With the assumptions of the model this distribution is binomial with $n = 30$ and $p = 0.576$. Tables of the binomial distribution then allow various percentage points to be evaluated. For example, approximately one year in six is estimated to have more than 20 rainy days in November. It is also straightforward to derive results on many other aspects that are of interest such as the distribution of total rainfall in the month, or the chance of a dry spell of a given length or more.[15]

Although the model described above is simple, it is too limited to be of real use, particularly because some of the basic assumptions do not hold. The proportion of rainy days through the year, evaluated using 10 day periods, shows that the assumption of a constant chance of rain is not particularly realistic, even for periods as short as a month, (see Figure 5). A curve is therefore fitted to the observed proportions and is also given in Figure 5. This shows clearly the bimodality of the pattern of rainfall occurrence with the chance of rain rising to its highest value of 0.63 in November.

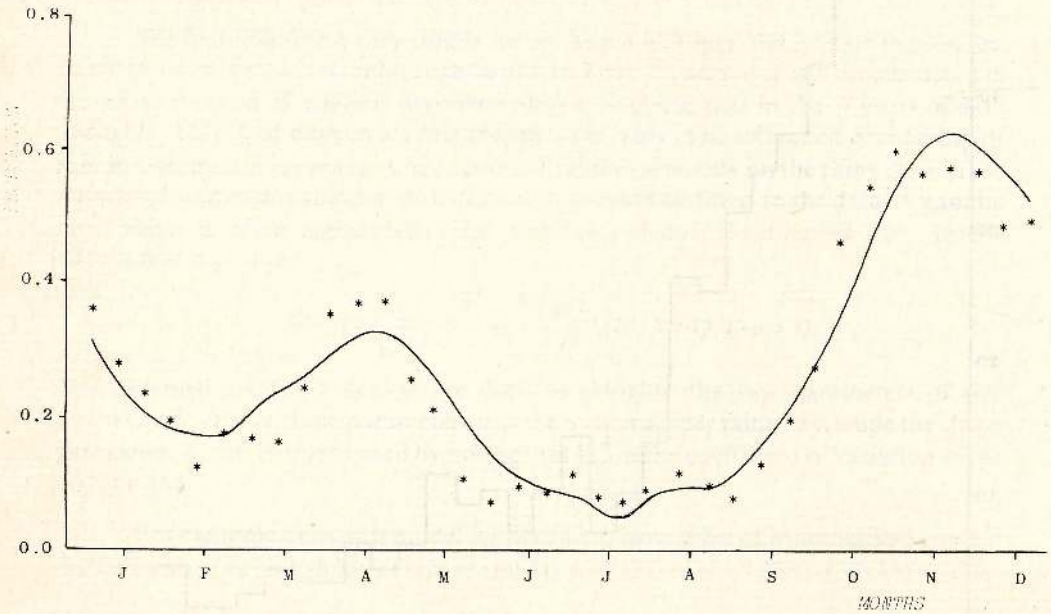

Figure 5. Observed proportion of rainy days together with a fitted curve.

Very frequently, the chance of rain on any day is conditional on the dry or wet state of one or more of the previous days. If it can be assumed that this dependence is limited to the state of the previous day, then two curves are needed to describe the chance of rain. One of these curves gives the probability of rain on a given day conditional on the previous day being dry, while the second curve gives the corresponding probability conditional on the previous day being wet. For Maradankadawala it is found that four curves are required to model the data adequately. The observed data are given in Figure 6 and the corresponding fitted curves in Figure 7. These curves give the estimated chance of rain depending on whether or not either of the two previous days were dry or rainy. For example, in November the chance of rain is estimated to be about 0.3 if the two previous days were dry compared with about 0.8 if both had rain.

In statistical terminology, what has been done in Figure 7 is to fit a Markov Chain to the data on rainfall occurrence. It is a two state (dry or rainy), second order chain, with non-stationary transition probabilities. The model has been fitted using the computer package GLIM [11] and a binomial error structure has been assumed.

The distribution describing the rainfall amounts has also to be generalised. It is often found that rainfall amounts per rainy day tend to vary through the year. For instance at Maradankadawala the average amount of rain per rainy day during the monsoon is greater than in the intermonsoonal period. Figure 8 gives the mean rain per rainy day through the year together with the fitted curve for the rainfall record at Maradankadawala. The curve fitted was a Fourier series with four harmonics and is fitted assuming a gamma error structure. It shows for example that in June, rainy days had an average of 0.18 inches and that this rose to 0.64 inches in November. Thus instead of a single gamma distribution to model rainfall amounts, a gamma distribution with varying mean was used. The second parameter of the gamma distribution, k, was approximately constant through the year and was estimated as 0.74.

A more appropriate model for Maradankadawala now consists of the equations of the curves given in Figures 7 and 8 plus the estimate of k. With this model and employing the method of derivation described in Stern,[12] it is possible to estimate the percentage points of the 10 day totals. These are given in Figure 9 and it can be seen that the results are very similar to the corresponding results derived from the direct analysis, (Figure 2). Figure 10 gives results on the chance of dry spells of different lengths, which is to be compared with the corresponding results from the direct analysis given in Figure 3.

One advantage of using the modelling approach is that results for any characteristic of interest can be derived directly from the model, whereas with the direct method we have to refer repeatedly to the daily data. A second point to be noted is the

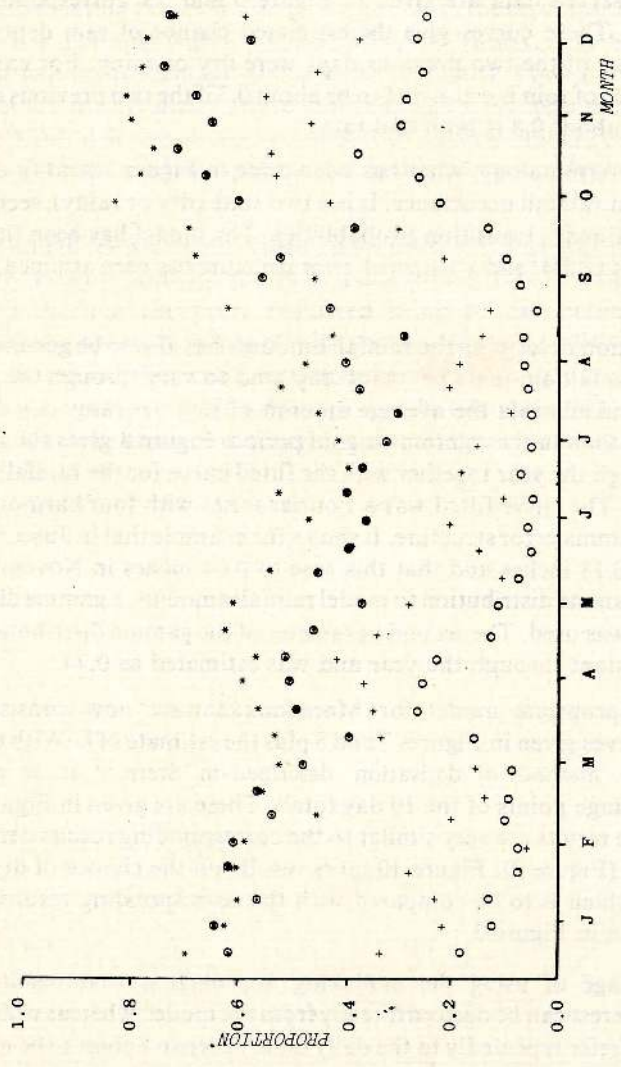

Figure 6. Proportion of rainy days conditional on whether the two previous days were dry or wet.
(a) Yesterday dry, day before dry is denoted by o ;
(b) Yesterday dry, day before wet is denoted by + ;
(c) Yesterday wet, day before dry is denoted by o ;
(d) Yesterday wet, day before wet is denoted by * .

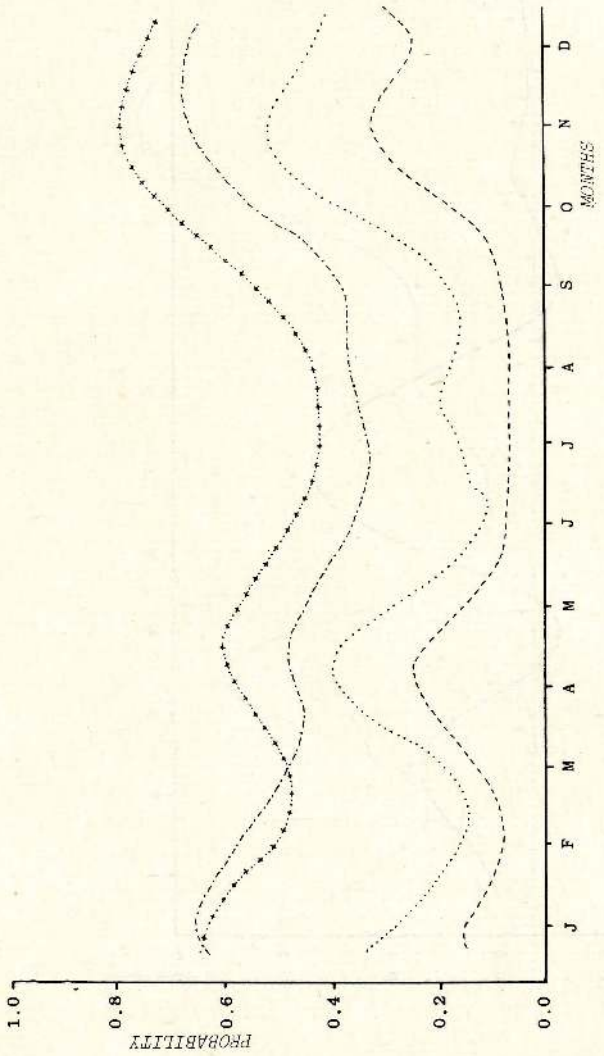

Figure 7. Second order Markov chain analysis for the probability of rain at Maradankadawala.
The four curves represent: +..+..+ P(R/RR) ; -.-.-.- P(R/DR) ;
..... P(R/RD) ; ------- P(R/DD) ;
Where for example, P(R/RD) denotes the probability of rain given dry the day before and rain two days earlier.

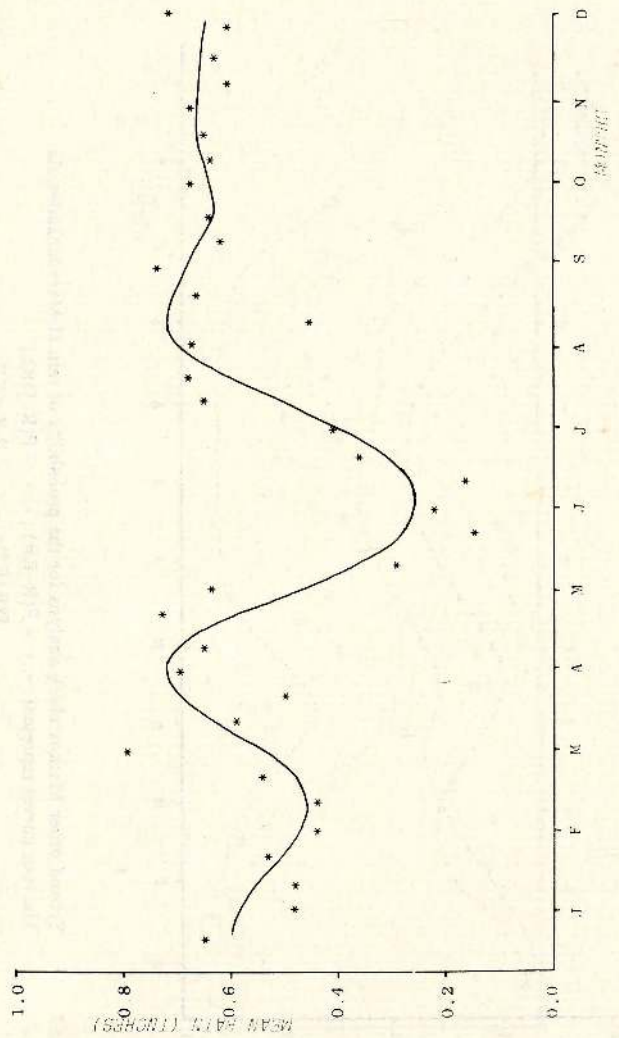

Figure 8. Mean rain per rainy day (in inches) together with a fitted curve.

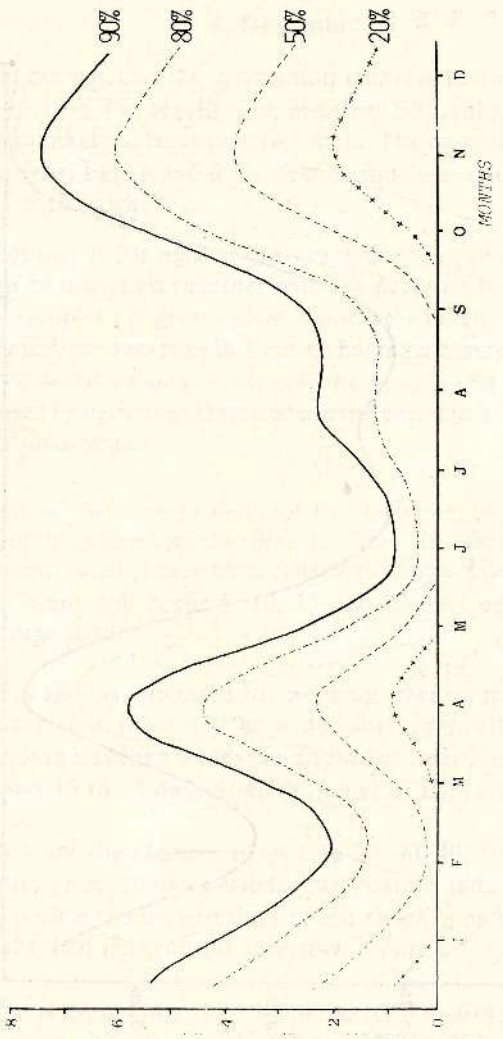

Figure 9. Percentiles for the 10 day total rainfall amounts at Maradankadawala.

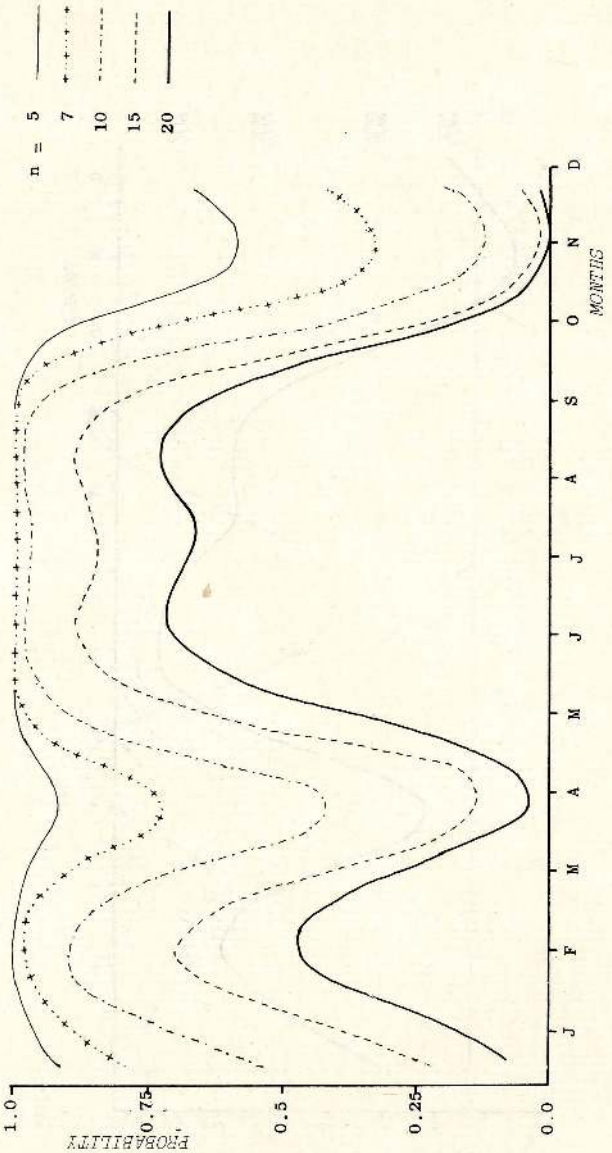

Figure 10. Probability of a dry spell of n or more days (n = 5, 7, 10, 15, 20) at Maradankadawala.

smoothness of curves obtained from the model; (compare for instance Figures 9 and 10 with Figures 2 and 3). This makes it far easier to compare the pattern of rainfall at different sites. As an example, Garbutt *et al*[8] discuss the fitting of models similar to the one adopted here for 11 sites in West Africa and make use of these models to compare the distribution of the data of the start of the rains.

4. Discussion

The type of model discussed in the last section seems to model the pattern of rainfall well in many countries[2,8]. The results obtained from Sri Lankan data indicate that this type of model is also likely to be appropriate here. The necessary computing facilities are now available in Sri Lanka and it is therefore timely to assess the practical use that could be made of such work.

One prerequisite is for agricultural researchers to visualise the wide range of questions that can be answered together with the necessity to phrase these questions precisely. A few examples are given below. These were taken from a recent case study which analysed data from two sites in Kenya,[6] having a bimodal rainfall pattern with the 'short' rains centered around April and the 'long' rains round November. The questions were posed by agriculturalists and are not entirely satisfactory, but they serve to illustrate some possibilities.

(i) What is the average date for the beginning of the rainy season? This event is defined as the first day after 10 March that rainfall reached 20 mm, totalled over three consecutive days. What is the probability that this event will occur 5, 10, 15 and 20 days earlier or later than this average date?

(ii) A dry spell is requested for weeding after crop emergence. What is the chance that there will be a dry spell (defined as no rain or as rain totalling less than 5 mm per day) of at least 5 days duration during the period 15 to 25 days after the onset of the rains?

(iii) What are the chances of getting 20, 30, 40, 50 mm or more in a day within given 10 day periods? Impressions indicate that heavy showers fall within the first 30 days of the short rains before a crop canopy is established and run-off therefore occurs.

(iv) What is the average date for the end of the rains? (A range of definitions are given for this event[6]). What is the probability that the end of the rains will occur 5, 10, 15 and 20 days earlier or later than the average date?

Finally, we do not wish to give the impression that the research is over from a statistician's point of view and that all that is required is for agricultural researchers to ask the appropriate questions. Even within the limited field of the analysis of rainfall data, there are many important questions which still remain to be explored on the range of models that can be fitted and the ways in which they can be used. In addition, at present the analysis is limited to single sites. Little work has been done on the way in which the results could be extended to allow maps to be drawn showing, for example, the risk of a long dry spell over a region of the country.

We believe that the application and the extension of the methods of analysis discussed in this paper are rewarding areas for collaborative research in Sri Lanka, involving meteorologists, agriculturists and statisticians and we believe that it is possible for the results to make a significant contribution to agricultural planning in Sri Lanka.

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A Comparative Study of the Glycoside Fractions of some Holothurians Found in Sri Lankan Waters

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Abstract: Glycoside fractions from ten holothurians were isolated and subjected to a comparative examination. All ten species contained holothurin A. Except *Holothuria edulis* and *Havelockia versicolor* all other species were found to contain holothurin B. The acid hydrolysis of glycoside fractions of all species examined yielded mainly two genins (22, 25 - epoxy - 7, 9 (11) holostadien-3-17-diol and its deoxyanalogue) and four sugars namely glucose, xylose, 3-0-methyl glucose and quinovose.

1. Introduction

The toxicity of sea-cucumbers has been known for many years.[5] The active compounds, the greatest amount of which occurs in the Cuvierian glands[17] of the animal, have been given the general name holothurins.[11] These holothurins are triterpene glycosides and it has been ascertained that these glycosides possess diverse physiological activity.[2,9,10]

Extracts of sea-cucumbers possess antitumoural activity.[10] They show neurotoxic,[9] cytotoxic,[7] antifungal[14] and antiviral[13] effects. They also affect blood,[6] stimulate activity of RNA-polymerases in rat liver nuclei,[4] inhibit seed respiration,[8] as well as the incorporation of radioactive nucleosides and amino acids in rat marrow cells.[2]

This present study was carried out in order to compare the glycoside fractions of some of the holothurians found in Sri Lankan waters with the glycoside fractions of the holothurians found in the Pacific waters.[3]

2. Materials and Methods

2.1 Isolation of Glycoside Fractions:

Dried samples were ground and first extracted with CH_2Cl_2 in order to remove fat. Extraction was carried out in a soxhlet apparatus. This was followed by extractions with methanol. The methanol solution was evaporated to dryness (in

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vacuo). Water was added to the dry residue and this was extracted with butanol with subsequent evaporation of the extract under vacuum until a slight turbidity appeared. Cholesterol was added to the solution while vigorously agitating (70-80 mg of cholesterol per 1 g of dry ethanol extract residue). The mixture was held at 40-50°C for 15 min and left to stand for 24 hrs. The resultant precipitate was separated by centrifugation and washed with ether. In order to dissociate the complex, the residue was dissolved in pyridine (3 ml of pyridine per 0.1 g of residue) and after being left to stand for 5-6 hrs the solution was diluted with ether (4-5, v/v). The glycoside residue which separated was washed with ether.

2.2 Thin-layer Chromatography of glycoside fractions

The glycosides were analysed on silica gel plates (Merck, Kieselgel 60 F 254) using the following solvent systems;

(1) Butanol-Ethanol, 5:1, v/v, saturated with water.

(2) Chloroform-Methanol-water, 75:25:1, v/v
Spray reagent-Vanillin (1g) in concentrated sulphuric acid (100ml)[15]

2.3 Glycoside hydrolysis

Hydrolysis of the glycoside was carried out in 2N HCl (1 ml per 40 mg of saponin). After filtration, the residue (aglycones) was extracted into ether and the ether evaporated.

2.4 Examination of Aglycones

The aglycones were analysed by TLC on silica gel plates (Merck, Kieselgel 60 F 254) using benzene-ethyl acetate; 10:1 (v/v) as the solvent system.

2.5 Analysis of sugars

The sugars were analysed by Paper Chromatography (Whatman, No. 1) using the following solvent systems.

(1) Butanol: Acetic Acid : Water mixture, 4 : 1 : 2.
Spray reagent - Diphenyl amine, Aniline & Phosphoric acid in Ethanol.[15]

(2) Phenol-Water mixture, 100: 40 (v/v)
Spray reagent - Phthallic anhydride/aniline in Butanol.[15]

3. Results and Discussion

The results obtained for ten species of sea cucumbers are given in Table I.

All ten species studied contain predominantly the glycosides, holothurins A and B, except *Holothuria edulis* and *Havelockia versicolor* which lacked the latter

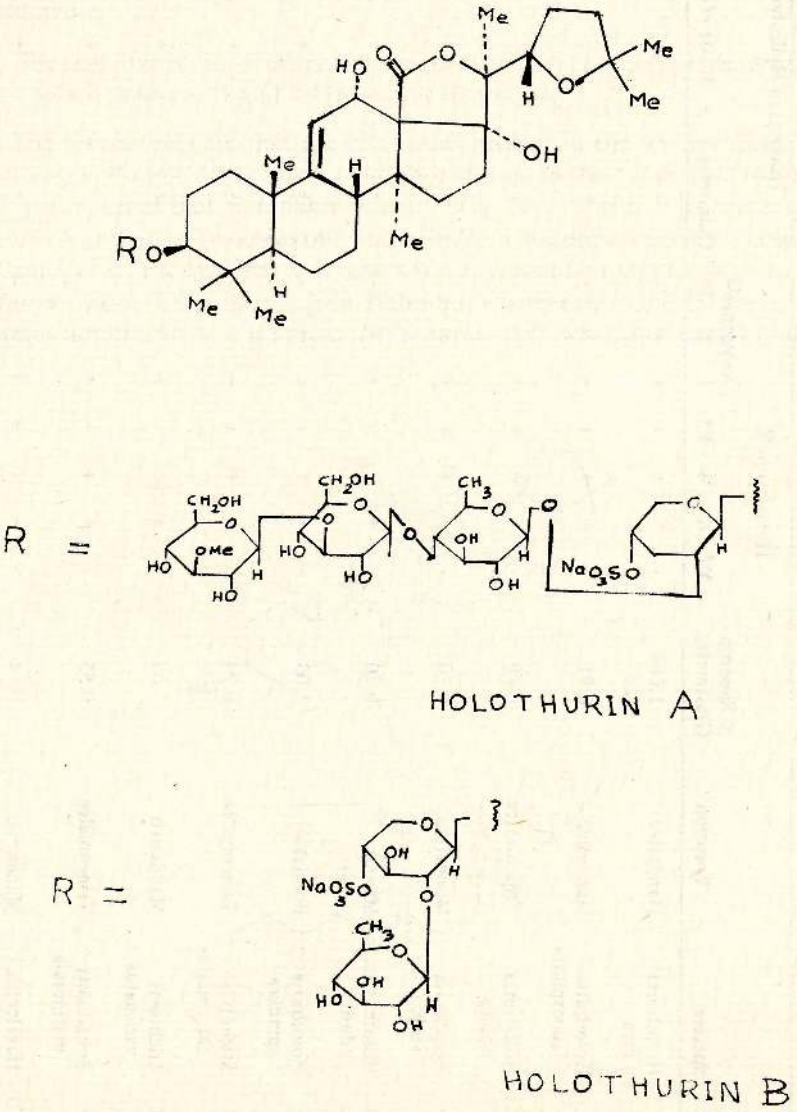

Figure 1. Structures of Holothurins A and B

Table 1. Glycoside Composition and Hydrolysis Products of the Glycoside Fraction from the Family Holothuriidae

	Species	Location	% Saponin Gravimetry	Holothurins●				Aglycones○			Products of Hydrolysis			
				Y*	A	B	K*	I	II	P*	Sugars			
											Quinovose	3 - 0 - Me - Glu	Kylose	Glucose
1.	Holothuria atra	Mandativu	1.06	-	+	+	+	+	+	-	+	+	+	+
2.	Holothuria leucospilota	Mandativu	0.91	-	+	+	+	+	+	-	+	+	+	+
3.	Holothuria nobilis	Trincomalee	0.28	-	+	+	+	+	+	-	+	+	+	+
4.	Holothuria scabra	Mandativu	0.30	-	+	+	+	+	+	-	+	+	+	+
5.	Holothuria edulis	Mannar	0.70	-	+	-	-	+	+	-	+	+	+	+
6.	Holothuria spinifera	Poonakari	1.03	-	+	+	+	+	+	-	+	+	+	+
7.	Stichopus chloronatus	Trincomalee	0.74	-	+	+	+	+	+	+	+	+	+	+
8.	Stichopus variegatus	Mandativu	1.08	-	+	+	-	+	+	-	+	+	+	+
9.	Bohadschia marmorata	Trincomalee	0.55	-	+	+	+	+	+	-	+	+	+	+
10.	Havelochia versicolor	Mandativu	2.14	+	+	-	+	+	+	-	+	+	+	+

*Unidentified

● Refer Figure 1

○ Refer Figure 2

holothurin. In addition, all ten species, except *Holothuria edulis* and *Stichopus variegatus*, contained an unidentified holothurin (denoted as X). The species *Havelockia versicolor* was unique in that it contained a holothurin (denoted as Y) which was found to be absent in the other nine species.

It is known that, with acid hydrolysis holothurin A and B from 22, 25-epoxy-7, 9(11), holostadien-3-17-diol (figure 2.1) as the main component, in lesser quantities its deoxyanalouge (figure 2.11) and four sugars namely glucose, xylose, 3-0 methyl glucose and quinovose.

The acid hydrolysis of the glycosides (of all ten Sri Lankan species) also yielded the same genins (figures 2.1 and 2.11) and the four sugars.

The results indicate that the glycosides present in the species found in Sri Lankan waters do not differ much from those found in the Pacific waters. Elyakov *et.al.*[3] have reported that *Holothuria nobilis* (Viti Levu Island, Fiji) contained only holothurin A and genin I whereas our studies indicate the presence of both holothurins A & B and genins I & II. They also report the absence of holothurin A in the species *Holothuria scabra* (Efate Island, New Hebrides) whereas the same species studied by us contains holothurin A. The species *Holothuria edulis* was found to lack holothurin

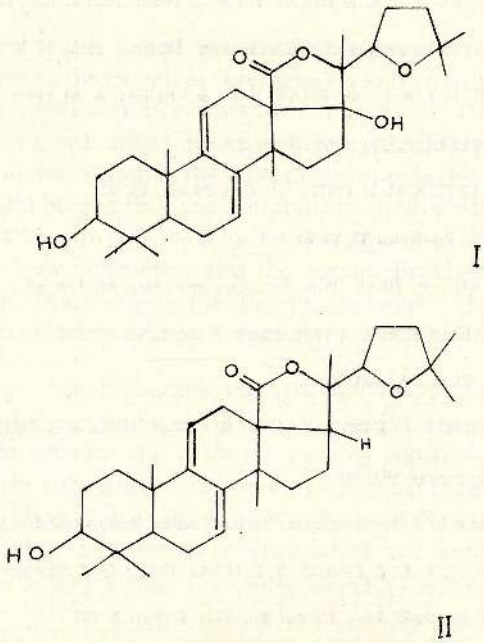

Figure 2. Structures of Aglycones

whereas Elyakov *et al.* have reported its presence in *H. edulis* collected at Maraki Islands and Gilbert Islands.

The species of *Bohadschia marmorata* studied by us contains both holothurins A & B and both genins I & II unlike the results obtained by Elyakov *et.al* which indicates the absence of any of them. Our studies on *Stichopus chloronatus* and *Stichopus variegatus* gave completely different results to that obtained by Elyakov *et al.* Both species were found to contain both holothurins A & B and also contained the two genins I & II.

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On the Problem that some known Carcinogens do not appear to be Mutagens in Short-term Tests

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Abstract: An explanation is sought as to why certain known carcinogens do not appear to be mutagens. It is hypothesized that an intermediary substance and not the suspected carcinogen itself, is the actual carcinogen. A model for the mechanism of carcinogenesis is constructed utilizing forms of DNA damage and repair as known at present. When equations are obtained for the carcinogenic response via this intermediary substance, it is found that these equations can explain not only the commonly observed response patterns, but also certain peculiarities in response which have been observed in some experiments. An experiment to estimate the ratios of the parameters in the model could show if indeed this is the mechanism that occurs, and possibly identify the type of damage that leads to carcinogenesis.

Key Words and Phrases: Mutagens, Metabolite carcinogens, mechanism of cancer, Carcinogenesis.

1. Introduction

Some carcinogens that are tested for mutagenic properties do not appear to be mutagens. For example, the chemical "urethane" is known to cause tumors in rodents but has not given positive results in tests for mutagenicity. One explanation may be that these substances cause mutations in a way that is different from the process of forming mutations in, for example, the Salmonella used in the Ames[1] test described in Ames.[2] Another could be that they cause mutations so severe that the colonies cannot grow. The first problem can be solved by developing strains of organisms that would be sensitive to the new substance, and the second problem could be studied by examining if indeed the organisms are severely damaged. This examination can be done perhaps by introducing a known mutagen to see if revertants occur again.

Still another explanation comes from the fact that rat liver is sometimes used in the Salmonella test for metabolic activation. It could be that some metabolite other than rat liver might activate the mutation causing substance. The explanation of interest here is that the substance in its original form is not the actual mutagen. The rat liver metabolic activation is an example of this. Perhaps the substance in the presence of some other substance turns into a product which is a mutagen. Or the substance itself may do nothing, but it may turn into mutagens other substances which are usually harmless.

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Another unusual feature that has recently been noticed is that the carcinogenic response is linear at very low doses, becomes a quadratic curve as the dose rises, switches suddenly to a linear form as it rises further, and then becomes a second order curve again before the response curve finally stops rising because the substance becomes toxic at higher doses.

The process described in what follows can be equally well applied to mutagenicity and carcinogenicity by substituting the appropriate words (for example, "mutagen" for "carcinogen" and "colonies" for "tumors"). The model used is an extension of that used in the paper.[2]

2. The Formation of the Actual Carcinogen

We shall call the substance under study S1 and the actual carcinogen S2. First, a supply of S1 has to be provided. Then, either the presence of S1 causes another substance to transform into S2, or it is S1 itself that transforms into S2 because of the presence of some other substance. The substance S1 itself, in its original form is not a carcinogen. The formation of S2 will depend on the availability of S1. The more there is of S1, the more of S2 will be formed. We shall also assume that there is a process of repair or elimination. The units of S2 could be made harmless (repaired) by some other agents or eliminated by either physical removal or transformation into another substance. We shall be interested in the amount of S2 available at time, say, t. It is this quantity and not the amount of S1 which will be the "actual dose" of carcinogen.

Assumptions

(i) The supply of S1 is made available at an instantaneous rate of $Df(t)$, where D is the dose used and $f(t)$ is some function which vanishes for $t < 0$ and as t tends to infinity while its integral from zero to infinity is equal to unity. (2.1)

(ii) In a small time period h, the presence of S1 causes a unit of S2 to be formed with probability $vDf(t)h$ where v is a constant. (2.2)

(iii) In the time period h, a unit of S2 can be repaired or eliminated with probability ph. ..... (2.3)

(iv) The probability that any combination of the events in (ii) and (iii) would occur in the period h is of small order in h. (2.4)

Let

$p_n(t)$ = P[There are exactly n units of S2 at time t]. (2.5)

These assumptions lead to the equation

$$P_k(t+h) = P_{k-1}(t)vDf(t)h + P_{k+1}(t)(K+1)\rho h + P_k(t)[1 - h(vDf(t) + k\rho)] + o(h). \quad (2.6)$$

Multiplying by s^k, summing over k and letting h tend to zero, we have in the limit an equation in the probability generating function.

$$\frac{\delta}{\delta t}G(s, t) = (s - 1)\, vDf(t)\, G(s, t) + (1 - s)\rho \frac{\delta}{\delta s}G(s, t). \quad (2.7)$$

If we denote the expected value of the number of units of S2 at time t as R(t) and its derivative with respect to t by $R^1(t)$, we obtain the following equation by partially differentiating (2.7) with respect to s and then putting s = 1.

$$R^1(t) = vDf(t) - \rho R(t) \quad (2.8)$$

which is easily solved to yield

$$R(t) = e^{-\rho t}\int_0^t e^{\rho x} vDf(x)dx \quad (2.9)$$

This equation gives the expected amount of the actual carcinogenic substance S2 which will be available at some time t after the substance S1 is first supplied. Since this is the actual carcinogen, we will need it in the next section as something similar to an "actual dose" of carcinogen.

3. Method of Carcinogenesis

We shall assume that cancer cells are caused by mutations or some other sort of damage that occurs in normal cells. What is likely is that the DNA in a normal cell is slightly altered, slight enough not to kill it, but altered enough for it to pass on wrong information and somehow create mutant cells that form growths. If these growths become large enough, they can be observed as tumors. What causes the DNA damage could be radiation,carcinogens and perhaps some other malevolent phenomena. Here, we shall be interested in the case where it is the carcinogens that cause the damage.

The DNA damage can be caused in several ways. In the presence of the carcinogen a normal cell could be damaged just the right amount to transform it into a mutant cancer cell. But it could also be that the damage is too slight for it to become a cancer cell and that it changes to an intermediate stage which we shall call a primary cell. After a while, the primary cell could be repaired by the normal repair mechanisms of the body and revert back to a normal cell. It could also die or divide into two daughter cells. In division,either of two things could occur. On the one hand, the two daughter cells could have the same mutations as the mother cell and so be two primary cells. On the other hand, it has been found that there exists a repair mechanism which

could operate during cell division, and if this occurs, they turn into two normal daughter cells. If the possibility exists that one daughter cell turns out normal while the other remains a primary cell, then this leaves the number of primary cells unchanged, and as far as the number of mutant cells are concerned, nothing has happened. Finally, the primary cell could undergo a second damage. If damaged too much it will die, but if the damage is of just the sufficient amount then it will turn into a cancer cell. Cancer cells could also divide or die, but if tumors are to be formed they should be undergoing a supercritical growth process.

This may be the mechanism behind the process of carcinogenesis as it appears at present. We shall attempt to form a model that will conform with this mechanism and see if the consequences of the model conform with the results of observations.

Assumptions

The DNA damage is caused by the presence of the actual carcinogen. Hence, it appears reasonable to assume that the chances of any such damage being caused are proportional to the amount of the actual carcinogen present at the time. This amount can be approximated by its expected value, R(t), (2.9). In view of this, we shall base our model on the following assumptions.

In a small space of time h,

(i) a normal cell could be damaged and turn into a cancer cell with probability $K_1 R(t)h$ (3.1)

(ii) a normal cell could be damaged and turn into a primary cell with probability $K_0 R(t)h$ (3.2)

(iii) a primary cell could be damaged and turn into a cancer cell with probability $K_2 R(t)h$ (3.3)

(iv) a primary cell can divide unrepaired into two primary cells with probability λh (3.4)

(v) a primary cell could be repaired, die or be repaired in the process of division with probability μh (3.5)

(vi) a cancer cell can divide with probability Λh (3.6)

(vii) a cancer cell can die with probability Mh (3.7)

(viii) the probability that a combination of the above events will occur is of small order in h. (3.8)

In the above K_0, k_1, k_2, λ, μ, Λ and M are constants.

We shall also assume that the cancer cells form a supercritical growth process and that the probability that a cancer cell starting at time t will have grown to be a tumor and is observable at time T is given by $\pi(T - t)$ as calculated in the paper by Neyman and Scott (1967). The result we require is that when T tends to infinity.

$$\pi(T - t) \rightarrow (1 - \frac{M}{\Lambda}). \tag{3.9}$$

Suppose that

$Y(t)$ = number of primary cells at time t;

$Z(t, T)$ = number of tumors counted at time T, which were formed at time t;

E_Y = expected value of $Y(t)$;

E_Z = expected value of $Z(t, T)$;

$P_{m,n}(t) = P[Y(t) = m, Z(t, T) = n]$; and

$G(u,v,t)$ = Probability Generating Function of $Y(t)$ and $Z(t, T)$.

By considering a small time interval $[t, t + h]$ and the events that can occur in it, we get the following equation.

$$\begin{aligned} P_{m,n}(t + h) = {} & P_{m,n-1}(t)K_1R(t)h\pi(T - t) + P_{m,n}(t)K_1R(t)h[1 - \pi(T - t)] \\ & + P_{m-1,n}(t)K_0R(t)h \\ & + P_{m+1,n-1}(t)K_2R(t)h(m + 1)\pi(T - t) \\ & + P_{m+1,n}(t)K_2R(t)h(m + 1)[1 - \pi(T - t)] \\ & + P_{m-1,n}(t)(m - 1)\lambda h + P_{m+1,n}(t)(m + 1)\mu h \\ & + P_{m,n}(t)[1 - h(K_0R(t) + K_1R(t) + (\lambda + \mu + K_2R(t)(m)] \\ & + o(h) \end{aligned} \tag{3.10}$$

Multiplying this by $u^m v^n$, summing over m and n, and taking the limit as h tends to zero, we get an equation in the probability generating function.

$$\frac{\partial}{\partial t} G(u,v,t) = [(u - 1) K_0 + (v - 1)\Pi(T - t) K_1 + K_1] R(t) G(u,v,t)$$
$$+ [(u - 1)(\lambda u - \mu - K_2 R(t) + \Pi(T - t) K_2 (v - 1) R(t)] \frac{\partial}{\partial t} G(u,v,t) \quad (3.11)$$

What we now need is an expression for the expected number of tumors. This will probably depend on the number of primary cells; hence, we seek equations in both E_z and E_y. We do this by differentiating (3.11) in turn with respect to u and v, and then by setting both u and v to unity.

$$\frac{d}{dt} E_y = K_0 R(t) + [\lambda - \mu + (K_1 - K_2) R(t)] E_y. \quad (3.12)$$

$$\frac{d}{dt} E_z = \Pi(T - t) K_1 R(t) + \Pi(T - t) K_2 R(t) E_y + K_1 R(t) E_z. \quad (3.13)$$

Equation (3.12) can be solved through the multiplication by an integrating factor without much difficulty to yield,

$$E_y(t) = e^{g(t)} \int_0^t K_0 R(y) e^{-gy} dy \quad (3.14)$$

where $$g(x) = \int_0^x [\lambda - \mu + (k_1 - K_2) R(w)] dw.$$

To proceed further we need to postulate the nature of the function f(t). In most cases, S1 is administered in the form of an injection or some other form which is given suddenly at one dose. Especially in the case of urethane it has been found that it is then speedily removed from the body. Under these circumstances we choose f(t) to be the impulse function described in the appendix (A.1). Other cases of interest could be studied using some other appropriate functions as f(t). Then, using the value of R(y) (2.9), and the result of integration of impulse functions (A.2.2), we have

$$E_y(t) = e^{h(t)} \int_0^t K_0 \nu D e^{-h(y)} e^{-\rho y} dy \quad (3.15)$$

where $$h(x) = (\lambda - \mu)x - (K_1 - K_2) \nu D(e^{-\rho x} - 1)/\rho.$$

We would like to know what occurs after the mechanism has had sufficient time to function, which means we have to examine the behavior as t tends to infinity.

CASE 1. When $\lambda > \mu$

We first consider the case when $\lambda - \mu$ is positive, so that the probability of a primary cell dividing unrepaired is greater than the probability of a primary cell being eliminated without forming a cancer cell. It can be shown that the integral in (3.15) is bounded from below, away from zero, and that its multiplying factor tends to infinity as t tends to infinity. Hence,

$$E_Y(t) \to \infty \text{ as } t \to \infty \text{ when } \lambda > \mu. \tag{3.16}$$

In this case, there being an unlimited supply of primary cells so long as K_2 is non-zero, there will be an infinite number of tumors as T increases. The relationship with the dose may be obscured by the fact that there are too many tumors, if the dose is large.

CASE 2. When $\lambda < \mu$

We next consider the case when $\lambda - \mu$ is negative. If $\rho > \mu - \lambda$ the non-negative integral in (3.15) is bounded above by unity while the multiplying factor tends to zero, as t tends to infinity. If $\rho < \mu - \lambda$, it can be shown that (3.15) which is non-negative is then bounded above by an expression that tends to zero as t tends to infinity. Thus,

$$E_Y(t) \to 0 \text{ as } t \to \infty \text{ when } \lambda < \mu \tag{3.17}$$

This is almost equivalent to the case where the primary cells take no part in the process of carcinogenesis since they die off too fast. If they do take no part, we can approximate this process by having $K_0 = 0$ in case 3.

However, if they do contribute a little and (3.17) still holds true, we cannot simplify the equations any further.

CASE 3. When $\lambda = \mu$

Although it is unlikely that the case $\lambda = \mu$ will hold exactly, it is reasonable to assume that λ and μ could be approximately equal.

Now we can use (A.3.1) and integrate to obtain

$$E_Y(t) = \frac{k_0}{k_1 - k_2}\left[e^{\frac{\upsilon}{\rho}D(k_1 - k_2)(1 - e^{-\rho t})} - 1\right]. \tag{3.18}$$

In the limit

$$\lim_{t \to \infty} E_Y(t) = \frac{k_0}{k_1 - k_2}\left[e^{\frac{\upsilon}{\rho}D(k_1 - k_2)} - 1\right] \tag{3.19}$$

which means that for small doses D, (3.19) is approximately

$$\frac{k_0 \upsilon}{\rho} D + \frac{k_0 \upsilon^2 (k_1 - k_2)}{2\rho^2} D^2 \tag{3.20}$$

We are interested in $E_y(t)$ only because we need it to obtain $E_z(t)$. Returning to $E_z(t)$, we can solve (3.13) too through the use of integrating factors and get

$$E_z(t) = e^{r(t)} \int_0^t e^{-r(y)} R(y)\, \pi(T - y)\, [K_1 + K_2 E_y(y)] dy \tag{3.21}$$

where $r(x) = K_1 \int_0^x R(w) dw$,

Letting T tend to infinity, π becomes $(1 - \frac{M}{\Lambda})$, and using the impulse function as f, we get

$$E_z(t) = \upsilon D (1 - \frac{M}{\Lambda}) e^{-r(t)} \int_0^t e^{r(y)} e^{-\rho y} [K_1 + K_2 E_y(y)] dy \tag{3.22}$$

where $r(x)$ is now $\frac{k_1 \upsilon D}{\rho}(e^{-\rho x} - 1)$ and $E_y(y)$ is as given in (3.18).

The integral can be calculated using the result(A.3.1) several times, which will finally yield

$$E_z(t) = (1 - \frac{M}{\Lambda}) [e(K_1, t) - 1 + \frac{k_0 k_2}{(k_1 - k_2)} [e(K_1, t) \frac{1 - e(-k_2, t)}{k_2} + \frac{e(k_1, t) - 1}{k_1}]] \tag{3.23}$$

where $e(K, t) = e^{\frac{K \upsilon D}{\rho}(1 - e^{-\rho t})}$

From this result we get the behavior in the limit:

$$\lim_{t \to \infty} E_z(t) = (1 - \frac{M}{\Lambda}) [e(K_1) - 1 + \frac{k_0 k_2}{k_1 - k_2} [e(K_1) \frac{1 - e(-k_2)}{k_2} + \frac{e(k_1) - 1}{k_1}]] \tag{3.24}$$

where $e(K) = e^{\frac{K \upsilon D}{\rho}}$

For small doses D, this is approximately

$$(1 - \frac{M}{\Lambda}) [\frac{k_1 \upsilon}{\rho} D + \frac{k_1^2 \upsilon^2}{2\rho^2} D^2 + \frac{k_0 k_1}{k_1 - k_2} [\frac{2\upsilon}{\rho} D + \frac{(3k_1 - k_2)\upsilon^2}{2\rho^2} D^2]]. \tag{3.25}$$

4. Resulting Consequences of the Model

At first glance equation (3.25) is a quadratic in the dose D. When the dose is small, the second order in D will be negligible and it would be a linear response. This quadratic or linear approximation would fit most commonly observed response curves. However,

this is not all, the co-efficients of D are not necessarily constants: K_0, K_1 and K_2 while being constant for a particular dose or dose range, could take different values in certain dose ranges.

Recalling the definitions of K_0, K_1, K_2, we see that K_1 represents forming cancer cells in one stage and, K_0 and K_2 represent forming them in two stages - first K_0 to form the primary cell and then K_2 to form the cancer cell. When the dose is very small the chances are that it is very unlikely that a second damage could occur to the same cell. In other words, K_2 will be very small or negligible when compared to K_0 or K_1. As the dose gets larger, K_2 becomes a substantial quantity, even of the order of K_1 but still is very likely to be smaller than K_1.

In view of this, equation (3.25) has some surprising implications. At first, K_2 is approximately zero so the terms with K_2 drop out. For very small doses, D^2 is negligible, and hence we have only the first term. Thus, at small doses D, we have an approximately linear curve which, as the dose gets a little larger, becomes a quadratic since the second term becomes prominent. At some point, K_2 becomes no longer negligible and since there is a factor of $K_1 - K_2$ in the denominator which are of the same order, $\left(\frac{0}{k_1 - k_2}\right)$ becomes a large quantity and the first two terms are masked. The curve becomes linear again. Next, the second D^2 term becomes prominent and we have a second order curve once more.

FIGURE I

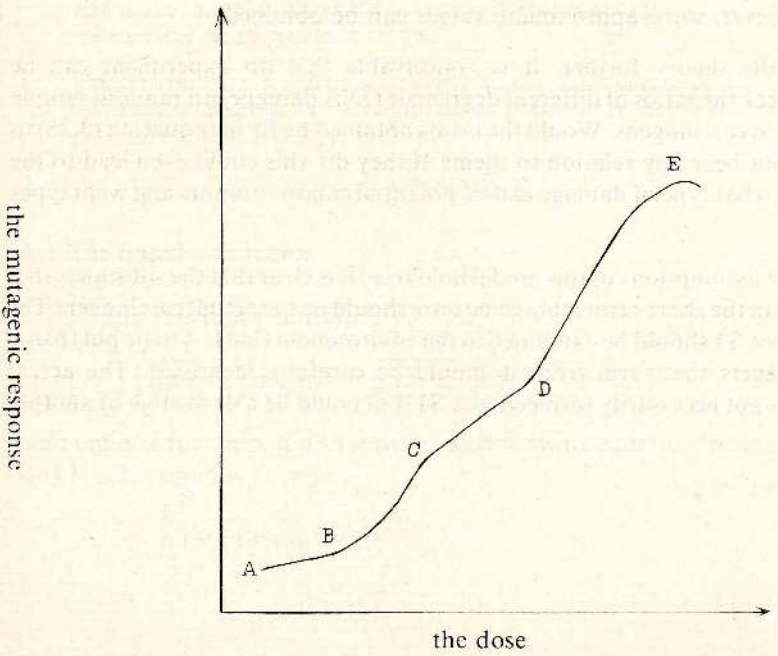

Figure – 1. This figure shows an example of the described phenomenon of a linear curve switching to a quadratic twice over in the mutagenic response. The figure is not to scale in order to show the four segments clearly. AB and CD are the linear segments, while the dose becomes toxic near E. (Produced here with the kind permission of Dr. Kendric C. Smith.)

This is exactly what some experiments (e.g., Sargentini and Smith 1979) have shown: a linear curve smoothly becoming a quadratic, a sudden switch to linearity with a steeper gradient than the previous linear segment, and once again a quadratic before finally the dose becomes lethal (see Figure 1).

From A to C the dose is too small for a second damage to occur to the same cell, thus K_2 is negligible. From C onwards.

$\frac{k_0 k_2}{k_1 - k_2}$ is comparatively large because K_2 becomes non-zero and

K_1 is of the same order of magnitude as K_2. Hence, there are two segments (AC and CE) where approximately linear curves (AB and CD respectively) switch to quadratics as the dose increases, before the dose finally becomes toxic around E. (See equation 3.25).

At least in the shape of the curve, the observations seem to agree remarkably with the model. If one assumes the first two terms can be neglected once K_2 comes into prominence, the relative ratios of the K's can be estimated from the experimental data (all having a multiplicative factor of $\frac{v}{\rho}$, only the ratios can be obtained). This assumption may not be justified, since being masked by other factors in experimental data does not imply that these terms can be totally neglected when it comes to estimation. However, some approximate values can be obtained.

To test the theory further, it is conceivable that an experiment can be performed to check the ratios of different degrees of DNA damage in a random sample of cells exposed to carcinogens. Would the ratios obtained by fitting equation (3.25) to experimental data bear any relation to them? If they do, this could even lead to the identification of what type of damage causes potential cancer tumors and what types are repairable.

When the assumptions of this model hold true, it is clear that the substance that should be tested in the short-term mutagenic tests should be the actual carcinogen. The original substance S1 should be examined in the environment that it is to be put to use, and all by-products that form from it should be carefully identified. The actual carcinogen S2 is not necessarily formed from S1, but could be a derivative of another

substance transformed in the presence of S1. Hence, it is important to carefully examine other substances in the usual environment in the proximity of the original substance, S1. Any changes in these substances in the proximity could well be a clue to the identity of the actual carcinogen.

Acknowledgements

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APPENDIX

A.1 The impulse function

Any function f satisfying

$$\int_0^{\infty} f(w) = 1 \text{ and } f(w) = 0 \text{ for all } w > 0 \qquad (A.1.1)$$

is an impulse function. It also satisfies the following equation for any function F which is continuous at zero.

$$\int_0^{\infty} f(w)F(w)dw = F(0) \qquad (A.1.2)$$

A.2

If f is any function such that $\int_0^\infty f(w)dw = 1$ then using a Laplace transform it can be shown that

$$\int_0^\infty R(x)dx = \frac{\upsilon D}{\rho} \qquad (A.2.1)$$

where R(x) is given by (2.9). When f is the impulse function of A.3.1, then

$$\int_0^y R(x)dx = -\upsilon D \frac{e^{-\rho y} - 1}{\rho} \qquad (A.2.2)$$

A.3

A result of integration:

$$\int_0^x e^{-at} Ae^{-at} e^{e^{A} - e^{Ae^{-at}}} \frac{}{aA} \qquad (A.3.1)$$

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Aflatoxin Contamination of Coconut Oil from small scale Mills: Toxin Levels and their Relation to Free Fatty Acid Content

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Abstract: Coconut oil which was mechanically extracted in small scale mills, from intermittently processed (sun-dried or smoked) Grade III or substandard copra kernels, was assayed for free fatty acid and aflatoxin B1. Oil from these samples showed significantly high levels of aflatoxin B1 (mean value 186 ppb in 115 samples of oil) than the levels found in oil from adequately processed copra extracted in large scale industrial mills. The attention of the coconut industry is drawn to this problem as a potential health hazard to humans and animals, from the consumption of the oil and press cake from such inadequately processed kernels.

The relationship between free fatty acid (FFA) content and aflatoxin B1 levels in 100 samples of coconut oil from the small scale mills has been investigated. No correlation was found. The conventionally used FFA content as a chemical index of the 'quality' of oil does not reflect the degree of aflatoxin contamination, making it necessary to apply separate assays for aflatoxin contamination in coconut oil, from commercial sources. Possible reasons for the absence of a correlation between FFA and aflatoxin levels in such oils are discussed.

1. Introduction

In recent years, new small scale rural oil extracting mills have been set up in Sri Lanka, for extracting coconut oil from domestically cured copra. The latter kernels are those which have been rejected by large industrial mills. We hypothesised that the incomplete and inadequate curing of these kernels with consequent fungal spoilage might result in higher degree of aflatoxin contamination than is found in oil extracted from adequately cured copra, in large industrial mills. In this study, the aflatoxin levels in oil from these small scale mills were estimated and compared with the levels of toxin which were detected in oil from the large commercial mills in a previous study.[9] The aflatoxin levels in some of the oil samples from domestically cured copra

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extracted in the small mills were appreciably higher than those found in the oil from the large industrial mills, indicating that the domestic curing of kernels entails a potential hazard through inadequate curing and fungal spoilage of kernels, which merits early attention.

The free fatty acid (FFA) content is one of the most widely used chemical indices of the quality of commercial coconut oil. This index reflects the hydrolysis of the main lipid constituent, the triglycerides, principally by microbial (bacterial and fungal) lipases in the original copra. The lipolysis results in heavy economic losses to the coconut industry in respect of both the loss of lipid and the quality of the oil and residual meal (press cake).

With the discovery of aflatoxins as potent hepatotoxic and carcinogenic substances, and their frequent occurrence in oil seeds, the assay of aflatoxin levels in oil seed products (mainly oil and press cake) assumed great economic and biological importance. These assays are however time-consuming and expensive. Since the predominant cause of FFA accumulation in oil seeds is the lipolytic activity of contaminant micro-organisms which include fungi, notably aspergilli which are also the source of aflatoxin, it was considered useful to investigate the relation between FFA levels and aflatoxin, since a positive correlation between these two indices may make the conventional FFA estimation, a simultaneous indicator of aflatoxin contamination. No correlation was found and this absence is discussed in terms of the origin and fate of aflatoxin and FFA in coconut oil.

2. Experimental

2.1 Coconut oil.

50-100 g samples of oil were obtained from 3 small scale private rural mills in the Kuliyapitiya District. Each sample had been mechanically expelled from a 10 -50 kg batch of copra kernels. These copra kernels had been processed domestically by rural folk, the majority of kernels having been sundried without the conventional smoke treatment which is applied on copra kernels in large scale industrial mills. The domestically cured kernels were generally of Grade III or discards which were rejected by the large mills. Further details of the processing of these substandard kernels are discussed below.

The samples of oil were collected into dark glass bottles to minimise exposure to light and were stored at 4°C in the dark pending FFA and aflatoxin assay.

2.2 Aflatoxin assay. The oil with its particulate deposit which formed on standing, was well homogenised by manual shaking. Ten g aliquots in duplicate were extracted by the aqueous acetone method.[8] Extracts of aflatoxin in chloroform were titrated on 250 nm TLC plates which were developed in 3% methanol in chloroform, by visual

comparison with standard inocula of pure aflatoxin B1 in chloroform, under 365 nm UV light. Aflatoxin G1 was not estimated since its occurrence was infrequent in the samples tested.

2.3 FFA determination

About 10 g of oil was weighed accurately into 50 ml of 96% ethanol. Phenolphthalein indicator (0.5 ml) was added and the mixture was heated to boiling point in a water bath. The hot solution was titrated against 0.1N potassium hydroxide until a pink colour which persisted for 15 sec appeared to signify the end point of the titration.

3. Results

3.1 FFA levels

The frequency distribution of FFA levels in the 100 samples of oil examined, is shown in Figure 1; the modal value was between 0.5 and 1% in a range from 0.33 to 19.25%. The mean FFA content of the series was 3.56%.

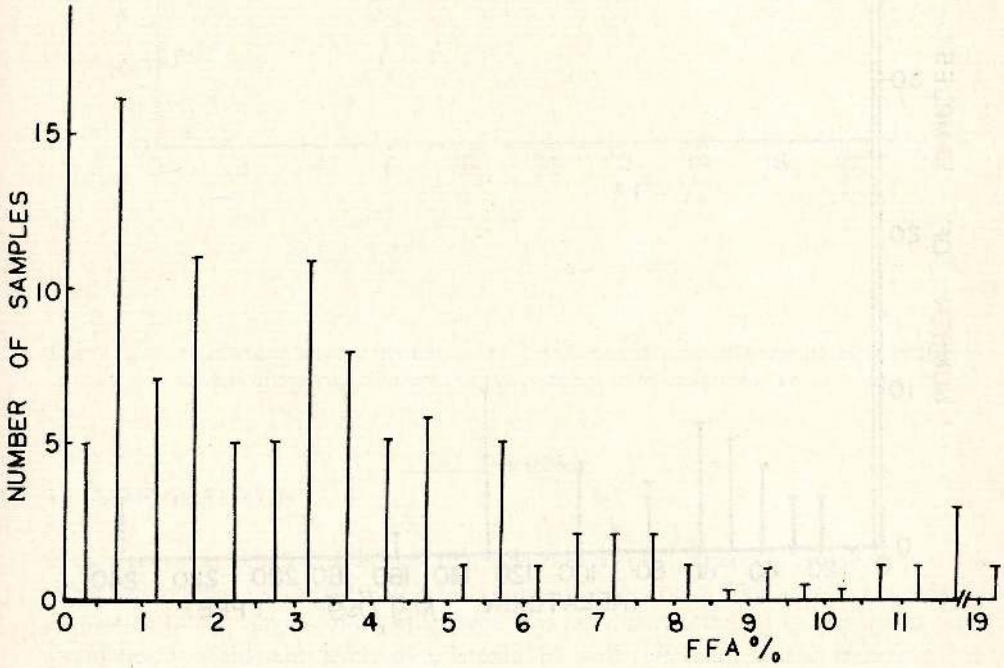

Figure 1. Frequency distribution of free fatty acid (FFA) levels (expressed as a percentage by weight) in 100 samples of coconut oil, mechanically extracted from substandard copra kernels.

3.2 Aflatoxin levels

The frequency distribution of the aflatoxin B1 levels in 105 samples of oil, is shown in Figure 2. The values ranged from 0 (below 1 ppb) to 250 ppb. In 10 further samples the levels ranged from 500 ppb (5 samples) through 1000, 1750, 2000, 3000 to 5000 ppb. The mean aflatoxin B1 content of the 115 samples was 186 ppb (μg/kg). This value is significantly high at 5% level in comparison to mean value for large scale mills.

3.3 Correlation between FFA content and Aflatoxin B1 content

Figure 3 shows the relationship between the FFA content (%) and aflatoxin B1 concentrations (μg/kg or ppb) in 100 samples of oil. There was no correlation between these two indices ($r = +0.0648$).

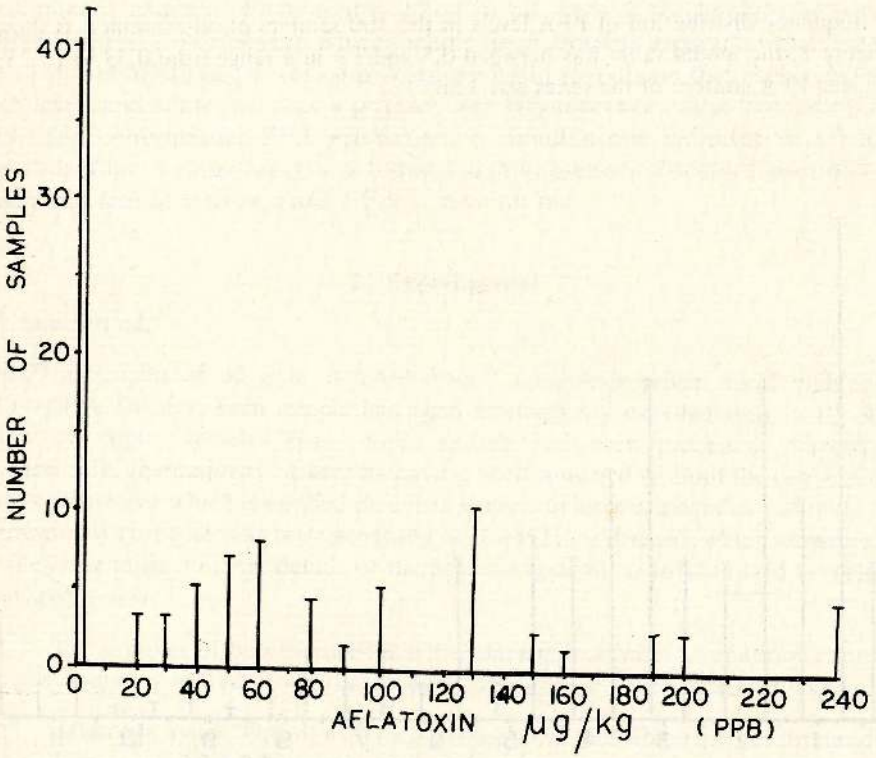

Figure 2. Frequency distribution of Aflatoxin Bl levels (μg/kg parts per billion-PPB) in 105 samples of coconut oil, mechanically extracted from substandard copra kernels.

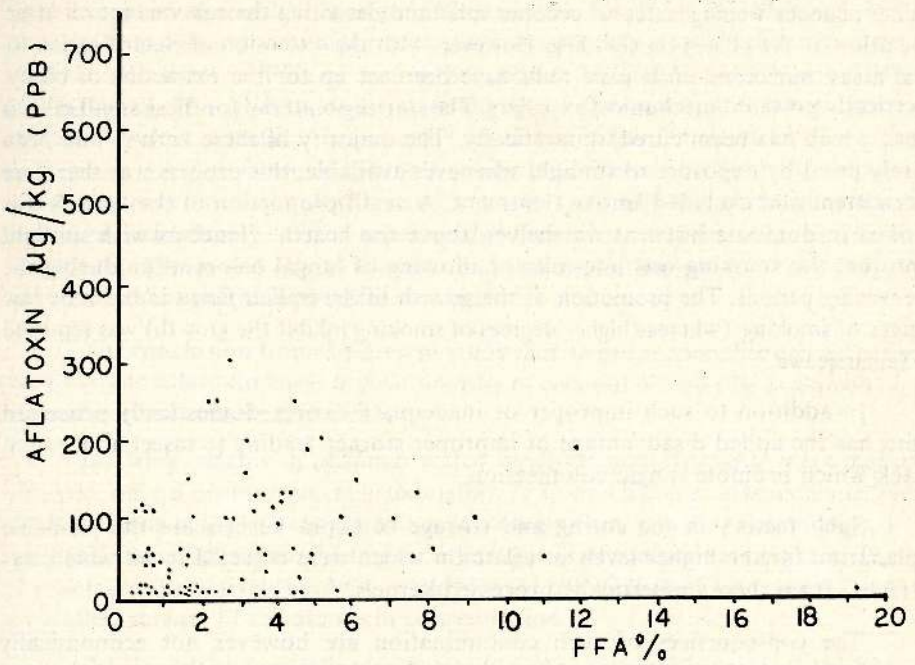

Figure 3. Relationship between free fatty acid (FFA) content (%) and Aflatoxin B1 levels (PPB) in 100 samples of coconut oil, mechanically extracted from substandard copra kernels.

4. Discussion

4.1 Aflatoxin B1 levels

Samarajeewa[9] concluded from an extensive survey of aflatoxin contamination of industrial coconut products (mainly oil, copra and copra press cake) that an appreciable proportion of the samples of oil which were processed during the dry or wet seasons had economically significant levels of aflatoxin B1 with reference to the recommended permissible maximum of 30 ppb (µg/kg) of aflatoxin B1 (WHO/FAO/UNICEF). These coconut oil samples were derived by mechanical extraction from copra processed in large industrial mills. From 116 samples of coconut oil which were collected during the wet and dry seasons in 1973, the mean level of aflatoxin B1 detected was 50 ppb with a range from 0 to 400 ppb. None of the samples had levels above 400 ppb. In contrast, the mean level of aflatoxin B1 detected in the present study of 115 samples from small scale mills in the same district was 186 ppb with 10 samples having had levels of 500 ppb (5 samples) or more (5 samples having had 1000, 1750, 2000, 3000 and 5000 ppb respectively).

Coconut oil is extracted from smoke cured copra in Sri Lanka, mainly by large scale industrial mills which use power driven mechanical expellers. Small quantities of oil for domestic use were extracted in stone mills ('sekku') at the village level three to four years ago. At the household level oil, was extracted by the traditional technique of boiling aqueous homogenates of coconut milk and decanting the supernatant oil after separation of the phases on standing. However, with the extension of electrification to rural areas, numerous small scale mills have been set up for the extraction of oil by electrically powered mechanical expellers. The starting material for these small mills is copra which has been 'cured' domestically. The majority of these kernels had been merely dried by exposure to sunlight whenever available; this process was therefore intermittent and excluded smoke treatment. A small proportion of the kernels was smoked in domestic kitchens on shelves above the hearth. Hence as with sunlight exposure, the smoking was intermittent allowing of fungal colonisation during the intervening periods. The promotion of the growth of *Aspergillus flavus* in broth by low degrees of smoking (whereas higher degrees of smoking inhibit the growth) was reported by Samarajeewa.[9]

In addition to such improper or inadequate curing, domestically processed copra has the added disadvantage of improper storage leading to insect and rodent attack which promote fungal colonisation.

Such factors in the curing and storage of copra kernels are the probable explanation for the higher levels of aflatoxin which were detected in oil which was extracted from these domestically processed kernels.

The consequences of such contamination are however not economically significant in relation to the export market since these products (oil and press-cake) are solely for domestic use in the villages. The notable effect of this contamination would on the other hand be in relation to intoxication of human and farm animal populations which consume the oil and press cake derived from such substandard copra kernels.

The health hazard posed by domestically processed copra is heightened by two factors. (a) The contaminated kernels in domestic batches are not mixed as in the large mills, with non-mouldy kernels, with the result that the aflatoxin levels are not reduced by dilution; (b) the consumers of these products are either the rural folk who process these kernels for their own use or are those living in the vicinity of the mills, both categories of persons being regularly exposed to such contaminated oil. This is in contrast to the products from the large mills which are distributed by sale in a wider area both within and outside the district making it less likely that consistently contaminated oil or press cake is consumed by humans or animals in a restricted locality.

4.2 Relation between aflatoxin and FFA levels. Eyre[4] reported that of 13 strains of *Aspergilli* from mouldy copra which were tested, all had lipolytic activity. Hiscocks[6] noted that *A. flavus* in common with *Aspergillus niger, Aspergillus fumigatus* and *Aspergillus awamori* had marked lipolytic activity among 9 species of *Aspergilli* tested. Since strains of *Aspergillus flavus-parasiticus* are the source of the aflatoxins and are common contaminants in mouldy copra, it is theoretically possible that a proportionality between levels of FFA as hydrolytic products of lipolytic activity and aflatoxin may be found. This expectation is supported by the demonstration that both glycerol[2] and fatty acids especially lauric acid[5] which is a major constituent of coconut triglyceride, are promoters of aflatoxin production. Pattee and Sessoms[7] reported a correlation between fungal growth score and both fatty acid and aflatoxin concentrations in peanuts which had been experimentally inoculated with an aflatoxigenic strain of *A.flavus*. Diener and Davis[3] however found no correlation between free fatty acid and aflatoxin in experimental cultures on peanuts.

The conclusion from the present study that no proportionality existed between the FFA and aflatoxin levels *in field samples* of coconut oil, may be explained on the basis of several considerations:-

(a) While strains of *A.flavus* tested by Eyre[4] and Hiscocks[6] were markedly lipolytic, only a proportion (approximately 75%[6] or 43%[1]) are aflatoxigenic. Hence contamination with *A.flavus* would result more uniformly in the accumulation of free fatty acid than of aflatoxin. Moreover other species of contaminating *Aspergilli*, some of which are also actively lipolytic, could also contribute to the FFA content but not to a parallel increase of the aflatoxin concentration.

(b) Apart from fungal lipases, bacterial and endosperm lipases and spontaneous non-enzymatic hydrolysis may also increase the FFA levels, in copra and the derivative oil. Such FFA release will not be paralleled by an increase of the aflatoxin level.

(c) It has been shown that the aflatoxin level in contaminated coconut oil decreases with age of the oil [1] resulting probably from exposure to daylight.[9] The FFA level will conversely tend to increase due to the action of residual lipases derived from the original kernel.

Thus the multiplicity of factors which increase the FFA level is in contrast to the single source of aflatoxin and this together with the non-parallelism of the increase or decrease of the levels of these two components, could in our opinion explain the absence of a correlation between the FFA and aflatoxin levels in coconut oil.

Acknowledgements

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Preliminary Laboratory Studies on Eppawela Apatite - II

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Abstract: Investigations carried out earlier showed that the phosphate in Eppawela apatite can be converted into a citric acid soluble form by treatment with soda ash. In the present series of experiments apatite obtained from the grinding plant at Eppawela was used. Calcination of this powdered apatite at 1400°C. complete conversion of P_2O_5 to citric acid soluble form was obtained. The chemical and the energy dispersive spectrometer analyses of the powdered sample of apatite showed that it contains alumina, iron oxide and silica as main impurities. These impurities favoured the conversion of P_2O_5 in apatite to citric soluble form. Treatment of pure apatite with red clay containing alumina, iron oxide and silica also showed a positive effect on the conversion of P_2O_5 to citric soluble form.

1. Introduction

Laboratory studies carried out on the beneficiation of Eppawela apatite showed that by calcining a mixture of apatite and soda ash the phosphate (P_2O_5) in Eppawela apatite can be converted into citric acid soluble form.

X-ray diffraction studies of the calcined product showed the formation of sodium calcium phosphates (*eg.* $NaCaPO_4$, $Na_3Ca_6(PO_4)_5$ etc.). The product has been reported to be substantially more effective than superphosphate on several acid tropical soils, because of its alkalinity and resistance to fixation by the soil.[4] In some crops or soils the sodium or soil-soluble silica may be beneficial.

In the present investigation attempts were made to develop a product with high citric soluble phosphate (P_2O_5), without addition of alkali salts in the process of calcination.

2. Experimental

2.1 Starting Material

The term commercial apatite is given to the sample obtained from grinding factory and pure apatite for sample obtained from primary deposit.

Both samples were ground to pass BS 100 mesh sieve and used in the present investigation.

Chemical analysis of both starting materials were carried out according to standard method[3]

2.2 Calcination

Calcination experiments were carried out upto 1400°C in platinum crucibles in temperature controlled furnaces. The experiments were carried out in duplicate.

The calcined products were analysed for 2% citric acid solubility according to official method of analysis AOAC,[2] P_2O_5 content was determined by a spectrophotometric method using ammonium vanadate reagent.

2.3 Differential Thermal Analysis

Differential thermal analysis curves of both samples and the clay used were taken by using model spectromom 190 A, Derivatograph.

2.4 XRD Studies

X-ray diffraction patterns of the samples were taken using JEOL JDX-8S, type X-ray diffractometer fitted with graphite monochrometer.

2.5 Scanning Electron Microscope

Scanning Electron Microscope microphotographs of the samples were taken using a JSM T-200, JEOL Scanning Electron Microscope.

3. Results and Discussion

3.1 Preliminary Studies

3.1.1 Chemical Analysis

Given below were the results of the chemical analyses carried out on pure apatite and commercial apatite (Table I).

Table 1. Chemical Composition of the Apatite Sample used

Constituent	Commercial Apatite % w/w	Pure Apatite % w/w
CaO	48.11	55.52
P_2O_5	31.65	39.35
SiO_2	1.96	0.35
Fe_2O_3	6.14	0.27
MgO	0.19	0.10
Al_2O_3	3.20	0.63
Loss on ignition	0.95	0.21
Moisture	3.94	—

The effectiveness of these apatite samples as a phosphatic fertilizer were determined as 2% citric acid soluble P_2O_5 content and results obtained were as follows (Table 2).

Table 2. Citric Acid Solubility of Apatite Samples

Sample	2% Citric Acid soluble P_2O_5 %	Total P_2O_5 %	%Conversion P_2O_5 to Citric Acid soluble form
Pure apatite	5.18	39.35	13.16
Commercial apatite	4.63	31.65	19.61

3.1.2 X-ray Diffraction Analysis

X-ray analysis showed that Eppawela Apatite is mainly in the form of hydroxyl apatite $Ca_5(PO_4)_3(OH,Cl,F)$ with a little amount of fluorapatite $Ca_5(PO_4)_3F$ (Figure 1) In the case of commercial apatite peaks due to small amounts of α-quartz, goethite was observed.

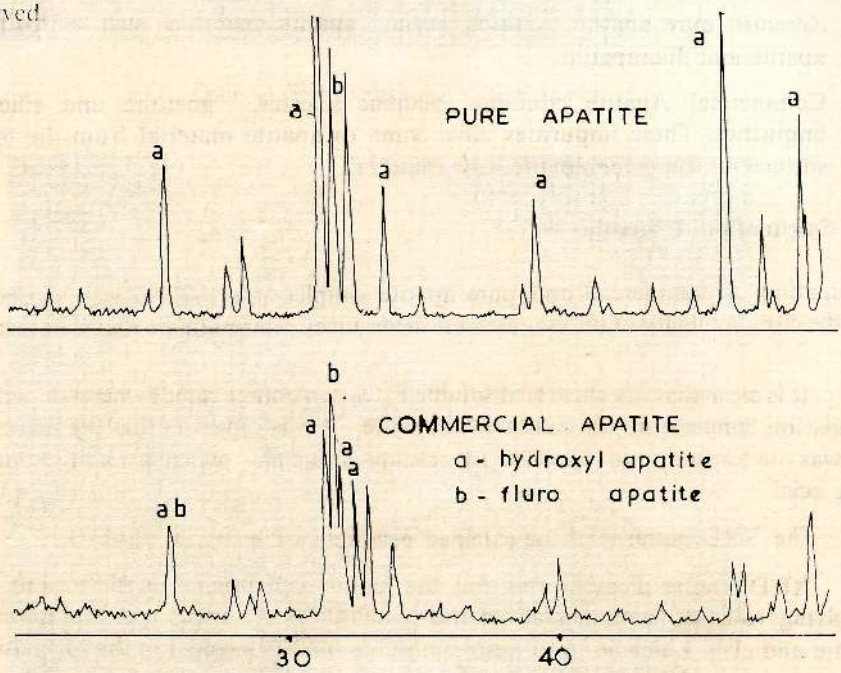

Figure 1. XRD Patterns of Apatite

From this it was clear that pure apatite consists mainly of apatite material and commercial apatite contains small amounts of clay, goethite, silica sand as impurities along with apatite materials.

3.1.3 Scanning Electron Microscopic (SEM) Studies

SEM photographs taken on a apatite rock are given in Figure 2. The white patches indicate the presence of impurity in the rock.

The SEM microphotograph of the sample used for Energy Dispressive Spectrometer (EDS) studies is given in Figure 3.

The EDS analysis of the top surface of the rock labelled as 'A' showed that it consists mainly of clay and 'B' of pure apatite with silica as impurity.

These results clearly show that the green surface 'B' is pure apatite and the brown surface 'A' from matrix of the deposit. Brown surface consists of mainly alumino silicates (from clay).

From this preliminary analysis we can conclude that:

(a) Greenish pure apatite contains mainly apatite materials such as hydroxyl apatite and fluorapatite.

(b) Commercial Apatite contains alumino silicates, goethite and silica as impurities. These impurities have come to apatite material from the brown surface on the green apatite rock material.

3.2 Calcination of Apatite

Calcination of commercial and pure apatite samples upto 1400°C were carried out and the citric solubility of the samples were determined. The results are shown in Figure 4.

It is clear that the citric acid soluble P_2O_5 percentage rapidly increase with the calcination temperature for commercial apatite. It was observed that the reason for this was the formation of $[Ca_3(PO_4)_2]$ calcium phosphate which is readily soluble in citric acid.

The XRD patterns of the calcined products are given in Figure 5.

XRD studies also showed that the major constituents in the residue after dissolving calcined commercial apatite (1400°C) in 2% citric acid was unreacted apatite and clay. Calcination of pure apatite at 1400°C resulted in the formation of stoichiometric hydroxyl apatite. Formation of hydroxyl apatite did not increase the citric acid solubility of pure apatite at high temperatures.

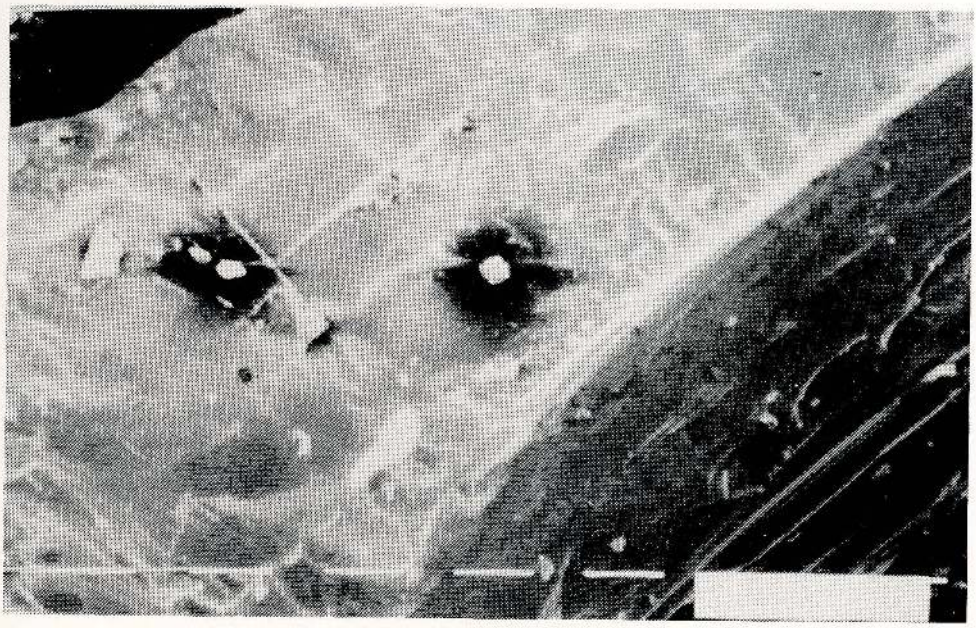

Figure 2. Sem Microphotographs of Apatite

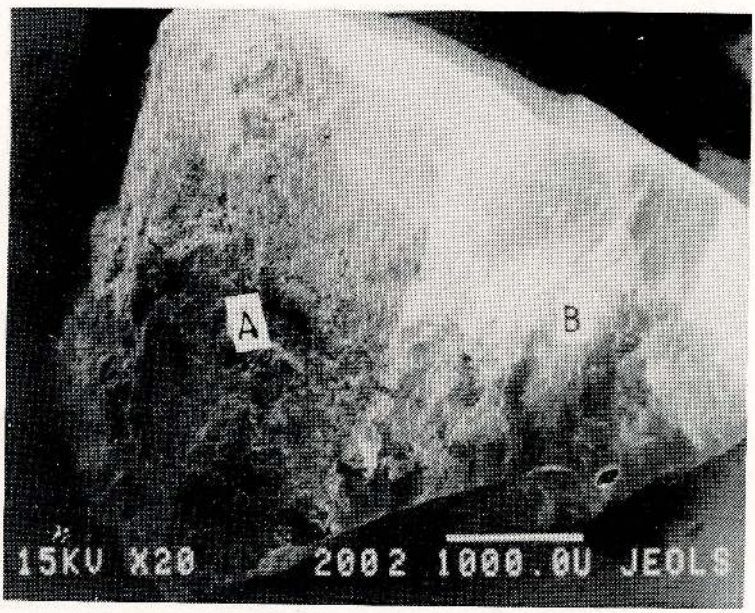

Figure 3. Rock Apatite used for eds analysis

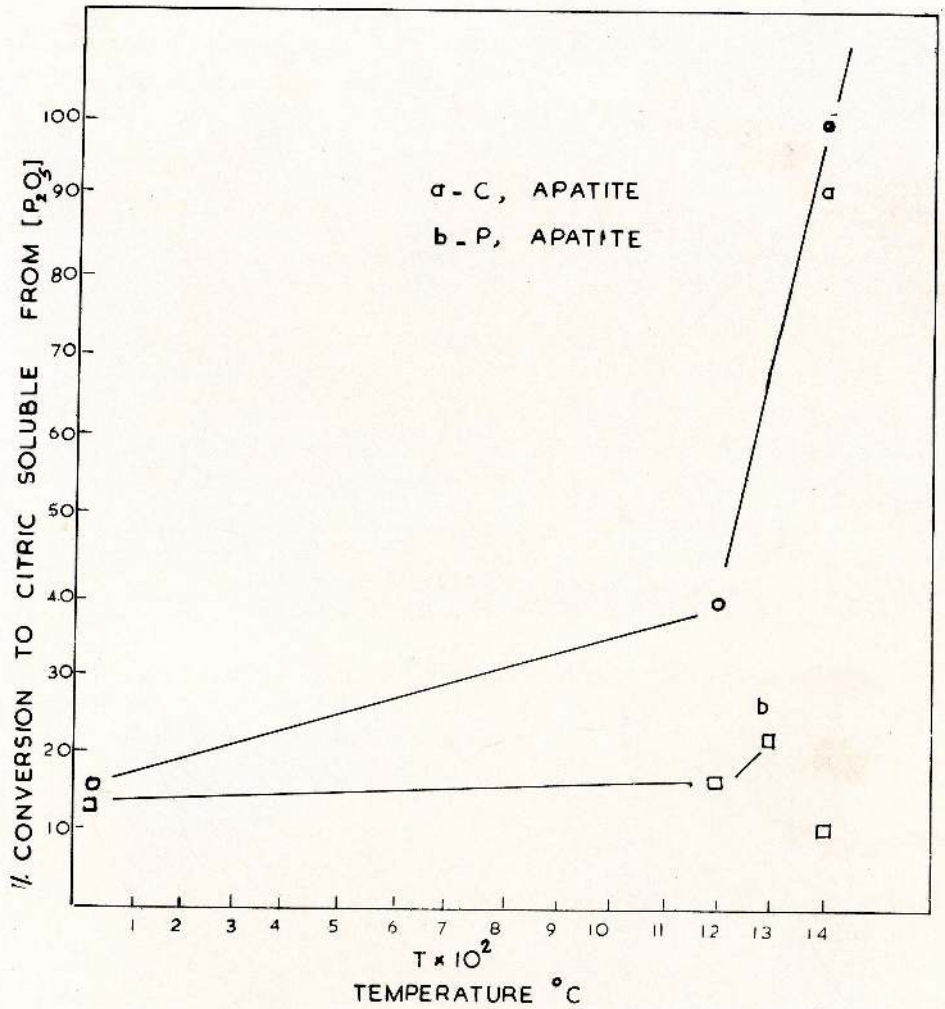

Figure 4. Effect of temperature on citric solubility of Apatite

The preliminary investigation clearly shows that,

(a) Increase of citric acid solubility in calcined samples is due to the presence of appreciable amounts of silica, alumina in commercial grade of apatite which would have come to the sample from gangue material clay or from free silica.

(b) These impurities had influenced the formation of citric acid soluble $Ca_3(PO_4)_2$ from the hydroxylapatite.

(c) Corresponding results for pure apatite were very low, due to the absence of these impurities and hence formation of purely crystalline hydroxyl apatite.

Further experiments were carried out on commercial apatite samples by calcining with powdered silica sand (100 mesh) from Nattandiya to investigate the effect of free silica on the conversion of P_2O_5 to citric acid soluble form.

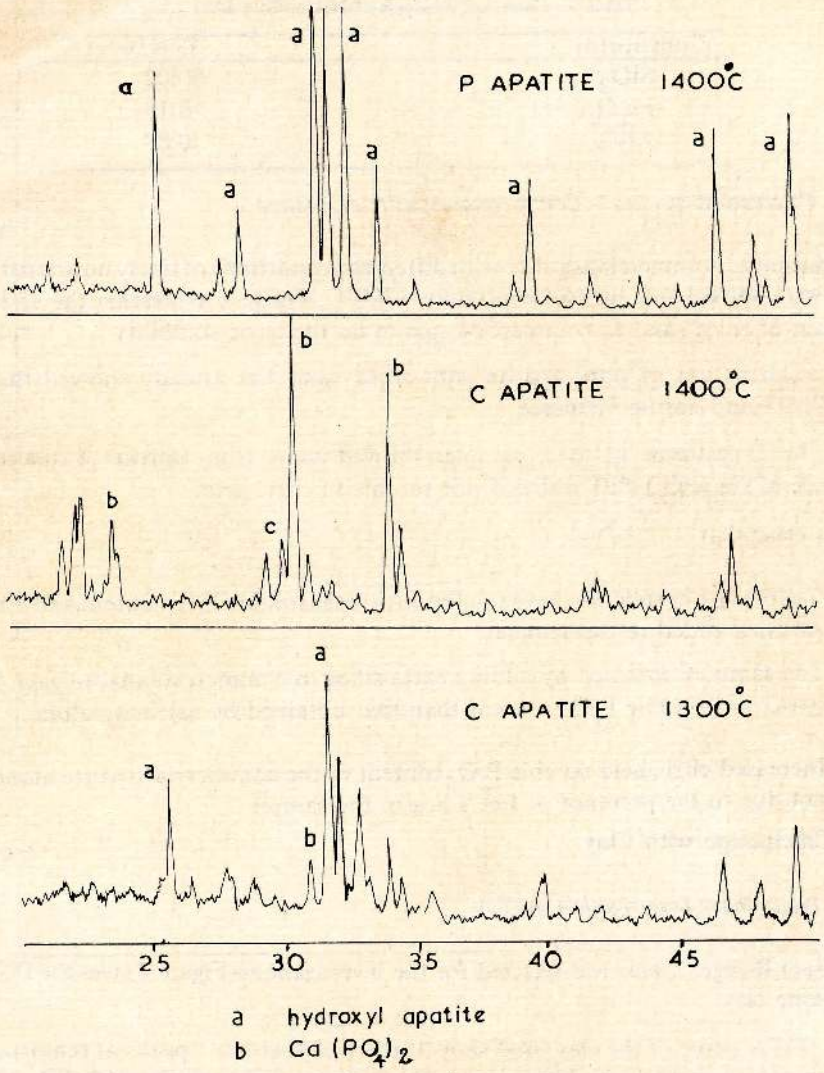

Figure 5. XRD Patterns of calcined apatite.

3.3 Calcination of Commercial Apatite with Silica Sand

3.3.1 Preliminary Analysis of Silica Sand

3.3.1.1 Chemical Analysis

Following were the results of the chemical analysis on Nattandiya sand used. (Table 3)

Table 3. Chemical Analysis of Nattandiya Sand

Constituent	% w/w
SiO_2	99.02
Fe_2O_3	0.18
Al_2O_3	0.88

3.3.2 Calcination Studies – Commercial Apatite and Silica

Calcination of commercial apatite with different proportions of finely powdered silica sand were carried out up to temperature 1300°C. Figure 6 represents the effect of addition of silica sand to commercial apatite on the citric solubility.

Calcination of pure apatite with silica sand has already showed that the solubility could not be increased.

XRD patterns of these samples showed apart from unreacted apatite the presence of $Ca_5(PO_4)_2SiO_2$ which is not soluble in citric acid.

It was clear that

(a) There is no correlation between the citric acid soluble P_2O_5 content and amount of silica added to the samples.

(b) The samples obtained by adding extra silica to commercial apatite gave lower citric acid soluble P_2O_5 content than that obtained by calcining alone.

(c) Increased citric acid soluble P_2O_5 content of the commercial apatite alone was not due to the presence of free silica in the sample.

3.4 Calcination with Clay

3.4.1 Preliminary Investigation of Clay

Clay from Biyagama area was selected for the investigations. Figure 7 gives the DTA of Biyagama clay.

DTA curve of the clay used show three endothermic peaks at temperatures around 110°C, 300°C and 530°C and a weak exothermic peak at 900°C. Normally

kaolinitic clays show a weak peak below 200°C and endothermic peak around 570 - 580°C and exothermic at 970°C. Ferruginous materials (mainly goethite) show an endotherm around 350°C but the peak temperature may vary according to the crystallinity of the material. Kaolinite - gibbsite clays show an endotherm around 320°C and other kaolinite peaks at 580°C (endotherm) and 970°C (exotherm).

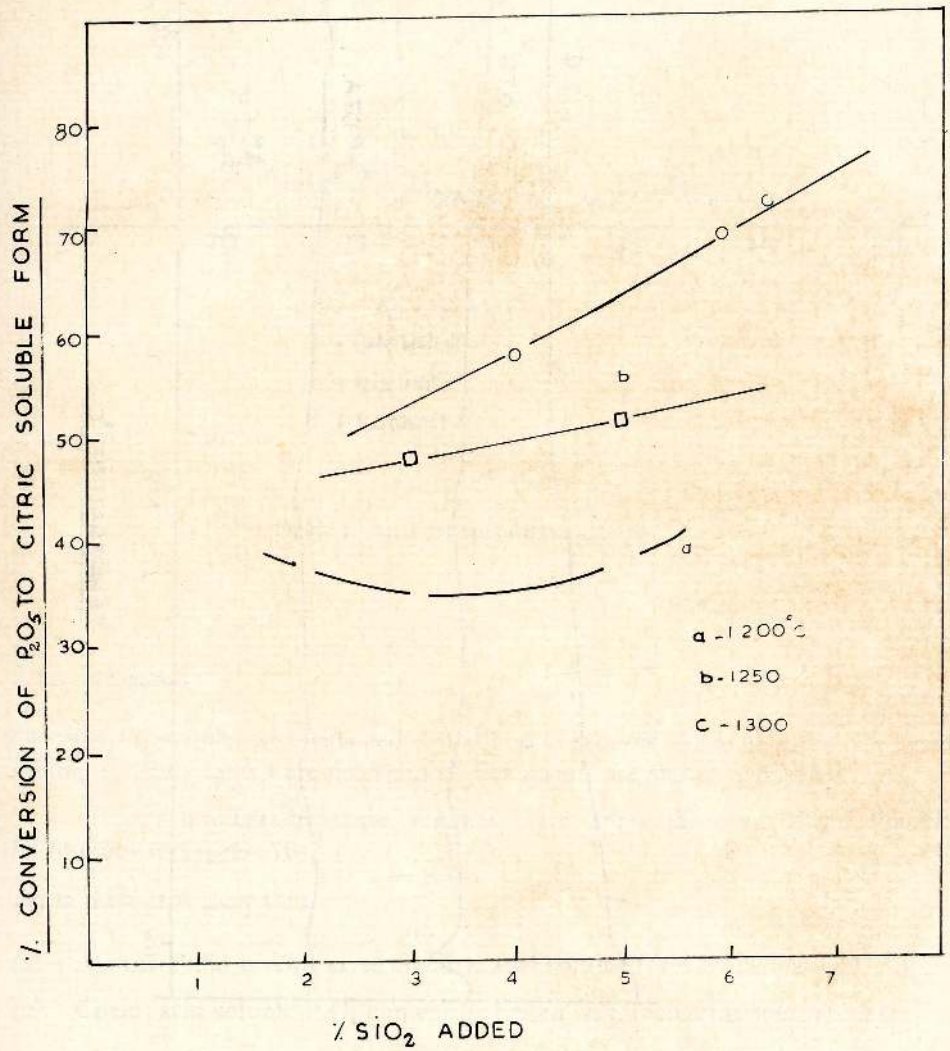

Figure 6. Effect of addition of SiO_2 on citric solubility of commercial apatite at different temperatures.

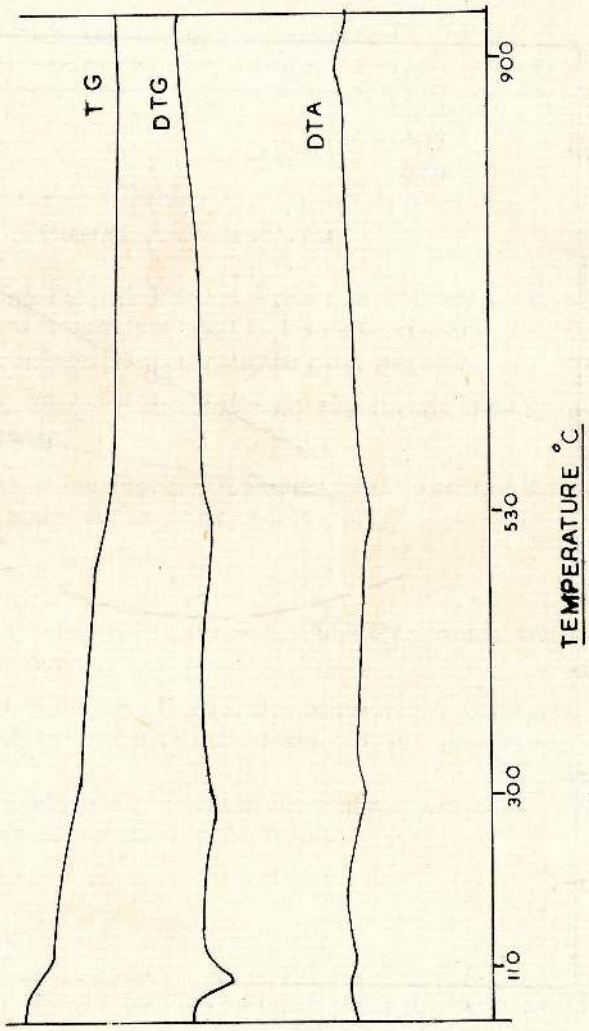

Figure 7. DTA curve of Biyagama clay.

XRD study (Figure 8) of clay show the presence of kaolinite, quartz, gibbsite and goethite. Hence the clay used is a kaolinite - gibbsite - goethite type clay.

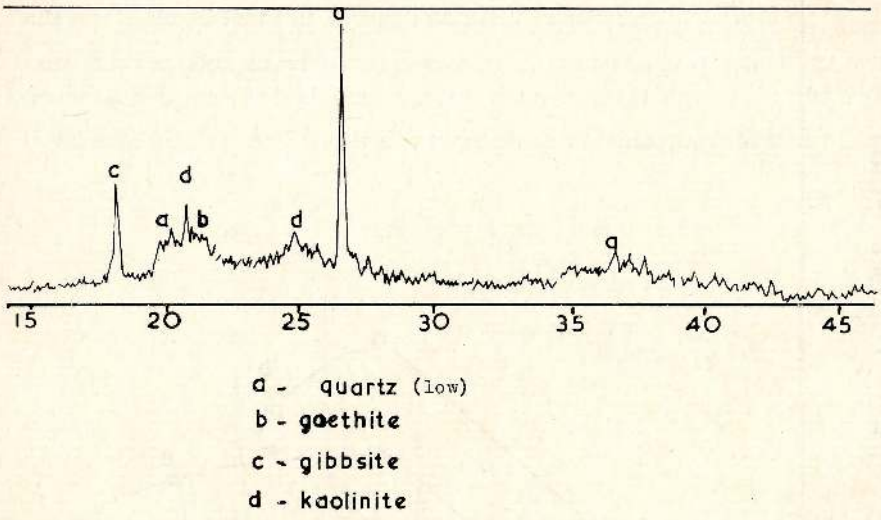

Figure 8. XRD pattern of Biyagama clay.

3.4.2 calcination

Pure apatite samples were calcined with different proportions of clay and citric acid soluble P_2O_5 contents were determined. The results are shown in Figure 9.

Phases present in these samples were analysed using X-ray Powder Diffractometer (Figure 10).

From these it is clear that,

(a) Apatite could be converted to citric acid soluble form by fusing with clay.

(b) Citric acid soluble P_2O_5 content increased with increasing temperature.

(c) Citric acid soluble constituent in these calcined products is mainly $Ca_3(PO_4)_2$.

(d) With increase of apatite to clay ratio beyond 10:4 the solubility decreases. This is due to unreacted clay remaining in the sample.

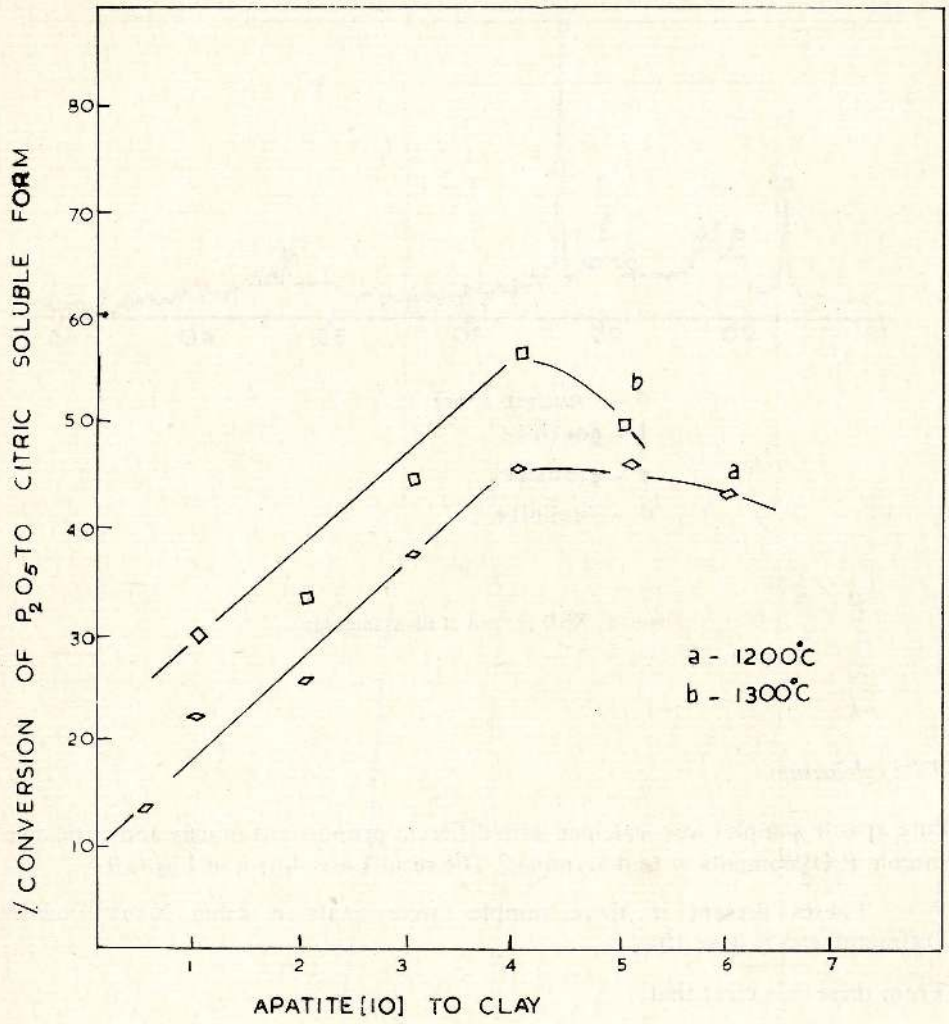

Figure 9. Effect of clay on citric solubility of pure apatite.

4. Conclusion

(1) Commercial grade Eppawela Apatite and Pure Apatite are not suitable as fertilizers since they have a low citric acid soluble P_2O_5 percentage.

(2) Commercial Apatite can be converted to a product having almost all the phosphorous in citric acid soluble form by calcining it at 1400°C.

(3) Pure Apatite cannot be converted to a more citric acid soluble form like commercial grade. by simply calcining to high temperature.

(4) Reason for higher citric acid soluble phosphorous in calcined commercial apatite is the presence of alumino silicates, which acts as a flux.

(5) Pure apatite also could be converted to more citric acid soluble form by calcining with clay at high temperature (above 1200°C)

(6) In all experiments the citric acid soluble phase obtained was $Ca_3(PO_4)_2$.

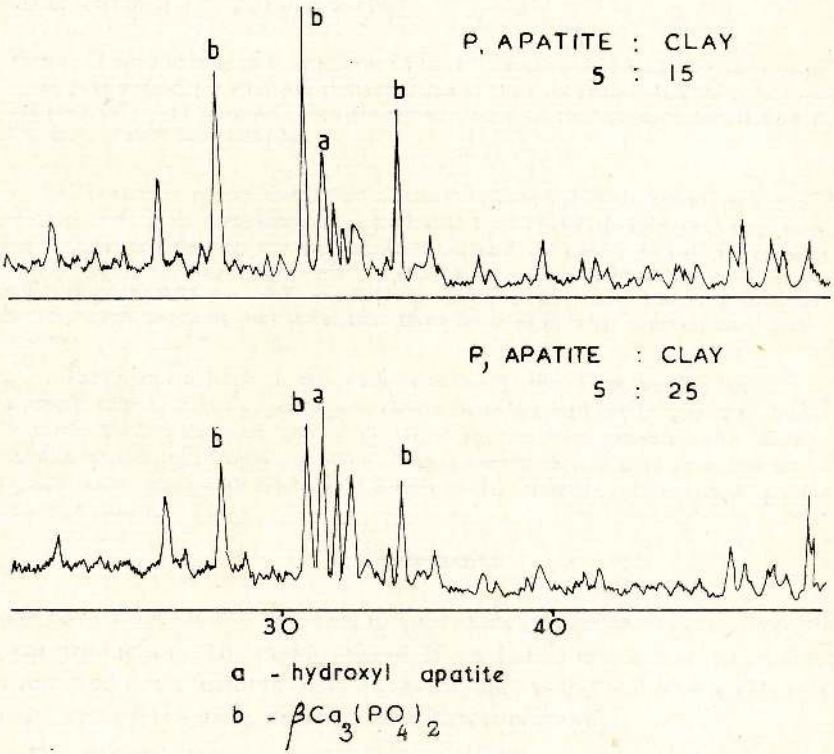

Figure 10. XRD patterns of calcined apatite with clay.

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A Survey of Aflatoxin Contamination of Coconut Products in Sri Lanka; Incidence, Origins and Recommendations

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Abstract: Forty five large scale mills in the 'Coconut Triangle' of Sri Lanka were studied over a one year period, for aflatoxin contamination of their products – mainly copra, oil and press cake – to determine the incidence and levels of aflatoxin contamination, and the origin of such contamination.

Of 344 samples, approximately 50% contained medium-high levels (0.05 to 1 μg/g,ppm) of aflatoxin B1. None of the samples had levels over 1 ppm. In 99 selected copra kernels with heavy fungal colonisation, the levels ranged from 0.05 to 4 ppm in 50% of the kernels. Only 2 kernels had higher levels with 10 and 20 ppm: 29% of kernels had levels between a trace and 0.05 ppm while no aflatoxin was detected in 18%. The levels detected in cured copra products were lower than those reported in other oilseeds; reasons are discussed.

The aflatoxin levels in the products from 25 mills which were in continuous production during the survey period, were classifiable as 'regularly high', 'occasionally high', 'regularly medium-low' and 'low or nil'. These patterns were correlated with rainfall techniques for curing of copra, conditions of storage, prolonged storage of copra, admixture of high quality copra with substandard kernels for oil extraction and the lack of quality control measures.

1. Introduction

Oilseeds have been shown to be good substrates for the growth of aspergilli and aflatoxin production. The major oilseed in Sri Lanka is coconut; its products are important food items for both humans and animals in this and several other tropical countries, apart from being items in their export economy.

The economic losses incurred in copra manufacture in Sri Lanka due to fungal spoilage, have been estimated to be approximately 25% of the total production.[7] Extensive data on the biological effects of the aflatoxins, with reports of acute intoxication in both humans and farm animals, with indirect evidence for a possible aetiological relationship between the aflatoxin loads in foods and the incidence of cancer of the human liver, necessitated a detailed study of the aflatoxin problem in

relation to coconut products. This need was accentuated by the demonstration[2] that fresh coconut was an excellent medium for the accumulation of large amounts of aflatoxin. The economic implications of fungal spoilage in terms of the losses of substrate and lowering of export quality were further reasons for an in-depth study.

A preliminary survey of retail samples of coconut products in the Kandy District[1] did show economically significant levels of contamination. The present survey was undertaken to provide more detailed data on the incidence and origins of aflatoxin contamination in coconut products in the major coconut producing area in Sri Lanka, with special reference to the formulation of remedial measures for the prevention and control of contamination.

Coconut based animal feedstuffs were also included in this study on account of the adverse effects of aflatoxin ingestion by farm animals such as on meat production and egg output, as well as on the possibility of ingestion by humans of milk containing the toxic metabolite aflatoxin M1 derived from aflatoxin B1 after ingestion by lactating animals.

2. Experimental

2.1 Samples – Samples were collected from 45 out of 58 registered coconut oil mills in the area within the 'coconut triangle' bounded by Chilaw, Kurunegala and Colombo, and along the coastal belt from Puttalam to Beliatta. The few mills in the Jaffna peninsula were not surveyed as this was not a major coconut industrial area. Thirteen registered mills in the 'coconut triangle' which were not functioning during the survey period were excluded from this study.

Samples of the major coconut products – copra, copra press cake (copra meal, poonac) and coconut oil were collected during the three seasons January to April, May to August and September to December in 1973, to investigate the effect of rainfall as reflected in the wet and dry periods of these seasons. In addition, samples of parings, parings oil, parings press cake, coconut refuse ('Polkudu'), refuse oil, refuse press cake, animal feed containing coconut, and desiccated coconut (both export quality and rejected) were also collected for assay from these mills whenever they were available.

Single copra kernels which showed heavy fungal colonisation with aspergilli and penicillia were selected from copra stores for separate analysis.

2.2 Sampling Coconut Oil — Samples were withdrawn from bulk storage tanks by lowering a bottle into the oil. The oil in the tanks was assumed to be homogeneous as regular addition and removal of oil was expected to result in some degree of mixing of the contents of the tank; no other means of homogenising the contents of the tank, was available.

2.3 Copra powder and press cake — Samples (10 g) were withdrawn from adjacent layers, 30 cm in height in the case of conical heaps. The number of samples

withdrawn from each of such layers starting from the top of the heap, were in the ratio of volumes 1 : 7 : 19 : 37 : 61 : 91....., these being the ratios of volumes in a cone when horizontal layers of equal thickness were considered. When long beds of material were sampled, they were assumed to be a series of cones and the samples were withdrawn accordingly.

The withdrawn samples were then mixed and subsamples were used for analysis.

2.4 Preparation of samples for assay — The press cake samples were pulverised in a sponge mill No. 3. The resulting product had the following sieve (BS) analysis:

10 mesh retained approximately	10%
10-20 mesh retained approximately	50%
20 mesh through approximately	40%

The copra samples were minced to a particle size of 2 mm or less.

2.5 Aflatoxin assay — The samples were extracted by a modified 70% aqueous acetone procedure with 3 successive homogenisations instead of shaking as in the original procedure.[8] Titration of the extracts in chloroform was done on 250nm silica gel G (Merck) thin layer plates, by visual comparison with inocula of pure aflatoxin B1 and G1 in chloroform, under UV light at 365 nm. On account of the predominant occurrence of Aflatoxin B1, only the values relating to B1 are shown in the tables and figures.

3. Results

3.1 Aflatoxin levels

Following the classification of aflatoxin levels in foods suggested by the Tropical Products Institute, London[5] the samples were assigned to 4 groups as follows:

group	Aflatoxin B1 content μg/g (part per million)
Low or negative	less than 0.05
medium	0.05 to 0.25
high	0.25 to 1.0
very high	more than 1.0

About 50% of all the samples tested contained medium or high aflatoxin levels.

The distribution patterns of aflatoxin B1 in the products are shown in Table 1.

The mean aflatoxin levels detected in copra powder, coconut oil and copra press cake collected from 45 mills are 0.08, 0.05 and 0.09 /μg/g respectively. Among 99

copra kernels which showed heavy colonization with fungi, only two samples had levels of 10 /μg/g or more, with 10 and 20 /μg/g respectively; both these samples were collected from the same mill but on two different occasions. Aflatoxin B1 levels ranging from 0.05 to 4 μg/g were present in 50% of the copra kernels. Low levels (below 0.05 μg/g) were detected in 29 (29%) samples. These were only 18 (18%) samples which did not contain detectable aflatoxin.

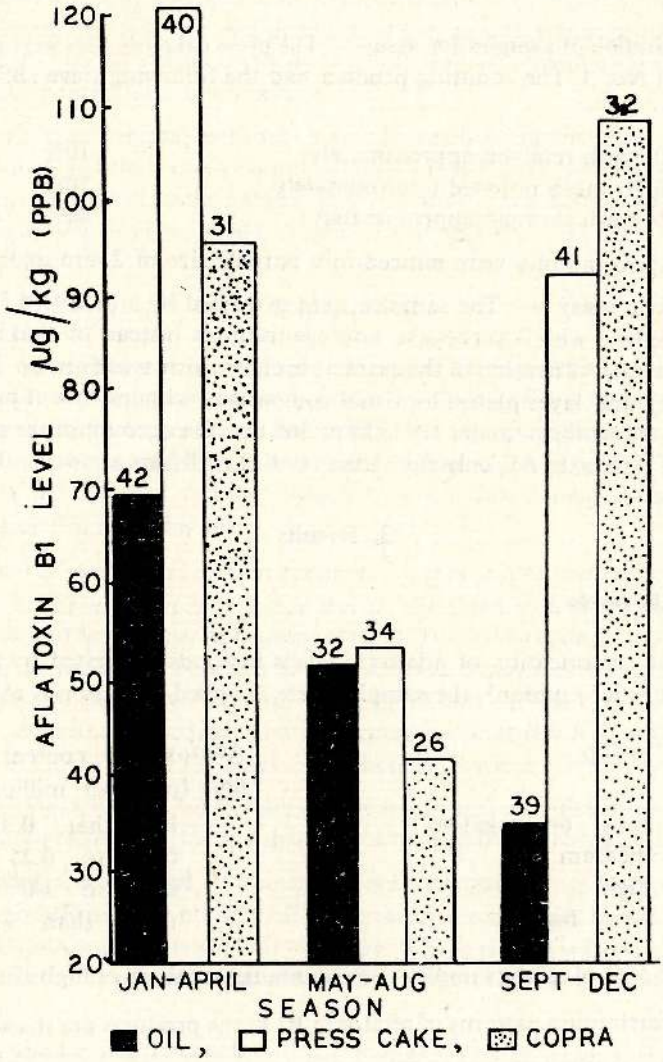

Figure 1. Variation of Aflatoxin Bl contamination patterns in commercial coconut oil, copra press cake and in copra powder with season. Figures on bars refer to the number of samples assayed. Aflatoxin levels represent mean values.

3.2 Aflatoxin levels in relation to rainfall: The rainfall figures recorded during the survey period showed same pattern of monthly variation in intensity at all the stations along the coast from Puttalam to Beliatta with slightly higher figures in the Kalutara District. The Kurunegala District had low rainfall throughout this period. In all Districts the maximum and minimum rainfall were recorded in the following months:

Month	Pattern
December (previous year)	Maxima
January/February	Minima
April/May	Maxima
August/September	Minima
October/November	Maxima

The mean aflatoxin levels detected in copra powder, coconut oil and copra press cake during the three collections are shown in Figure 1. The aflatoxin levels were high in all the samples of all three products which were collected during January to April period. The levels were lower in samples collected during May-August period. The levels in copra powder and copra pressed cake increased following the high rainfall in August-September while the aflatoxin levels in coconut oil however did not show a corresponding increase during this period.

3.3 Aflatoxin B1 levels in samples from individual coconut oil mills

Data from 20 mills which were not in continuous production during the survey year, was insufficient for a comprehensive analysis and is excluded from this record.

The data presented below is from 25 mills which were sampled continuously throughout the test year; their contamination levels showed a definite pattern and these 25 mills were classified as follows according to the levels of aflatoxin in their samples:

(a) 'Regularly high' Two mills which processed lower grade copra fell into this category. The aflatoxin levels in their products are shown in Figure 2a.

(b) Occasionally high' High levels of aflatoxin were observed in these 6 mills. These levels were related to high rainfall. Their pattern of contamination is shown in Figure 2b.

(c) 'Regularly medium low' These 4 mills purchased under-smoked or contaminated substandard copra as starting materials, from a few producers. This copra was mixed with good quality copra prior to oil extraction or before deposition for storage. The levels of aflatoxin detected in the samples from these mills are shown in Figure 2c.

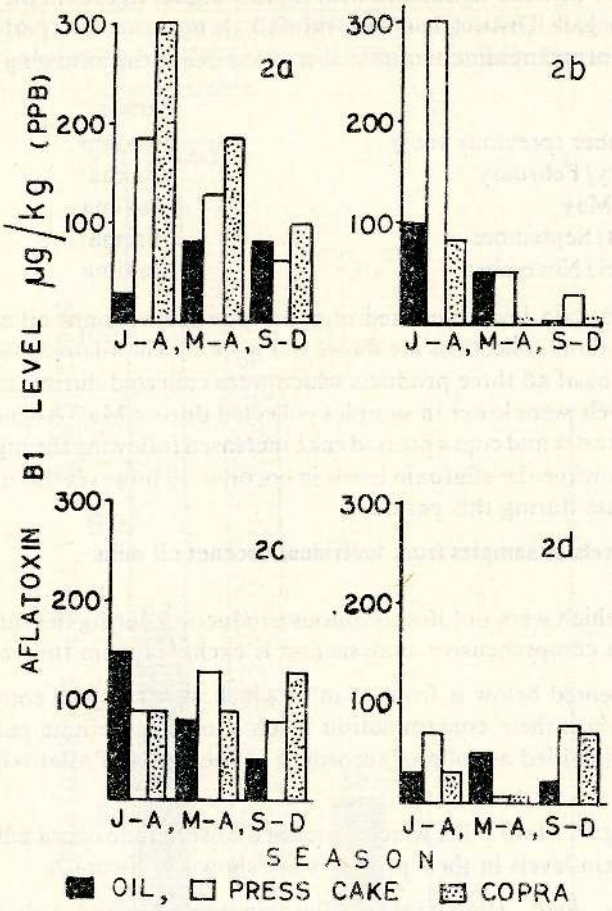

Figure 2. Variation of Aflatoxin B1 contamination patterns in commercial coconut oil, copra press cake and in copra powder with season: 2a - mills with regularly high levels; 2b mills with occasionally high levels; 2c - mills with regularly medium low levels; 2d - mills with low or nil levels.

(d) 'Low or high' These 13 copra processing mills were mainly concerned with expelling oil from either coconut parings, which were produced as a by-product of their desiccated coconut industry or had their own smoking kilns which produced high quality copra. Their aflatoxin levels are shown in Figure 2d.

4. Discussion

4.1 General aspects: The aflatoxin levels detected in copra and its products were appreciably lower in comparison with the levels attained in fresh coconut, experimentally contaminated with *Aspergillus parasiticus* or *Aspergillus flavus*[2]. The observation that colonisation of field samples of copra kernels by *A. flavus-parasiticus* was evident in adequately smoked kernels only in and around the areas which were damaged by breakage or rodent attack provided a possible explanation for this paradox, i.e. the mechanical or rodent damage to copra kernels exposed the depths of the kernel which were not exposed to the deposition of the constituents of the smoke. This led to the hypothesis that these smoke constituents were probably inhibitory to fungal colonisation and/or toxin production, a hypothesis which was confirmed experimentally.[3] For the same reasons the low levels of aflatoxin in smoked copra kernels and the coconut oil contrast with the high levels which are sometimes detected in other oilseeds notably groundnut, which are not smoked but merely dried during their processing.

4.2 The influence of moisture on aflatoxin accumulation in coconut products: Fungal colonisation occurs in copra which contains more than 6% moisture. The curing of copra reduces the moisture content to 4-6%. However the average moisture content of copra in the field lies between 7-9%.[7] During the rainy season, the kernel absorbs moisture from the humid atmosphere resulting in sufficient moisture levels for fungal colonisation. This process is promoted by the practice of some millers who store copra for up to 4 months before expelling oil, as it is claimed by them that, oil is expelled more easily from kernels which have a higher moisture content and which are partially deteriorated.

The higher aflatoxin levels which were detected in the first batch of samples (Figure 1) were probably associated with copra stored through high rainfall which occurred during the last few months (October-December) of the previous year before the collection during January-March. The low rainfall during January-February is reflected in the lower values of aflatoxin in the products which were cured and stored during this period. Storage during this dry period would not have led to rehydration of the processed kernels with consequent aflatoxin formation. The higher levels observed again in samples of the third batch collected during the September-December period are likewise probably correlated with the high levels of humidity consequent on the heavy rains in April-May, during which period these samples were processed and then stored for a few months beyond that period. The coconut production is high during April-May and it is quite probable that large amounts of copra are produced and stored for oil expulsion during lean periods towards the end of the year.

The pattern of contamination of coconut oil however differs from that shown by copra and press cake described above. In the oil, there was a continuous drop of aflatoxin levels with the three samplings during the year. The explanation for the

decrease of aflatoxin levels in the oil contrasting with a rise in the levels in press cake, is obscure.

4.3 Variation of contamination with mill: Among the four categories of mills, those which belonged to the 'regularly high' category consistently bought low grade copra at cheap rates, to achieve greater profits. The high demand for coconut oil throughout the year and the lack of quality control measures would have also permitted the use of low grade copra for oil extraction and press cake manufacture.

The lack of proper storage facilities and the lack of knowledge on the part of the millers on the origins of fungal colonisation, are apparently serious causes of the high levels of contamination observed in association with rainfall in the 'occasionally high' category of mills.

Although the mills which showed 'regularly medium-low' levels were also compelled to buy substandard copra from outside to keep their mills running throughout the year, their practice of mixing different grades of copra (including high grade copra) as revealed by most of the millers at discussion would have contributed to the overall lower degree of aflatoxin contamination in the samples from these mills. The extent of mixing was found to vary depending on availability of different grades of copra.

The mills of the 'low-nil' category used copra which was cured in their own kilns and did not purchase copra which was cured elsewhere. These two factors would have ensured the use of high quality copra which was reflected in the 'low-negative' values for aflatoxin.

It appears that the problem of fungal contamination is more associated with the lack of the millers' knowledge of the mechanisms of spoilage and its consequences or with financial constraints in setting up their own processing plants, both of which result in the purchase of low quality copra for processing.

4.4 Millers' practices which encourage fungal spoilage and aflatoxin accumulation: During the stage of curing, underdrying of copra is a major problem. Many copra producers admitted that they do not subject copra to more than five rounds of drying. The resulting moisture levels in copra would be above 7 per cent. The main constraint appears to be economic — the reduction of fuel needs and the achieving of higher weights of the copra produced. The millers' belief that mould growth facilitates oil extraction or is an index of optimum drying is a further constraint to the proper curing of copra. Practices such as wiping off, of the fungal growth before mouldy copra is sold — a practice which some producers resort to — does not remove the aflatoxin which is already accumulated in the kernel. At the point of milling, substandard contaminated copra is processed again, for what appears to be economic reasons. Underdried copra is used to provide sufficient stocks of starting

material to keep the mills running and to ensure a regular stock of oil for sale. In addition this copra is stored for prolonged periods supposedly for easier extraction of oil. Such prolonged storage leads to deterioration of both copra and the extracted oil.

Another practice which results in the overall contamination of bulk oil and press cake is the mixing of substandard, mouldy kernels with high grade kernels, for oil extraction. The disadvantage of this mixing in respect of groundnut was illustrated by Goldblatt[4] "If just one peanut with a million ppb of aflatoxin is admixed with 10,000 kernels that contain none, the whole lot will assay at the relatively high level of 100 ppb of aflatoxin."

We would therefore recommend that substandard copra be processed separately for oil which could either be refined or diverted to the soap industry while the residual press cake be detoxified prior to use in animal feeds.

The storage conditions in most mills are unsatisfactory. There are often no proper store houses and the copra kernels both adequately dried as well as substandard and mouldy, are left together on the floor of dark, ill-ventilated rooms, exposing them to insect and rodent attack and to humidity. The contaminated mouldy kernels provide the fungal spore inoculum for colonisation of the rest of the heap which occurs with increasing moisture levels with rain, and the exposure of the unsmoked depths of the kernels caused by pest attack. Proper storage to minimize pest damage would be of greater importance with copra kernels than with press cake (poonac) since the occurrence of fungal colonisation and toxin accumulation could result from absorption of moisture by copra but not in press cake which has been rehydrated.[1]

An integral part of the aflatoxin control program would appear to be the education of the millers and producers on the mechanisms of fungal colonisation and the implications of aflatoxin accumulation and resultant intoxication in both humans and animals.

4.5 Comparison of coconut products with other oil seeds and their products in respect of aflatoxin contamination.

Data on the aflatoxin problem in coconut products processed in other tropical countries is scanty; Jones[6] recorded the following levels from a worldwide information survey of aflatoxin contamination in a variety of substrates:

Country	product	number of samples	aflatoxin content average level (ppb)
Philippines	copra	171	10
	copra meal	2	6
Marshall Islands	copra	4	30
Caroline Islands	copra	2	below 5
Western Samoa	copra	3	below 5

Table 1. Classification of Coconut products into grades according to Aflatoxin B1 content. Figures refer to number of samples.

Product	Aflatoxin B1 content (μg/g, parts per million) low or negative less than 0.05	medium 0.05—0.25	high 0.25—1	total number of samples tested
Copra powder	31	28	6	65
Press cake	34	49	9	92
Coconut oil	52	41	2	95
Pairings	10	3	0	13
Pairings press cake	6	7	2	15
Parings oil	10	1	0	11
Coconut refuse 'polkudu'	4	5	0	9
Coconut refuse press cake	1	8	0	9
Coconut refuse oil	4	0	0	4
Industrial coconut oil	6	0	0	6
Desiccated coconut	5	0	0	5
Desiccated coconut*	2	0	0	2
Coconut based animal feeds	9	9	0	18
Total	169	151	19	339

* *rejected*

In general the levels of aflatoxin in coconut products are lower than those which have been reported from technologically underdeveloped countries in other oilseeds and their products. This is in contrast to the excellence of fresh coconut as a substrate for colonisation by *Aspergillus flavus-parasiticus* and aflatoxin production in comparison, even with groundnut which is reported to be perhaps the most extensively contaminated oilseed. Some of the high levels of aflatoxin which have been reported in groundnuts are as follows (see Jones[6]):

country	product	number of samples	aflatoxin content average level (ppb)
India	groundnut cake	2200	302.000
		2340	385.000
		2850	996.000
		580	350
		602	290
		911	320
		405	770
Brazil	groundnut meal	7	790
		38	1.690

This difference between coconut products and groundnuts is apparently due to the smoking process which the copra kernels are subjected to during their curing, a process which is not applied to other oilseeds including groundnut. The inhibitory effect of smoke on aflatoxin accumulation has been commented on above.

In economic terms however the aflatoxin levels in coconut products are higher than the recommended permissible maximum (WHO/FAO/UNICEF) of 30 ppb, in an appreciable proportion of the samples tested. In view of the possible adverse economic consequences of such contamination on the export industry, the attention of the coconut industry is drawn to this problem.

Conversely in biological and toxicological terms, the levels of aflatoxin found in our copra products are perhaps too low to result in acute intoxication of either humans or farm animals. This situation is in contrast to the intoxication of humans and animals, which has been reported to have been due to the consumption of aflatoxin contaminated maize and groundnut respectively. Moreover the inhibitory effect of smoking of aflatoxin accumulation and conversely the excellence of unsmoked coconut as a medium for aflatoxin production was illustrated by the intoxication and deaths of farm goats which had been fed mixtures containing aflatoxin contaminated coconut refuse.[9]

Acknowledgements

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Geochemical Evidence for Palaeo-Environments of Algal Mats and Peat in Sri Lanka

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Abstract: V/Mn ratios with the organic carbon content and a C-29 sterol compound indicative of higher plants in a terrestrial environment have been used to demarcate the different palaeo-environments of algal mats and peat deposits of Sri Lanka. These chemical parameters were found to be especially useful in the delineation of marine, tidal-flat, lagoonal and terrestrial environments of deposition.

1. Introduction

Algal mats and peat are now being studied for their metal distributions as they may provide useful clues to the formation of certain metal-bearing mineral deposits, even during Precambrian times.[1, 15, 16] The classic work of Renfro[15] on the genesis of evaporite associated stratiform metalliferous deposits in sabkha environments laid the foundation for further research. Both algal mats and peat, being organic materials, are the subject of studies on metal trapping properties by naturally occurring organic matter.[2, 5, 7, 13, 14, 17]

A fundamental necessity in all these studies is the reconstruction of the palaeo-environment of the deposits and the conditions of deposition. It is the aim of this paper to make use of certain inorganic and organic constituents of the deposits to trace the source materials and the environments of deposition using two such deposits from Sri Lanka.

2. The Muthurajawela peat deposit

The Muthurajawela peat deposit (Figure 1) is the largest in Sri Lanka, but up to the present, this deposit has not been utilized. The area studied consists of flat land perennially in a water-logged condition with the depth of water varying from place to place. Specialized vegetation characterized by brackish water plants is prevalent. The swamp area representing the southern extension of the Negombo lagoon, is bounded

Figure 1. Location and geology of the Muthurajawela peat deposit of Sri Lanka. A, B and C denote the locations of bore-holes. The figure on the right shows the depth profiles of the peat deposit.

on the east by a belt of laterite (Figure 1) and on the south by a succession of laterite, peaty sand, and coastal sediments. Northward it is bounded by sandy peat and peaty sand. The peat deposit covers an area of approximately 21 km^2; the average thickness being 3.7 m. The maximum thickness is in excess[3] of 5 m.

Along the sea coast on the western side of the swamp, a beach sand belt containing heavy minerals occurs. There are no sharp contacts among the lithological variations, sand, peaty sand, and sandy peat passing gradually into each other. On the eastern side, peat is mixed with lateritic mud, and no obvious boundary exists. These intermediate areas are covered by paddy fields.

3. The algal mats of Mannar

These algal mats are located in the Mannar Island tidal flats off the northwest coast of Sri Lanka (Figure 2). They are laminated blue-green algal mats forming in the intertidal zone of a clastic (non-carbonate) tropical and lagoonal tidal flat. Gunatilaka[6] studied these algal mats in detail and recognized three different types namely:

(a) a smooth rounded-mat zone with discrete structures,
(b) a crinkled and blistered zone,
(c) a smooth flat-mat zone without any perceptible relief.

The mats were formed by the trapping and binding of sediment particles on to a sticky mucilaginous complex of algal filaments. All three zones are characterized by laminations produced by the alternation of thick sediment with thin algal-rich layers and show an accretion rate of 5-15 mm/week. For a detailed account on the biology and sedimentology of the present-day Mannar algal mats, the reader is referred to Gunatilaka[6]

4. Material and methods

Peat samples from three bore-holes A, B and C (figure 1) were taken at various depths and air-dried. Each air-dried sample was crushed, ground and the minus 63 μm fraction retained for analysis.

Approximately 0.5 g of the sample was weighed in a teflon crucible and heated for 20-25 minutes with 15 ml conc H_2SO_4 until the organic matter was thoroughly decomposed. A 70% mixture of conc HNO_3 and conc HCl were then added and carefully heated to dryness. 20 ml of 60% HF was added to the residue to dissolve any silica present. The final solution was then taken up in 25 ml of 3N HCl. The V and Mn contents were determined by Inductively Coupled Spectrometry (ICP) using a Bausch — Lomb ARL instrument.

The organic contents of the samples were determined by the pyrolysis and method of difference technique. The β-sitosterol contents of the peat samples were determined by ethyl acetate extraction and preparative thin layer chromatography (TLC).

The algal mat samples were collected from the inter-tidal zone and analyzed by the same procedure as mentioned above.

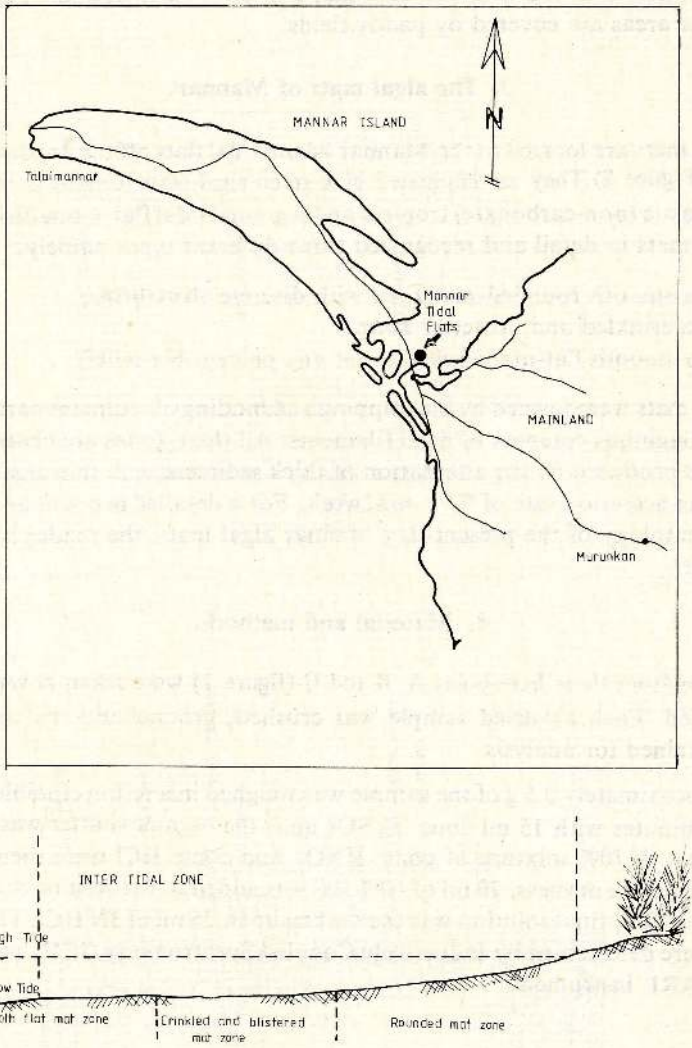

Figure 2. The source area of the algal mats of Mannar, Sri Lanka.

5. Results and discussion

Table 1 shows the analytical data obtained. In order to identify the nature of the source materials in the peat deposit, the compound β-sitosterol was used. In recent advances in organic geochemistry certain specific compounds have been used as environmental markers. As an example, the sterols are widely distributed as distinctive constituents of oceanic and terrestrial plants. The presence of branched side chains and asymmetric centres in the polycyclic sterol skeleton have allowed the development of a high specificity of certain sterols to certain types of plants![12]

The qualitative differences in the sterol contents of sediments depend on the diversity of floral population and hence on the environmental and biological sources. Huang and Meinschein[10] have observed a relationship between C-27, C-28, C-29 sterol composition and the depositional environments (Figure 3). It is of interest to note that vascular plants, the primary producers of terrestrial organic matter, have a tendency to synthesize β-sitosterol (a C-29 sterol) as the major sterol![12]

It has been established that although 10^{12} combinations of structural and optical isomers of C-27 to C-29 alcohols are theoretically possible, less than 10 distinctively structured C-27 to C-29 sterols comprise more than 90% by weight of biological sterols. It is the highly restricted number of structures which make it possible to use sterol analyses in ecological and environmental investigations![9, 11] These observations serve as guidelines in this study to evaluate the different environments that prevailed during the deposition of the Muthurajawela peat deposit.

Figure 3 illustrates the concentration of β-sitosterol as a function of depth for the locations A, B and C. The concentration of β-sitosterol is highest in the middle horizon whereas in the top and bottom horizons, its content is lower. It is clear that the anomalous increase in the sterol concentration coincides with the less decomposed tree trunk debris in the middle horizon. This indicates that the middle horizon is of an origin different to the top and bottom horizons.

Figure 4 illustrates the variations in sitosterol concentration in the sample versus V/Mn ratios. The latter ratio was chosen in view of the fact that the V content could be used to distinguish between terrestrial and non-terrestrial sources, V being more abundant in marine materials. From Figure 4 it is seen that the depositional environments for the top, middle and the bottom horizons of the peat deposit can be distinguished.

The negative correlation observed for the middle horizon is clearly a feature caused by abundant terrestrial input and a corresponding increase in the β-sitosterol content. With the increasing influx of terrestrial material there is a corresponding lowering of the V/Mn ratio due to the lower V contents of the terrestrial materials. A further point of interest is the higher gradient of the point clusters observed for the bottom horizon when compared to that of the top horizon. It appears that the bottom horizon constitutes partly terrestrial and partly marine source materials.

Table 1.— Analytical data for the peat and algal mat samples from Sri Lanka.

PEAT Sri Lanka)		**V** (ppm)	**Mn** (ppm)	**Org.** C%	*B-sisterol %*
Top horizon					
sample	A 1	53	25	28.6	0.084
	B 1	43	64	22.5	0.144
	B 2	34	63	24.8	0.152
	C 1	66	69	22.5	0.155
Middle Horizon					
sample	*A 3*	*32*	*44*	*37.0*	*0.045*
	A 4	*47*	*62*	*28.6*	*0.040*
	A 5	*47*	*88*	*25.5*	*0.028*
	B 3	*35*	*101*	*34.5*	*0.301*
	B 4	*28*	*96*	*28.6*	*0.258*
	C 4	66	101	19.7	0.083
Bottom horizon	C 5	*52*	*109*	*15.4*	*0.047*
sample	A 7				
		63	114	16.5	0.013
	A 10	103	239	8.7	0.006
	C 7	85	215	8.8	0.047
	C 8	65	156	9.2	0.038
ALGAL MATS (Sri Lanka)					
Sample	AM 3	100	698	2.51	
	AM 4	66	513	1.54	
	AM 5	126	1573	2.03	
	AM 7	42	271	3.67	
	AM 8	102	645	1.97	
	AM 9	80	596	2.46	
	AM 10	52	471	1.55	
	AM 11	56	436	1.89	
	AM 12	59	376	2.81	
	AM 13	48	803	4.31	
	AM 15	133	780	1.52	
	AM 17	51	361	2.63	
	AM 18	47	282	3.19	
	J 3	61	3722	3.11	
	2 top	73	557	2.86	
OTHER SAMPLES					
Black shales av: (Vine et.at[17])		150	150	5.1	
Marine sediments av: (Dobrick[4])		125	868	0.6	
Estuary sediments av: Hamilton et.at[8])		98	867	5.43	

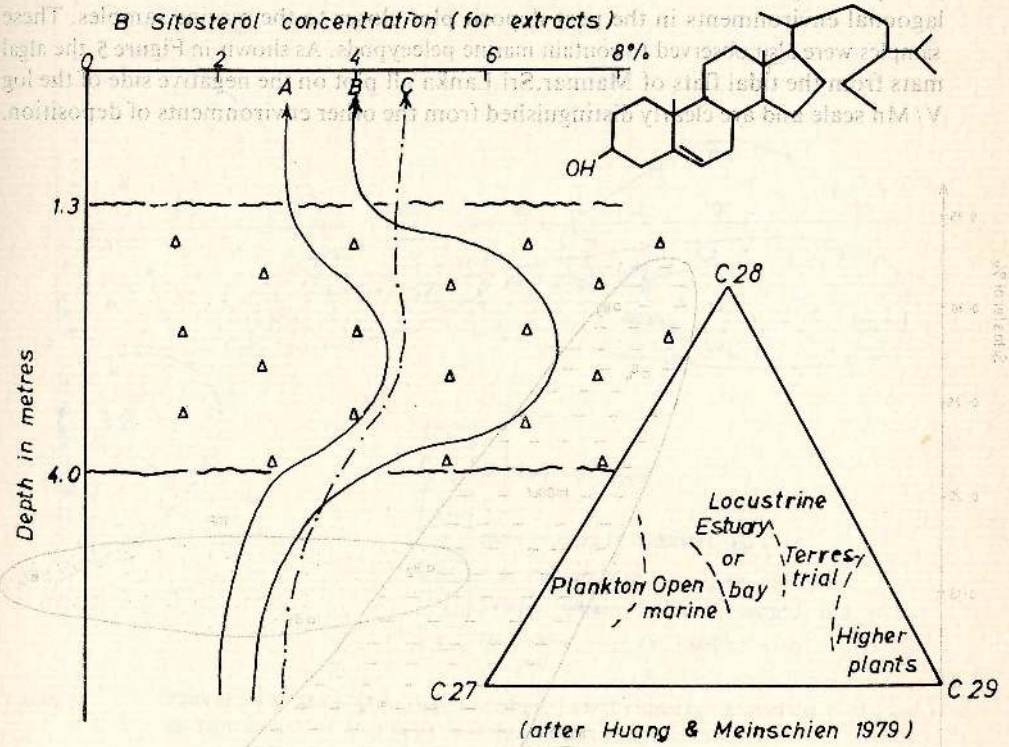

Figure 3. Variation of *B*-sitosterol concentration as a function of depth in the peat deposit of Sri Lanka.

The use of V/Mn ratios to delineate terrestrial and marine/semi-marine environments can be illustrated further in Figure 5. The different environments namely (a) geosynclinal (b) tidal flat (c) lagoonal (d) terrestrial — the top, middle and the bottom horizons of the peat deposit, (e) marine are demarcated.

The top, middle and bottom horizons of the peat deposit of Sri Lanka are again clearly distinguished and it is worthy of note that the more marine based samples of the lagoonal environments in the peat deposit plot closer to the marine samples. These samples were also observed to contain marine pelecypods. As shown in Figure 5, the algal mats from the tidal flats of Mannar, Sri Lanka all plot on the negative side of the log V/Mn scale and are clearly distinguished from the other environments of deposition.

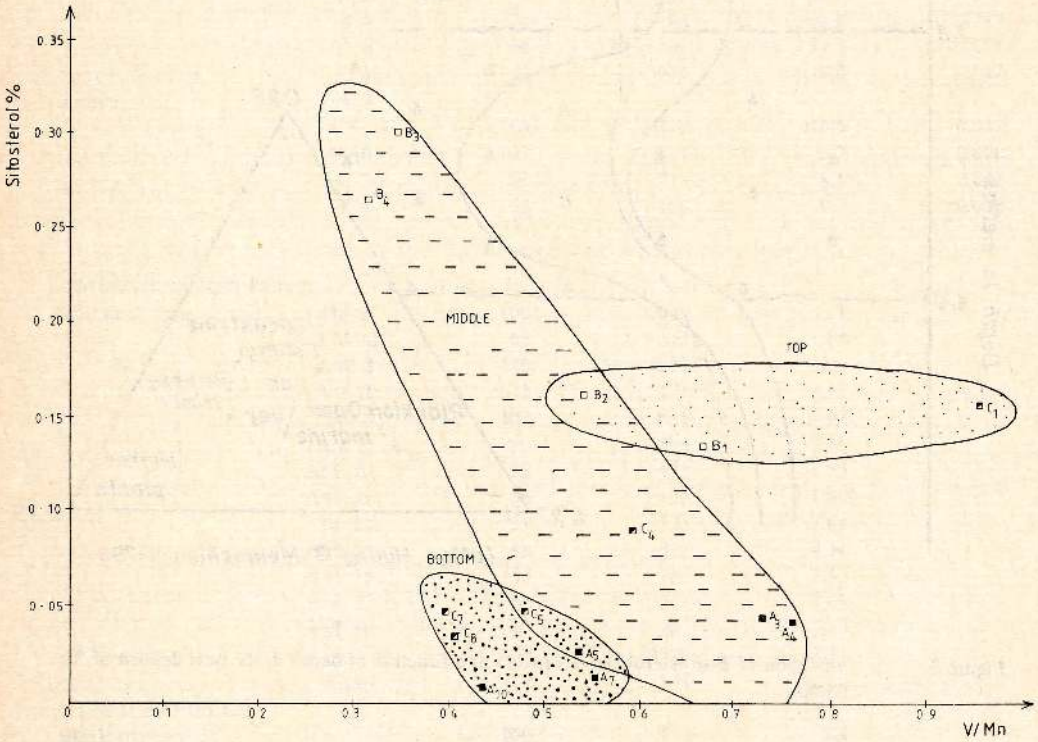

Figure 4. Plots of sitosterol concentration with V/Mn ratios for the top, middle and bottom horizons of the peat deposit of Sri Lanka.

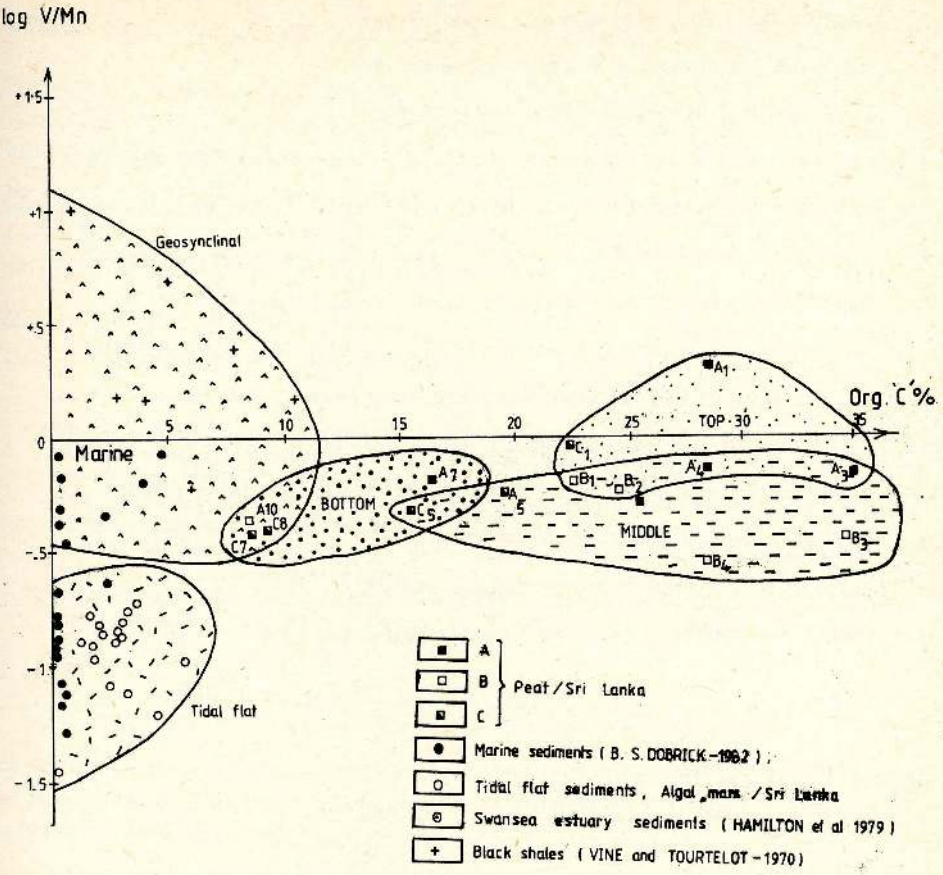

Figure 5. Plots of log V/Mn with the organic carbon % for the three horizons of the peat deposit of Sri Lanka and for other samples from different environments.

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A Survey of the Hygienic Quality of Market Foods in Kandy

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Abstract: A total of 183 samples of consumable items of food and drink exposed for sale in the Kandy Municipal area were subjected to bacteriological examination with regard to its hygienic quality. Only 19 per cent of the samples of ice cream examined were within the limits of the bacteriological standards laid down by the Sri Lanka Bureau of Standards. Other desserts (Fruit salad, Wood-apple cream) show lower mean bacterial densities (*Escherichia coli I*, faecal streptococci and total viable count) than ice cream. The levels of faecal contamination of the fruit drinks did not vary with the place of preparation. This was due to the low pH. The faecal streptococci appears to be better indicator of faecal contamination than *E. coli type I* under freezing and at low pH.

1. Introduction

Diarrhoeal disease due to consumption of unhygienic food is a common feature among the population of Sri Lanka. The enteric disease agent once it enters food, usesit as a medium for dissemination.

The control of the food borne diseases could be effected on application of correct control measures at the most appropriate link in the epidemiological chain of events leading to disease. A knowledge of the critical control points in the food processing and distribution system is required for such a control.

A previous study on the bacteriological quality of ice cream in the city of Colombo has shown the hygienic quality to be very poor.[4]

The present study was carried out within the limits of the Kandy Municipal Council to determine the hygienic quality of food served to the public within this area.

2. Experimental

2.1 Sampling and Preparation of Samples

A total of 183 samples of food were examined. The food under investigation included products such as ice cream (42), other desserts such as fruit salad, watalappan, etc (26), diluted fruit drinks (34), pastries (37) and fermented milk products (44). The samples

of ice cream investigated were from large and small scale producers. The small scale producer exposed their own ice cream for consumption within the premises. Samples of diluted fruit drinks included those prepared and sold in reputed establishments and on the pavement.

Collection of all products were done with the assistance of the Food Inspector, Kandy Municipal Council. Sterile precautions were taken during the opening of the packages and collection of samples. Representative samples of the food under investigation were obtained and examined within one hour of collection. Data pertaining to the manufacturer, date of manufacture were recorded.

Solid food were minced and 10 grams of the sample were shaken with 90 ml of sterile normal saline. Decimal dilutions of liquid food were directly prepared in sterile normal saline down to 10^{-8}.

2.2 Bacteriological Analysis

In the enumeration of *Escherichia coli I* and coliforms, Violet Red Bile Agar (B B L 11807) was used. One ml of the sample and dilutions respectively were inoculated using the standard pour plate method. Incubation of the inoculated plate at 37°C was carried out to determine the number of coliforms. Similarly at 44°C to determine the number of *E. coli I*. The spread plate method using Slanetz and Bartley medium (MERCK 5262) at 37°C was employed to enumerate faecal streptococci. Plate count agar (Oxoid C M 325) was used to determine the total viable count at 30°C. The pour plate method was employed using 1 ml amounts of the samples and the decimal dilutions.

To determine the presence of *Salmonella*, approximately 10 ml or 10 grams of the sample was incubated in a selective enrichment broth (PREUSS Potassium tetrathionate broth, Merck No. 5173) at 37°C for 16 hours followed by cultivation on solid selective media, Brilliant green lactose saccharose agar (Merk No. 7237) at 37°C. Suspicious colonies were confirmed by biochemical and serological tests.

3. Results

Results show that there are marked differences in the three indicator densities, the coliforms, *E. coli I* and faecal streptococci in the different types of food.

Of the 42 samples of ice cream examined, only 19 per cent were free of *E. coli I*. These were from reputed large scale manufacturers. The balance 81 per cent of the samples were mainly from the small scale producers where the consumption was within the place of manufacture.

The results in Table 1 indicates the number of samples and the percentage of the same, that belong to each category of indicator densities tested, namely<10, 11-100, 101-1000 and >1000 per ml of ice cream.

Table 1. Numbers of samples of different foods containing the indicators of contamination in the 4 categories

(<10, 11-100, 101-1000 and >1000 per gm or ml) indicated)

Food	Total No. of samples	Type of Indicator	Number of samples in the 4 categories							
			1 <10 (per gm or ml)		2 11-1000 (per gm or ml)		3 101-1000 (per gm or ml)		4 >1000	
			No.of samples	%	No.of samples	%	No.of samples	%	No.of samples	%
Ice cream	42	Coliforms	3	7.14	4	9.5	15	35.7	20	47.6
		E coli I	9	21.4	6	14.2	13	30.9	14	33.3
		Faecal Streptococci	11	26.19	2	4.7	9	21.4	20	47.6
Other Desserts Fruit salad Woodapple cream	26	Coliforms	3	11.5	7	26.9	14	53.8	2	7.6
		E coli I	9	34.6	11	42.3	6	23	0	0
		Faecal Streptococci	16	61.5	2	7.6	7	26.9	1	3.8
Pastries	37	Coliforms	32	86.4	3	8.1	1	2.7	1	2.7
		E coli I	35	94.5	0	0	1	2.7	1	2.7
		Faecal Streptococci	36	97.2	0	0	1	2.7	0	0
Fruit drinks	34	Coliforms	29	85.2	4	11.76	1	2.9	0	0
		E coli I	34	100	0	0	0	0	0	0
		Faecal Streptococci	32	86.4	1	2.9	1	2.9	0	0
Fermented milk products	44	Coliforms	20	45.4	12	27.2	8	18.1	4	9
		E coli I	44	100	0	0	0	0	0	0
		Faecal Streptococci	20	45.4	8	18.1	8	18.1	8	18.1

A < 10 B 11 - 100 C 101 - 1000 D >1000 Coliforms E Colitype I Faecal Streptococci

The faecal,indicator densities of the second group of food such as fruit salads, woodapple cream,etc are lower compared to ice cream. With this group of food (fruit salad etc) none of the samples showed *E. coli I* densities exceeding 1000/gram.

In the third group of food that were investigated, which were pastries (rolls, patties, cutlets,etc), around 95 per cent of the samples indicated faecal streptococci and *E. coli I* densities < 10/gram.

The results of the 34 samples of fruit drinks show that 85 per cent of the samples belong to the 1st category (Table I) where the indicator density is less than 10 with regard to coliforms and faecal streptococci. None of the fruit drink samples were positive for *E. coli I.* The *E coli* I densities of all the samples of fermented milk products are below 10/gram.

The distribution of the per centages of samples of the different types of food in the four categories A, B, C and D representing indicator densities < 10, 11-100, 101-1000 and > 1000/gram is illustrated in Figure I.

A greater percentage of the samples of ice cream fall into category D with indicator densities > 1000/gram. A greater percentage of pastries and fermented milk products fall into category A. In other types of desserts the samples are distributed in categories A, B and C.

The mean total viable count, the mean counts of the indicators *E. coli I,* coliforms and faecal streptococci and the pH range of the different types of food are shown in Table 2.

Table 2. Mean total viable count, mean counts of E coli I, coliforms and faecal streptococci and the pH range of the different types of foods examined.

Type of Food	*Mean total viable count at 30°C (per gm or ml)*	*Mean density E coli I (per gm or ml)*	*Mean density Coliforms (per gm or ml)*	*Mean density Faecal streptococci (per gm or ml)*	*pH range*
Ice cream	32×10^4	726	1436	1425	5.5 - 6.5
Fruit salad & Woodapple cream etc.	651×10^2	173	423	258	3.1 - 3.7
Pastries	115×10^2	36	55	12	–
Fruit drinks	280	0	8	10	2.1 - 2.7
Fermented milk products	342×10^7	112	202	439	3.2 - 3.8

Ice cream shows the highest mean bacterial densities among the non-fermented food.

The pH ranges from 5.5 to 6.5 in ice cream.

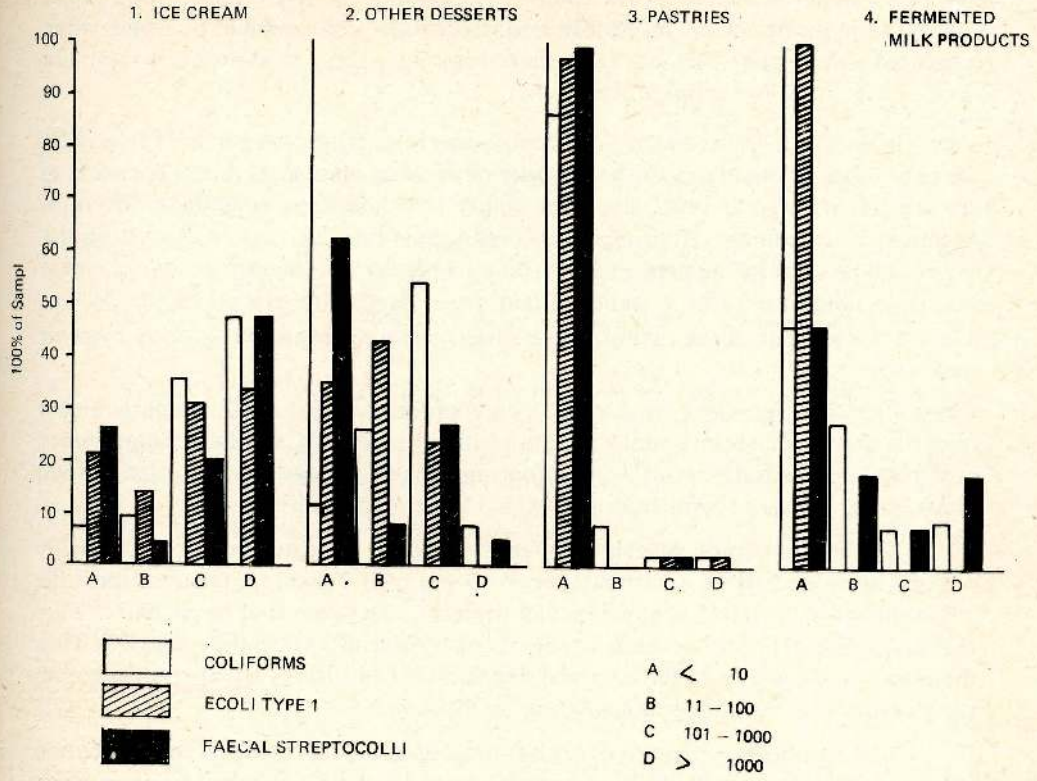

Figure 1. Distribution of the % of samples in the 4 categories (A, B, C & D) of Bacterial Indicator (Coliforms, E.coli type 1, and Faecal Streptococci) densities of the four different types of foods examined.

All food, except pastries show a significant difference between the mean *E. coli I* count and the mean faecal streptococci count. The faecal streptococci count is higher than the *E. coli I* count in these samples. None of the food samples examined were positive for salmonella species.

4. Discussion

The results of this survey indicate the risk involved in the consumption of a variety of food and beverage served to the public within the limits of the Kandy Municipal Council.

Ice cream is the most contaminated product of the five types of food under study. The hygienic quality of pastries and fruit drinks were found to be higher when compared to ice cream. The average bacterial counts in these food products serve as a basis of a general evaluation of the food.

In ice cream the average *E. coli I* count was found to be 726 per ml. This reflects the poor hygienic standards of the majority of the food manufacturers. 33 per cent of the samples showed *E. coli I* densities higher than the above mentioned average. According to the Bureau of Standards, ice cream should be free of *E. coli I*.[6] With the methodology used in the present study only 19 per cent of the samples of ice cream examined conformed to the standard laid down by the Bureau of Standards. The balance 81 per cent of the manufacturers need vast improvements in their hygienic standards.

The observed mean total viable count of ice cream at 30°C is slightly higher than the permissible total count.[6] A high viable count at 30°C indicate contaminated raw materials, unsatisfactory sanitation, improper storage. This excludes food prepared by means of fermentation activity of living organisms.

The present study reveals that faecal bacterial indicator densities are highly dependent on the pH of a particular food. A pH of 6-7 as in ice cream affords the environment for survival of a majority of bacteria. The survival of faecal bacteria are checked as the pH approaches 2-3. The pH of fruit drinks are in the range 2-3. Thus there was no difference in the bacterial densities of fruit drinks whether prepared on the pavement or inside reputable eating establishments.

The significance of micro-organisms used as indicators of faecal contamination of prepared food deserve some comment. The two species of intestinal bacteria which are of particular interest in food hygiene are *E. coli I* and faecal streptococci.[1] The numbers of faecal streptococci in faeces are usually lower than the number of *E. coli I*,[3] but they differ in their sensitivity to various physiochemical actions. Due to the significant difference that was observed between faecal streptococci and *E. coli I* counts in ice cream and fermented milk products, it can be said that faecal streptococci survive better than *E. coli I* in an acid environment and during freezing. In addition to the value of faecal streptococci as an indicator of faecal contamination in treated food, it has been shown that faecal streptococci has a food poisoning potential.[2,5]

In conclusion, it should be stated that production hygiene of food such as ice cream and fruit salads should be improved.

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Some Aspects of the Limnology of Bolgoda Lake II, Sri Lanka.
1. Composition and Seasonal Fluctuation of Zooplankton

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Abstract: The abundance, distribution and composition of various groups of zooplankton; Nauplii, Copepoda, Rotifera, Cladocera and Ostracoda inhabiting Bolgoda Lake II, Sri Lanka were studied. Some physical factors influencing the seasonal abundance and pattern of fluctuation were described. This investigation revealed that wind and rainfall were the major factors that contributed to the abundance of the zooplankton population during the monsoonal periods. The nauplii and the copepoda contributed about 70% of the zooplankton in the lake and their densities varied with depth.

1. Introduction

In Sri Lanka, a great deal of scientific research is now focussed on limnological studies of inland lakes and reservoirs[4,10,11,17] especially with the development of inland fisheries. Studies on the hydrobiology of Colombo lake[5] referred to monthly production of the total zooplankton while the density of zooplankton[7] for periods August-September 1979 and March-April 1980 have been determined for Parakrama Samudra, Sri Lanka. The importance of the abundance of zooplankton has been stressed in understanding the limnology for tropical countries Africa[13] India[14] and South East Asia[10] Larval fishes depend on zooplankton as the main food source[2] and some adult fishes feed on plankton exclusively or at certain size ranges. Zooplankton constituted the major food item for *Oreochromis mossambica (Tilapia mossambica)* of 25 mm[6] Since Sri Lanka reservoirs are stocked with *Tilapia* as a protein source for human consumption, studies on zooplankton abundance and composition are essential in assessing success of *Tilapia* production in various water bodies of Sri Lanka. Hence this study deals with the composition, distribution and population pattern of zooplankton taxa at Bolgoda Lake II.

2. Study Area

Bolgoda Lake 11 (Figure 1) is a man-made lake situated 22 miles to the south of Colombo at 79°55'E, 6°41'N at an elevation of 7.5 meters above sea level in the wet zone of Sri Lanka. The lake is shallow with an average depth of 1.93 meters and an area of 298 hectares. The inflow of water is from the Bolgoda Ganga (river) and the monsoonal rains, while the outflow is via the Talpitiya canal into the sea. The outlet into the sea is kept closed by a sand bar which is opened

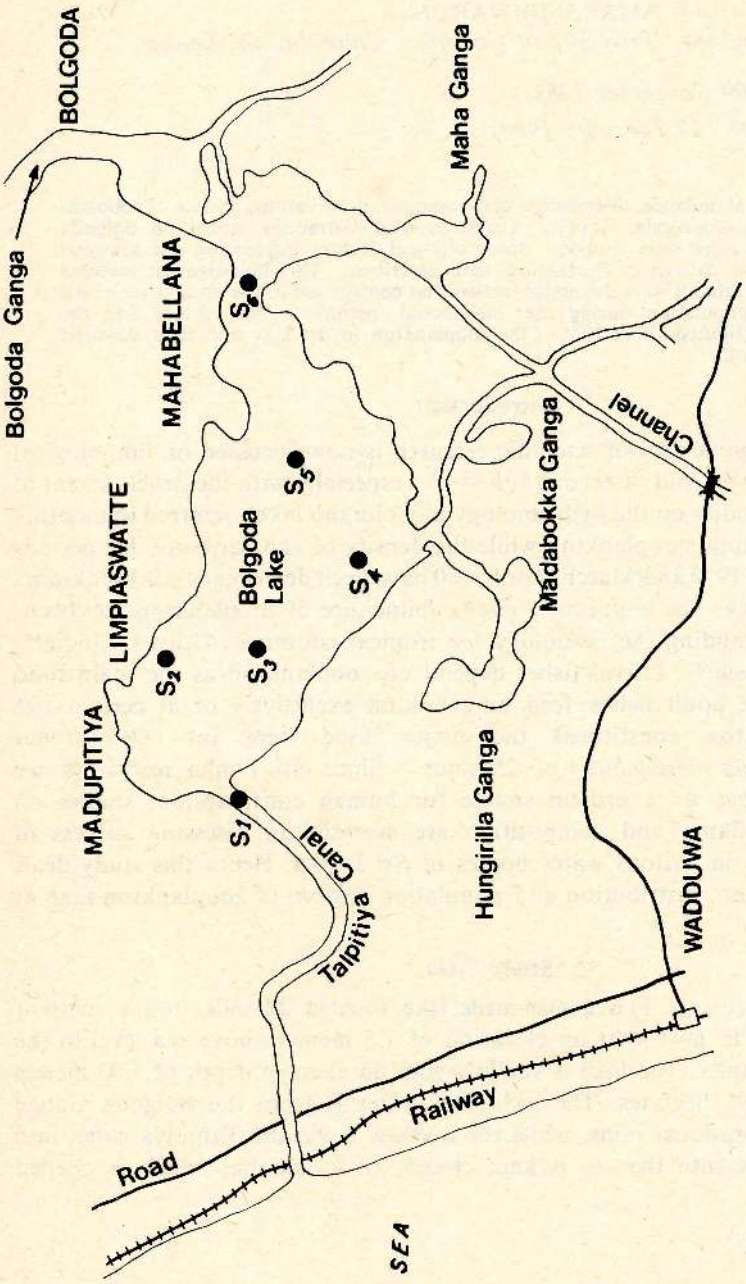

Figure 1. Map of Bolgoda Lake II showing sampling stations (S_1 - S_6).

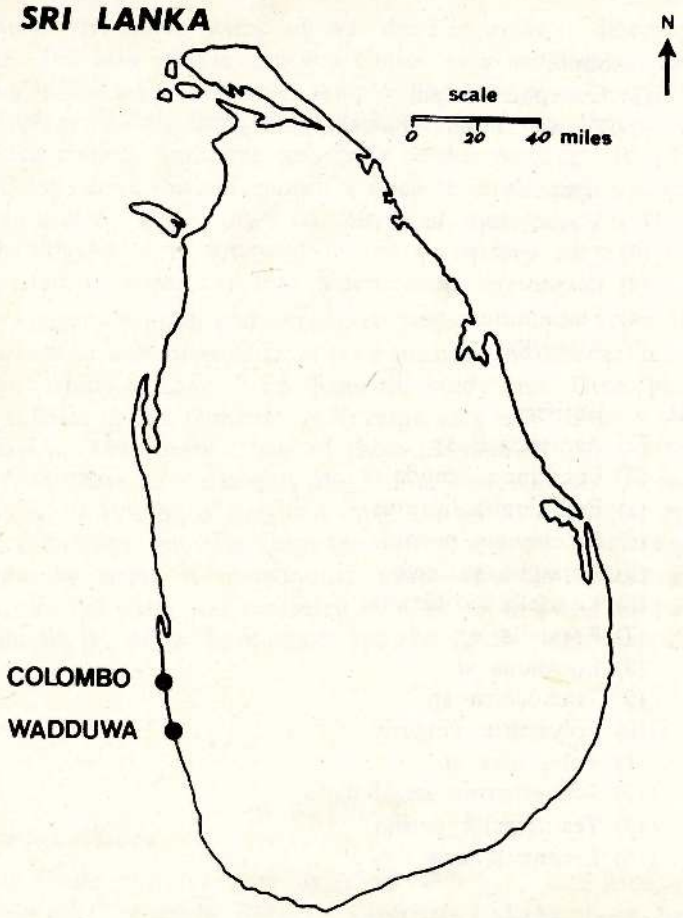

Figure 1. Geological Map of Sri Lanka.

periodically when the waters of Bolgoda Lake II begin to flood. During the period of study (October 1980 - September 1981) the sand bar remained closed. The sea water could enter the canal only through seepage.

The lake is used as a water source for irrigation of neighbouring paddy fields and fishing by inhabitants living in the vicinity of the lake.

Table 1. Composition of Zooplankton at Bolgoda Lake II during the Year 1980 – 1981.

Category I — Nauplii
(1) Copepod nauplii
(2) Prawn nauplii (Palaemonidae)

Category II — Copepoda
(1) Mesocyclops leukartii
(2) Microcyclops sp.
(3) Diaptomus sp.
(4) Eudiaptonus sp.
(5) Atteyella sp.

Category III — Rotifera
(1) Asplanchna sp.
(2) Brachionus caudatus
(3) Brachionus falcatus
(4) Brachionus nilsoni
(5) Keratella earlinae
(6) Keratella cochlearis
(7) Keratella sp.
(8) Euchlanis sp.
(9) Trichocerca sp.
(10) Polyarthra vulgaris
(11) Polyarthra sp.
(12) Synantherina semibullata
(13) Testudinella patina
(14) Lecane lunaris

Category IV — Cladocera
(1) Allona sp.
(2) Bosmina sp.
(3) Chydorus sp.

Category V — Ostracoda
(1) Cypricercus sp.
(2) Cypridiopsis sp.
(3) Cypris sp.

3. Materials & Methods

Six stations (Figure 1 - Stations 1 to 6) were chosen (inlet, outlet, edge and centre) for this study. Preliminary sampling was done in order to determine a suitable sample size. Ten litre sample size was chosen as a satisfactory measure of the zooplankton in the lake. A Ruttner sampler was used to collect the zooplankton from the surface, middle (at half the depth) and bottom (slightly above muddy layer) at each station. Sampling was done in the mornings till afternoon (9.00 am to 2.30 pm) at all stations, monthly. Each 10 litre sample was sieved through a 60 μ mesh and the zooplankton collected in 150 ml bottles in 4% formalin for storage. The samples were analysed in the laboratory using a Zeiss inverted microscope and numbers per litre determined.

The monthly rainfall and windspeed values (Table 2) were obtained from the Department of Meteorology from their recording station at Ratmalana (S.W. of Colombo) which is about 4 km from the study area. Other physical factors (Table 2) such as depth, temperature, transparency and turbidity were measured at each station. The mean values of these physical factors for the lake were calculated from these measurements obtained at each station. The monthly depth was measured by sinking a weighted tape, the air temperatures by a standard thermometer and the water temperature at the surface, middle and bottom at each station by using a temperature probe (Dectan Model ECT-S). The transparency of the water was measured by a Secchi disc and the turbidity of the lake determined by using the method outlined by the American Public Health Association[1].

4. RESULTS

4.1 Composition of fauna

Zooplankton fauna collected were identified [3,8,9,15], and grouped under the categories Nauplii, Copepoda, Rotifera, Cladocera and Ostracoda. In the samples the protozoans being extremely low were omitted from population studies of the plankton. Species present in zooplankton during the period October 1980 - September 1981 are listed (Table I). The copepods were represented by the cyclopoids *(Mesocyclops* and *Microcyclops),* the calanoids *(Diaptomus* and *Endiaptomus)* and the harpacticords by a single genus *Atteyella,* Ceylopoids being abundant in this category. In the rotifers the species richness was exhibited with nine genera and fourteen species. The *Keratella* and *Brachionus* were the most abundant. The cladocerans and ostracods were not common together contributing less than 7% of total zooplankton collected (Table 4) and represented each by three genera.

Table 2. Monthly variation of Turbidity, Depth, Transparency, Air and Water Temperatures, total monthly rainfall and mean windspeed at Bolgoda Lake II for the year 1980 – 1981 (±2 SE).

Month	Mean Turbidity (NTU)	Mean Depth (Meters)	Mean Trans-parency (Meters)	Mean Air Temperature (°C)	Mean Water Temperature (°C)	Total Rain-fall (m.m.)	Mean Wind Speed M=Morning A=Afternoon (k.m/hr)
October	9.60 ± 2.73	2.24 ± 0.13	1.39 ± 0.13	29.78 ± 0.63	29.90 ± 0.27	370.3	M - 4.3 A - 6.3
November	5.41 ± 3.36	1.83 ± 0.13	1.44 ± 0.03	30.75 ± 0.49	29.70 ± 0.27	333.5	M - 3.6 A - 5.3
December	8.51 ± 3.46	1.94 ± 0.18	1.54 ± 0.37	30.83 ± 0.47	28.51 ± 0.13	211.1	M - 5.0 A - 9.0
January	2.42 ± 0.72	1.91 ± 0.09	1.66 ± 0.11	31.33 ± 1.08	29.26 ± 0.49	155.2	M - 4.1 A - 8.7
February	0.97 ± 1.03	1.98 ± 0.057	1.67 ± 0.20	31.20 ± 0.88	29.86 ± 0.42	83.3	M - 3.8 A - 9.3
March	2.47 ± 1.14	1.86 ± 0.14	1.35 ± 0.24	33.71 ± 0.68	32.08 ± 0.27	69.4	M - 4.1 A - 8.9
April	2.66 ± 0.62	2.06 ± 0.06	1.38 ± 0.19	32.55 ± 0.52	31.93 ± 0.34	268.6	M - 4.0 A - 6.1
May	2.17 ± 0.33	1.93 ± 0.10	1.54 ± 0.11	32.78 ± 0.51	31.25 ± 0.37	528.9	M - 4.6 A - 6.5
June	3.00 ± 0.36	2.11 ± 0.07	1.61 ± 0.09	30.05 ± 0.61	28.59 ± 0.48	187.6	M - 8.1 A - 8.5
July	2.63 ± 1.53	1.76 ± 0.09	1.49 ± 0.09	30.0 ± 0.85	28.67 ± 0.37	19.6	M - 11.4 A - 10.5
August	2.06 ± 0.26	1.77 ± 0.15	1.59 ± 0.15	31.58 ± 0.70	29.46 ± 0.26	97.7	M - 7 .4 A - 7.3
September	2.34 ± 0.48	1.73 ± 0.04	1.50 ± 0.08	31.25 ± 0.61	29.98 ± 0.40	144.5	M - 8.5 A - 8.1

Table 3. Rations and Degrees of Freedom for Zooplankton Density Distribution at Bolgoda Lake II.

Taxa	F-values (* ≦ 0.01 and ** ≦ 0.001)		
	Station (5,187)	Depth (2,187)	Month (11,187)
Nauplii	21.14**	9.47**	17.99**
Copepoda	15.61**	5.03*	25.35**
Rotifera	9.42**	2.06	40.05**
Cladocera	3.18*	2.74	7.17**
Ostracoda	3.35*	2.90	21.42**

Table 4. Relative Abundance of Zooplankton at different stations at Bolgoda Lake II for the year 1980 – 1981.

Taxa	*Sampling Stations*					
	1	*2*	*3*	*4*	*5*	*6*
Total Zooplankton	3914.8	2021.4	2640.9	2906.7	3494.1	3440.4
Nauplii %	48.2	38.9	35.1	38.7	42.0	40.7
Copepoda %	31.2	33.6	35.7	35.4	32.8	33.2
Rotifera %	14.2	18.4	19.4	17.7	18.2	17.4
Cladocera %	3.8	6.4	6.1	4.4	4.1	5.0
Ostracoda %	2.6	2.7	3.7	3.8	2.9	3.7

4.2 Population Structure

Highest zooplankton recorded were at stations 1,5 and 6 (Table 4). Stations 5 and 6 are near the point of discharge of waters and debris from the Bolgoda Ganga. Station I was at the outlet of the lake; the entrance to the Talpitiya canal where large amount of debris was collected from the submerged and surrounding vegetation. A noteworthy feature was that the fish traps were placed by the fishermen close to stations 1,5 and 6.

The nauplii and copepods contributed to more than 70% of the total zooplankton in all the six stations (Table 4) while the rotifers, cladocerans and

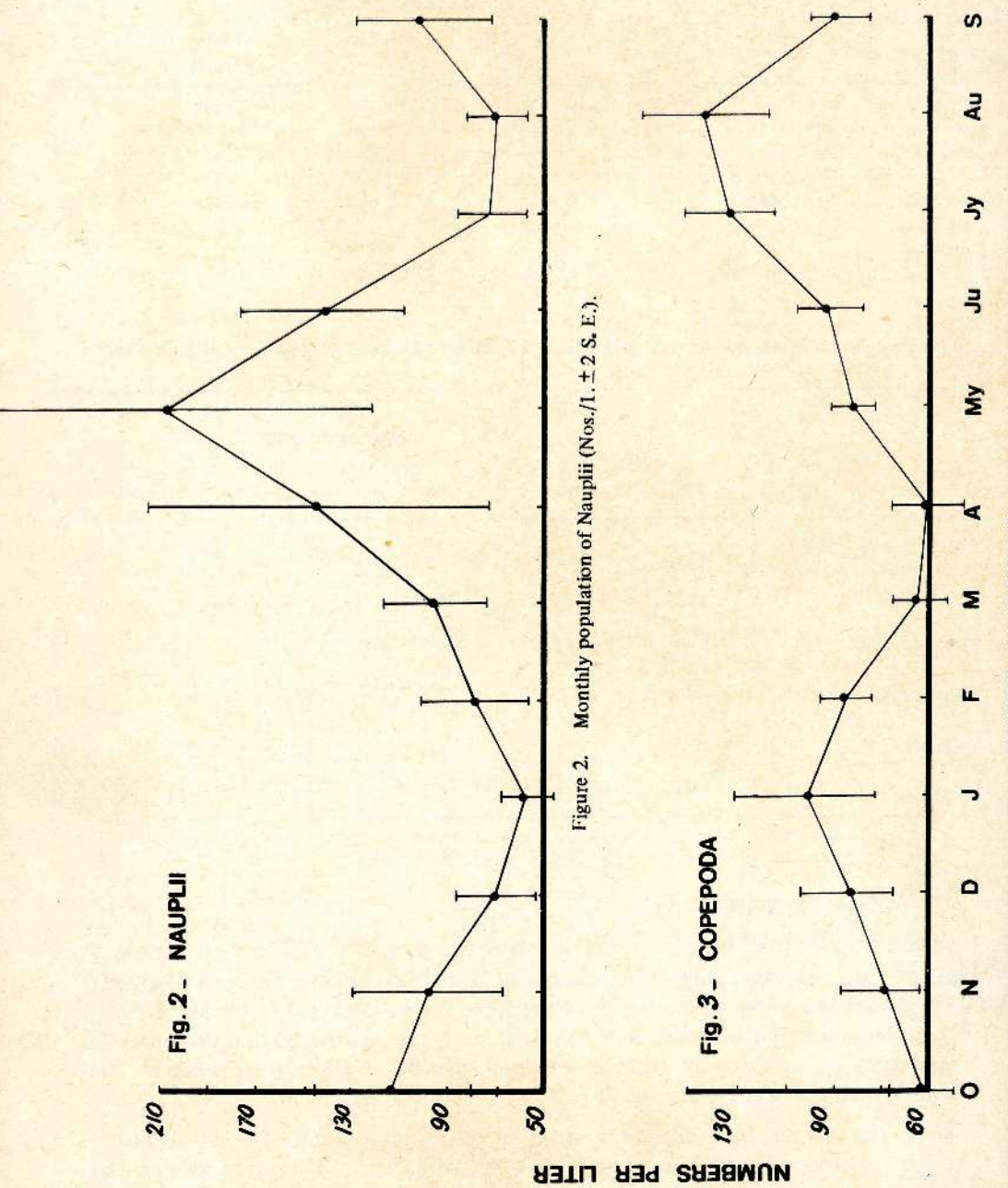

Figure 2. Monthly population of Nauplii (Nos./1. ± 2 S. E.).

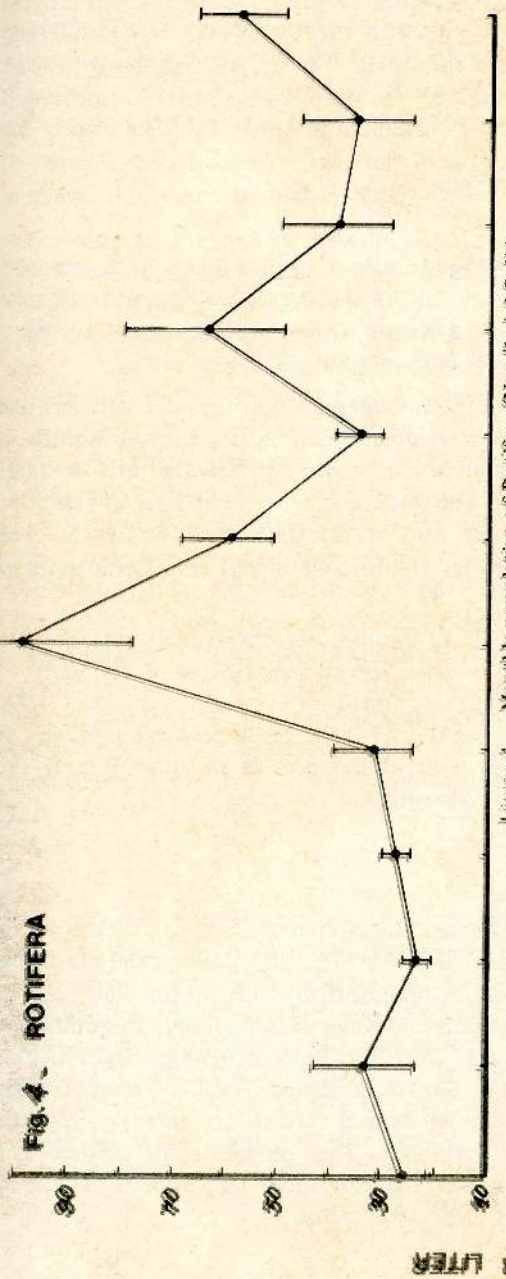

Figure 4. Monthly population of Rotifera (Nos./l. ± 2 S. E.)

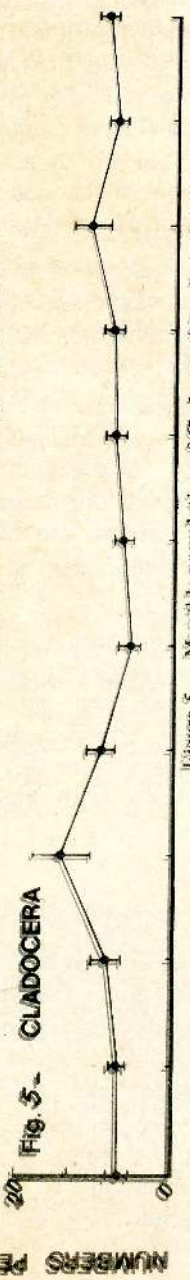

Figure 5. Monthly population of Cladocera (Nos./l. ± 2 S. E.)

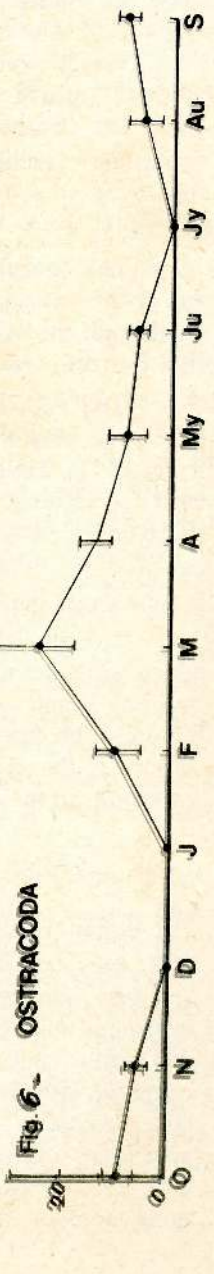

Figure 6. Monthly population of Ostracoda (Nos./l. ± 2 S. E.)

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ostracods formed less than 30% of the total zooplankton (Table 4). The nauplii which formed the major zooplankton were copepod and prawn nauplii. The standing crop of nauplii increased during the monsoonal months of October and May, the lowest recorded in the intermonsoonal months of January and August (Figure 2). The copepods (Figure 3) reached a maximum in January and August, the lowest numbers recorded were in October and April. The rotifers (Figure 4) showed pulses in March, June and September with lowest recorded in December and May. The cladocerans (Figure 5) showed a maximum in January and July while the population remained low for most months of the year. The ostracod (Figure 6) population disappeared in the months of December, January and July while a significant peak occurred in March.

The copepod and rotifer females with eggs occurred throughout the year but in most cases the eggs were detached. In the cladocera, the eggs were outside the brood chamber. This may be due to agitation while sampling and transport. However an estimate of females with eggs could not be made.

The zooplankton categories Nauplii, Copepoda, Rotifera, Cladocera and Ostracoda were statistically analysed in relation to stations, depths and months as indicated in Table 3. The nauplii abundance varied significantly at the 0.001 level for stations, depths and months. The copepoda also varied significantly at the 0.001 level for stations and months and at the 0.01 level for depths. The densities of rotifers, cladocerans and ostracods differed significantly with stations and months as shown in Table 3.

The relative abundance (Table 4) of nauplii was observed in stations 1, 5 and 6, with densities ranging from 35 - 49%. The copepodids were abundant at stations 3 and 4, and their percentage composition ranged from 31 - 36%. Similarly the densities of rotifers ranged from 14 - 20% with the largest density at station 3; the cladocera from 3 - 7% with abundance at stations 2 & 3; the ostracoda from 2 - 4% with highest densities at stations 3, 4 & 6.

4.3 Physical Factors

The highest rainfall (Table 2) was recorded during the monsoonal periods of the S.W. Monsoon in April, May and June and the N.E. Monsoon in the months of October, November and December. Comparatively less rain fell in the intermonsoonal periods January to March and July to September. In addition to the total rainfall the lake received water from the Bolgoda Ganga which in turn connects with Bolgoda Lake I and the Panadura Estuary (S.W. Colombo). The lake was calm in the mornings with windspeed (Table 2) increasing in the afternoons causing the water to be turbulent. This phenomenon existed from October to May. From June to September, the windspeed was approximately the same both in the mornings and in the afternoons.

The mean air temperatures ranged from 29 - 34°C while the mean water temperature varied from 28°to 32°C. The hottest periods were the intermonsoonal months. The depth varied from 1.7 m to 2.2 m. Various factors such as rainfall, windspeed, decomposition of debris, accumulation and movement of allocthonous material and seepage may be responsible for the change in depth of the lake. The transparency varied from 1.3 to 1.6 meters while the turbidity ranged from 0.9 to 9.6 NTU during the period of study. The turbidity was high during the monsoonal period, October to December.

5. Discussion

According to the trophic classification of lakes[16] the Bolgoda Lake II could be characterised as eutrophic. Unlike Parakrama Samudra[17] in the dry zone, the Bolgoda Lake lies in the wet zone and the water level varies only slightly per month even though the mean annual depth fluctuates during the year between 1.7 and 2.2 meters. The water level rises during the monsoonal periods to compensate for the loss during the prevailing dry season. Similarly there is not much disparity in the monthly water temperatures. It is difficult to draw any suitable conclusion regarding the relationship between water temperature and the zooplankton population? However it could be said that it is a combination of several external factors that govern the plankton fluctuations. The main external factors, wind effects, monsoonal rains, input from the Bolgoda Ganga, the movement of allocthonus material and bottom deposits probably play a role in the process of zooplankton production as evidenced by the largest concentration (Table 4) of zooplankton at the inlet (stations 5 & 6) and the outlet (station 1). These concentrations in population could be attributed directly or indirectly to the major external factors mentioned above. These factors in turn determine underwater light conditions and the nutrient necessary for phytoplankton production[12] on which the zooplankton feed. The interrelationship of the zooplankton and the phytoplankton at Bolgoda Lake will be discussed in a subsequent paper.

It was evident that in the zooplankton populations only the nauplii peaks coincided with the monsoonal periods. The nauplii population in the lake could only result from two sources (a) the population in the lake and (b) the contribution from the Bolgoda Ganga. These zooplankton included the larval stages of the copepodid and palaemonid prawn nauplii. Sampling was done at Bolgoda Lake in the mornings and in the afternoons at different depths and the analysis of densities (Table 4) of nauplii at different stations indicated a variation with depth, showing the possibility of migration or diurnal variation. Costa & De Silva[4] reported that the nauplii showed a tendency for migration to the surface only in the evening for Colombo Lake.

The noteworthy feature was that the rest of the zooplankton populations (Copepoda, Rotifera, Cladocera, Ostracoda) showed seasonal fluctuations with peaks during the intermonsoonal period. The copepodids showed peaks in January and August, rotifers with a major peak in March and minor peaks in June and September, the cladocera with peaks in the intermonsoonal months of January and July with the ostracoda in March. However the accumulation of zooplankton at the inlet and outlet of the lake were much greater and hence the fishermen had located their traps at these points for a better catch of fish.

The variation of nauplii densities with months confirmed the peaks obtained in October and May (Figure 2). The change in nauplii densities with depth may be connected with feeding or linked with other prevailing environmental factors. The copepodids being plankton feeders follow the movement pattern of the phytoplankton and zooplankton. The nauplii were the most abundant and hence the copepodids may have fed more on the nauplii rather than the rest of the zooplankton. Support for this phenomenon is seen in the alternation of the copepodid peaks with those of the nauplii. Furthermore a significant change in the copepodid densities with depth (Table 3) was observed which indicates the possibility of diurnal variation. The change in copepodid densities with months confirmed the peaks obtained in July and August. The variation of rotifer, cladoceran and ostracod densities with period confirmed the occurrence of peaks as observed in Figures 4,5 and 6, respectively. However as no variation occurred with depth it could be assumed that the rotifers, cladocerans and ostracods were uniformly distributed.

The zooplankton form the food of different species of fish and it is evident that a knowledge of their species composition and seasonal fluctuation patterns are of great value in the culturing of fish. Thus the data on zooplankton presented could be the basis for further research as it could be utilised in the development of inland fisheries.

6. Summary

(1) Population of zooplankton groups Nauplii, Copepoda, Rotifera, Cladocera and Ostracoda for Bolgoda Lake II was estimated during the period October 1980 to September 1981.

(2) Environmental factors such as rainfall, windspeed, air and water temperature, turbidity, transparency and depth were studied.

(3) Composition of species inhabiting the lake was determined according to the categories of zooplankton. The category rotifera was found to be rich in species even though less in abundance when compared with the copepoda.

(4) The nauplii and copepoda contributed about 70% of the zooplankton in the lake.

(5) The major factors effecting population abundance were wind and rainfall during monsoonal periods while other environmental factors mentioned were of minor importance.

(6) The nauplii and copepodid densities varied with depths while the other categories such as the rotifera, cladocera and ostracoda were uniformly distributed with depth.

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Nitrate-Nitrogen Content of Well Water and Soil from Selected Areas in the Jaffna Peninsula

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Abstract: This paper describes the results of a study concerning the amount of nitrate present in drinking water and soil in selected locations in the Jaffna Peninsula. In several places the amount of nitrate-nitrogen is above the safe level specified in the WHO International Standard for drinking water.

1. Introduction

In the Jaffna Peninsula there is a small acreage of Paddy lands but the majority of the cultivated lands is used for agricultural activity concerned with short term crops. Water for these is obtained from wells situated close by. Drinking water is also obtained from wells. In villages,each house or a group of houses has its own well. But in the Jaffna town and coastal areas like Kayts water is supplied by the Municipality and for this purpose the water is drawn from wells in the adjoining villages — Thirunelvely and Kondavil. These villages have a reasonable agricultural activity. Over the years it has been noted that Jaffna farmers have been using increasing quantities of fertilizers and attempts have been made to study the effect of large scale use of fertilizers on the ground water and soil. One of the serious problems is the increasing levels of nitrates and nitrites in drinking water which can be hazardous. Other sources of nitrates and nitrites are animal and human urine and excreta. It is also possible that some of the other nitrogen containing compounds are oxidised to nitrites and nitrates over the years.

It is well known that nitrates and nitrites above a certain level in drinking water and soil may cause serious health problems due to their toxicity. It has been reported[10] that if the drinking water contain more than 10 ppm nitrate-nitrogen (45 ppm - nitrate), it could affect the health of infants and children. Apparently a microorganism in the gastrointestinal tract can convert nitrate into nitrite which under the biochemical conditions oxidises the Fe^{++} in haemoglobin to Fe^{+++} , producing methaemoglobin. Methaemoglobin cannot transport oxygen in the blood and the resulting oxygen deficiency produces the characteristic bluish skin colour [8,9,10]. Therefore nitrates in the water consumed by infants may give rise to methaemoglobinaemia (blue babies).

That methaemoglobinaemia is associated with high nitrate content in drinking water, was first discovered in 1945. Since that time about 2000 cases of blue babies have been reported from North America and Europe.[8]

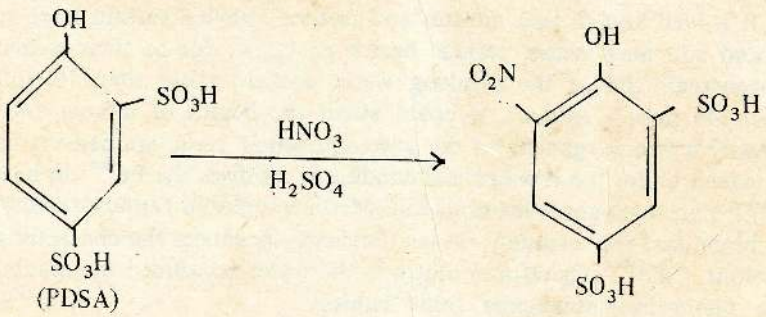
Excess of nitrate in the drinking water could also affect older children and adults. The nitrates can be converted to the nitrites which in turn can produce nitrosamines by reaction with suitable amino compounds in the body.[10] Nitrosamines are carcinogenic and hence a hazard to human health.

Increased nitrogen in the soil also may cause serious health problems because some plants such as carrots could store this excess nitrate and then reduce it partly to nitrite within itself. The nitrites could convert haemoglobin to methaemoglobin or produce nitrosamines and thus the carrots containing excess nitrate is a health hazard[9]

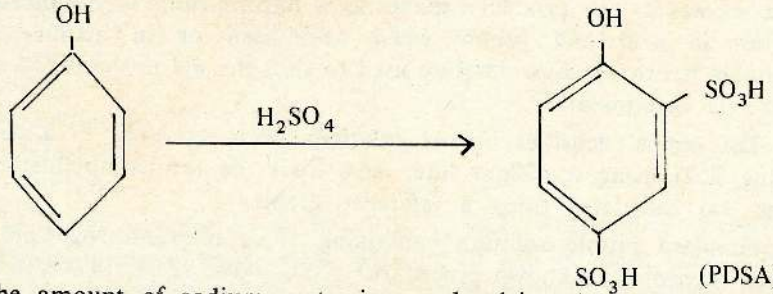
2. Experimental Methods and Materials

Several methods[3] are available for the estimation of nitrates. One method is to determine the total oxidised nitrogen and then subtracting the colorimetrically estimated value for the nitrite[1] The alpha naphthylamine-pink colour method[1] may be employed to determine the amount of nitrite colorimetrically. Reduction of nitrate and nitrite with hydrogen generated by either iron filings in sulphuric acid or Devardas alloy in alkaline solution has been employed to estimate total oxidised nitrogen. The reduction of nitrate to nitrite could be carried out by cadmium–copper reagent[2] and α-naphthylamine-pink colour method could be used to determine the total oxidised nitrogen. (It should be noted that α-naphthylamine is carcinogenic). Another method uses 2:6 xylenol as indicator in a colorimetric determination of nitrates.

In our investigation, the nitrate-nitrogen was estimated by nitrophenol-disulphonic acid yellow colour method[6] This method depends upon the nitration of position 6 of phenol-2,4-disulphonic acid.



Phenol-2, 4-disulphonic acid was prepared[6] by heating a mixture of phenol and conc H_2SO_4 in boiling water bath.



(PDSA)

The amount of sodium, potassium and calcium in water samples were determined immediately after collection using a Corning Model 400 flame photometer. The flame intensities for sodium were corrected for interference by calcium by the standard - addition method[5] The samples were collected in clean dry dark glass bottles with bakelite screw caps and when necessary they were stored at 0^0C. The nitrate-nitrogen was determined within three days of collection.

Two litres of water samples were concentrated and made up to 25ml with distilled water in a volumetric flask. These samples were used for colorimetric determinations.

The samples for colorimetric measurements were prepared as follows:

Concentrated Water sample (25ml)
↓ Ag_2SO_4 (Shake for 15 min.)
Filtrate
↓ Shake with $Ca(OH)_2$ and $MgCO_3$
Filtrate
↓ (i) Pipette 5.0 ml
(ii) Evaporate on a steam bath
Residue
↓ (i) Phenol-2, 4-disulphonic acid
(ii) Add 20 ml water after 15 min
Solution
↓ NH_4OH
Alkaline solution (Yellow) (made to 100 ml with distilled wate).

Soil sample
↓ Sieved
22 - 60 mesh size
0.2% $CaSO_4$ solution
Extract
↓ Shake with Ag_2SO_4
Filtrate
↓ Shake with $Ca(OH)_2$ and $MgCO_3$
Filtrate
↓ (i) Pipette 25.0 ml
(ii) Evaporate on a steam bath
Residue
↓ (i) PDSA
(ii) add 20 ml water after 15 min.
Solution
↓ NH_4OH
Alkaline solution
(Yellow) (made to 100 ml)

The aqueous extract of the soil or water sample was evaporated to dryness previous to determination since the reaction must be effected in the virtual absence of water. The product behaves as a nitrophenolic type indicator - it is colourless in acid and yellow when neutralised or in alkaline solution. Ammonium hydroxide was therefore used to shift the pH to the yellow range for colorimetric determination.

The optical densities of test solutions were measured in a colorimeter (Corning 252) using a 420nm filter and from the results obtained nitrate-N content was calculated using a reference graph.

Standard nitrate solution containing 10 μg nitrate-nitrogen per ml was prepared according to known procedure.[6] 5.00, 10.00, 12.00, 14.00, 16.00, 18.00, 20.00, 23.00, 25.00 and 30.00 ml aliquots of this solution were taken and subjected to identical procedure[9] as in the case of test samples and optical densities were measured.

3. Results and Discussion

3. 1 Nitrate in Soil

The results (Table I) shows that in several areas in the Jaffna Peninsula the soil samples have nitrates above the safe level. In plots where there is no cultivation, the amount of nitrate in soil adjoining the well is below 20 ppm in majority of cases. But in those plots where there is cultivation the soil adjoining the well seems to have fairly large quantity of nitrate, usually above 30 ppm. The results however are not conclusive.

3. 2 Nitrate in well water

The water samples from wells in plots where there is no cultivation have relatively low nitrate-nitrogen levels. Thus the wells in the following localities where there is no cultivation have less than 18 ppm of nitrate-nitrogen.

(i) Post Office and Hospital of the Jaffna Town
(ii) Kopay houses
(iii) Naranthanai
(iv) Karaveddy

(v) Thavady
(vi) Vannarponnai
(vii) Kokuvil
(viii) Uduvil
(ix) Irupalai
(x) Nallur
(xi) Kadduvan
(xii) Tellippalai
(xiii) Mirusuvil.

The water samples from the wells in plots where there is agricultural activity have nitrate-nitrogen levels between 20 and 50 ppm. The villages of Kondavil and Urumpirai where there is intense agricultural activity have very high nitrate-nitrogen level (30-50 ppm). Even water samples from wells in plots in these villages where there is no cultivation have more than 20 ppm of nitrate-nitrogen.

The water samples from the wells in Thirunelvely and Kondavil from which water is drawn for town supply have a high nitrate-nitrogen levels (26-33 ppm) which are about three times the safe level. Our investigations also indicate that the nitrate-nitrogen levels in the water of the wells used for town supply gradually increases year by year. Thus the nitrate-nitrogen level of Thirunelvely water supply well water increased from 15 ppm in December 1976 to about 22 ppm in December 1980 and to about 27 ppm in May 1982 (Table II). Similarly the nitrate-nitrogen level in the water sample from the town water supply well from Kondavil increased from 22 ppm in December 1976 to about 30 ppm in December 1980 and to about 34 ppm in May 1982.

It is apparent that the indiscriminate use of fertilizer is the chief reason for the rapidly increasing nitrate-nitrogen level in well water. We feel that the Jaffna farmers are using fertilizers far in excess of what is required. This conclusion is supported by the fact that the quantity of fertilizer sold in Jaffna is very large.

In certain parts of the Jaffna town area where there is no cultivation the nitrate-nitrogen level in well water approaches 20 ppm. This is probably due to inadequate sewerage disposal facilities. Also in thickly populated areas the wells are situated close to the soakage pits of the toilets and this may result in increased nitrate-nitrogen levels in well water. With increasing demand for houses, the local authorities are willing to reduce the minimum distance between the wells and septic tanks from 35 ft to about 25 ft. This could cause serious health problems in a district like Jaffna where the limestone rock is fairly close to the earth surface and hence minimum soakage and absorption is possible.

Table 1. Amount of Nitrate-Nitrogen in well water and soil and the amounts of Na, K and Ca in well water

Locality		Amount of Nitrate N in ppm in		In well water samples amount of		
		Soil*	Well Water*	Na^+/ppm*	K^+/ppm	Ca^{2+}/ppm
1. Jaffna Town (not cultivated)						
a) Post Office	i)	6.3	10.0			
	ii)	6.90	13.4			
b) Hospital	i)	8.1	14.6			
	ii)	9.1	17.7			
c) Station Road	i)	12.2	20.7			
	ii)	13.1	22.0			
d) Koddady East	i)	11.3	18.9			
	ii)	12.0	19.8			
e) Koddady West	i)	11.3	18.0			
	ii)	12.8	20.3			
2. Vannarpannai (not cultivated)	i)	3.0	12.0	161	7.4	22.8
	ii)	4.3	12.4	182	7.5	23.2
3. Nallur (not cultivated)		3.0	2.2	53	1.2	14
4. a) Kokuvil (not cultivated)		2.0	8.5	202	3.4	21
b) Kokuvil (cultivated)		2.5	18.6	—	—	—
5. a) Thavady (not cultivated)		3.1	6.7	122	2.2	22
b) Thavady (cultivated)		8.4	26.5	138	2.4	26
6. Thirunelvely area						
a) Thirunelvely water supply well		19.6	26.3	1242	5.7	30.1
b) Thirunelvely Agricultural research station		10.7	21.3	—	—	—
6. c) Farm School (cultivated)		22.3	22.1	—	—	—
d) Thirunelvely (cultivated)	i)	24.1	24.8	506	4.5	40
	ii)	21.3	23.6	454	4.2	36.5
7. Kondavil area						
a) Kondavil East Vanniasingam Veethy (cultivated)	i)	31.6	41.0	134	2.0	29
	ii)	25.6	28.5	146	2.2	25.8
	iii)	27.0	29.5	—	—	—
	iv)	28.8	32.6	—	—	—
b) Kondavil water supply well (not cultivated)		7.2	33.0	759	3.7	32
8. Irupalai (not cultivated)		5.0	6.0	851	4.0	40
9. Urumpirai (cultivated areas)						
a) Urumpirai East (samples from different wells)	i)	31.6	41.0	—	—	—
	ii)	47.0	43.0	—	—	—
	iii)	25.6	38.6	—	—	—
	iv)	38.8	39.6	—	—	—
	v)	35.0	44.4	—	—	—
	vi)	39.2	45.0	—	—	—
	vii)	53.8	48.0			
	viii)	21.3	45.6			
b) Urumpirai West	i)	310	53			
	ii)	58.8	50			

(contd.)

Table 1 (contd.)

Locality	Amount of Nitrate N in ppm in		In well water samples amount of		
	Soil*	Well Water*	Na^+/ppm*	K^+/ppm	Ca^{2+}/ppm
10. Kopay (not cultivated)	23.5	14.0	156	3.8	23
11. Uduvil (not cultivated)	26.5	15.0	—	—	—
12. Chankanai (not cultivated)	24.5	4.0	1702	7.8	38
13. Naranthanai (not cultivated)	38.3	14.2	3381	35.2	32
14. Chavakachcheri (Paddy cultivation)	1.2	1.5	53	6.0	6.6
15. Mirusuvil (not cultivated)	8.5	1.2	76	32.8	9.4
16. Tellipalai (not cultivated)	5.2	5.3	104	2.4	29
17. Erlalai (cultivated)	40.0	28.0	64.4	1.4	21
18. Kadduvan (not cultivated)	28.0	8.6	140	6.3	31.5
19. a) Karaveddy (not cultivated)	11.4	17.0	621	3.5	35.5
b) Karaveddy (cultivated)	31.6	38.0	759	4.3	34.8
20. Thampachetty	21.3	17.5	621	25.8	21

* Amount of Nitrate — Nitrogen in soil is expressed as μg of Nitrate - Nitrogen per g of soil where as that in well water as μg of Nitrate – Nitrogen per ml of water. The sodium values given are values corrected for interference by calcium.

Table 2. Jaffna Municipality Water Supply

	December 1976	December 1980	February 1982	May 1982
i) Thirunelvely water supply	15*	22	26.3	27.2
ii) Kondavil water supply	22*	30	33	34

* Report from water resources board — Jaffna.

4. Conclusion

The Nitrate-Nitrogen level in well water in the Jaffna Peninsula is well above the safe level of .10 ppm and is increasing year by year. The possible reason for this is the increase in the use of fertilizer.

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Genesis and Constitution of Sri Lanka Laterites

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Abstract: An account is given of the genesis and constitution of Sri Lanka laterites. The warm climate and abundant rainfall alternating with dry periods, favours the development of laterites and lateritic soils in the Island. Lateritic material was examined from coastal areas and inland regions. Majority of the laterites are formed on gneisses of various types, charnockites and granites. It is, however, not possible to identify the parent rock of an individual deposit due to the heterogenity of rocks composing the basement complex. The predominant aluminous mineral in the lateritic materials is the trihydrate, gibbsite (Al_2O_3 $3H_2O$) or hydragillite and the most common crystalline ferric oxide hydrate is geothite (Fe_2O_3 H_2O). Aluminous varieties approaching the composition of bauxites are rare. Massive highly ferruginous laterites rich enough in iron hydroxide, mainly goethite (poorly crystallised) to constitute iron ore are common in certain areas of the south-west sector of the Island. It is observed that the laterites of Sri Lanka including the ferruginous varieties are not of any worthwhile commercial importance. They are however, used as a building material (bricks), as clay ochers (specially yellow stains locally named 'samara') and the porous nature of laterites is a highly favourable factor for re-charge of groundwater. The lithomargic clay below the laterite acts as impervious strata and helps in building up the groundwater storage within the laterites.

1. Introduction

Sri Lanka, because of her warm climate and abundant rainfall alternating with dry periods, favours the development of laterites and lateritic soils. Laterites are well developed in the south-west sector of the Island. A systematic survey of the laterites of Sri Lanka has not been attempted. From time to time studies have been undertaken on various aspects of the material. Laterites have been defined[5] as a hydrated mixture of oxides of aluminium, iron and titanium of extremely varied composition and showing every gradation from ferruginous laterite almost free from alumina to aluminous laterite almost free from iron. When pure enough to be used as aluminium ore the laterite is generally known as bauxite. This definition adequately covers the most commonly occurring types of laterite in Sri Lanka. It is not proposed here to discuss in detail the lateritic soils of the Island.

Moorman and Panabokke,[12] Herath,[7,8,11] Herath and Pattiarachi[9], Herath and Grimshaw,[10] Dissanayake and Vitanage,[4] Dissanayake,[3] Dahanayake and Dissanayake[2] and Dahanayake[1] have in recent years made valuable contributions on the subject of laterites and lateritic soils of the country. Fernando[6] has presented the most detailed account of the Iron Ore Deposits of Ceylon (ferruginous laterites approaching the composition of iron ore). The present communication attempts to discuss the field characteristics of laterite in Sri Lanka and mention is made of the nature and possible origin of the lateritic materials. Many samples collected during geological surveys and drilling operations have been subjected to examination by X'Ray and differential thermal analysis methods. The chemical analysis of a large number of laterite samples has been carried out in the laboratories of the Geological Survey Department. Results of some of the analyses are reproduced in this paper for purposes of illustration. The main purpose of the present paper is an attempt to summarise the results of laterites examined and to discuss our present knowledge of laterites in the Island.

2. Climate and Geological Setting

Sri Lanka (Ceylon) is a tropical Island and lies 32 km to the east of the southernmost extremity of Peninsular India. It has an area of 65,600 square kilometers, and is 432 km long and 224 km at its greatest breadth.

The Island may be divided into two main physiographic divisions:—

1. The low lying coastal plain with little relief and traversed by rivers which have reached their base level of erosion in the coastal plain.

2. The central highlands with immature drainage pattern and marked relief abounding in numerous strike ridges, hills and mountains.

The coastal plain is narrow in the western and southern parts of the Island. The general level varies from sea level to about 150 metres and some erosional remnants may rise to 300 metres or more above sea level. The central highlands rise steeply from the coastal plain and the highest mountain (Pidurutalagala) attains an elevation of 2527 metres above sea level.

Sri Lanka lies in the monsoon region of south-east Asia and it has a humid tropical climate. The division into a Wet Zone and Dry Zone which merge in an Intermediate Zone is one of the most widely recognized geographical features of the Island. In Figure 1 the rainfall pattern is shown, clearly demarcating the Wet and Dry Zone. The average rainfall varies from below 127 cm in the north-west and south-east parts of the lowland zone to over 508 cm in the south-west slopes of the central hill country. The mean rainfall for the Island is 203 cm. In the Wet Zone areas the average

mean temperature varies between 70 and 85°F and in the Dry Zone it may be nearer 90°F. In the highlands the mean temperature ranges between 58°F and 78°F according to elevation.

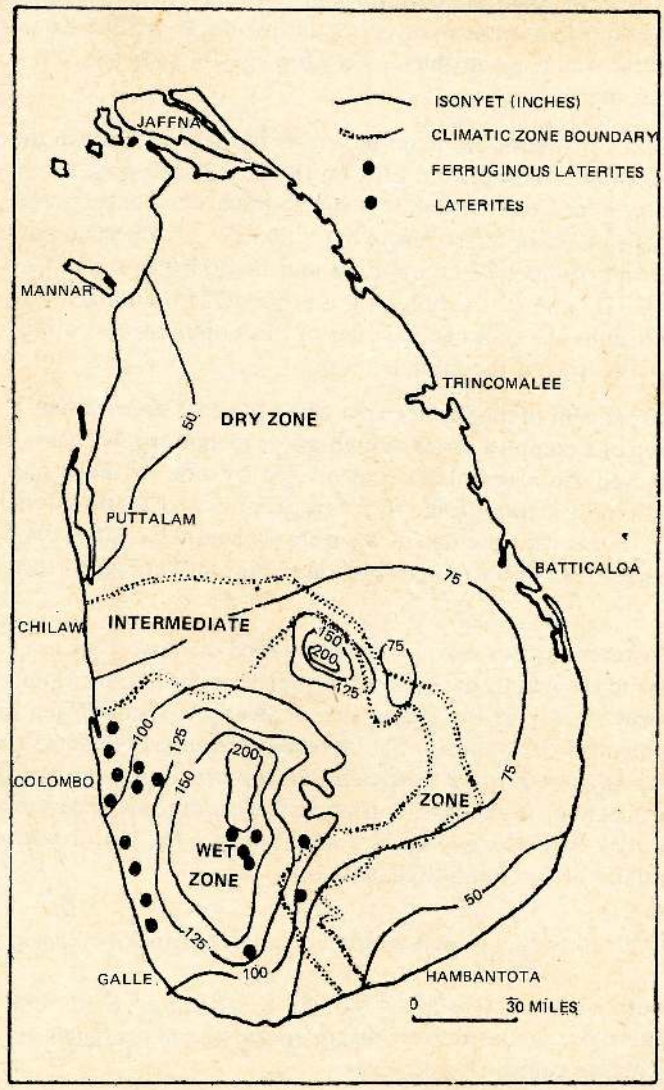

Figure 1. Rainfall pattern in Sri Lanka and Sample Locations.

The rivers are for the most part radial. The upper reaches are mainly confined to the central hill country. The radial pattern is the dominant element in the drainage pattern of Sri Lanka. The greatest problem of Wet Zone hydrology is that of flood control. Inundation of low lying areas is almost inevitable and vast stretches of ground are subject to serious flooding during the wet seasons. This has resulted in the development of deep and extensive deposits of alluvial material along the lower reaches of the major river systems draining this region. In the Dry Zone it is a seasonal shortage of water which is a problem. Very few rivers rise in the Wet Zone and flow into the Dry Zone.

The main concentration of settlement is in the Wet Zone in the whole of the western, south-western and central hills. In the Dry Zone areas, for example, in the north, north-central and east-central parts of the Island the concentration is slight.The population of Sri Lanka in 1963 (Census of Ceylon 1963 — Department of Census and Statistics) was approximately 11.5 million and in 1971 (Census of Ceylon 1971) the population was 12.7 million. At present it is around 15 million, growing at the rate of 1.7 per cent per annum. About 80 per cent of this population is confined to the rural areas where agriculture is the main activity.

Over 90 per cent of the surface area of the Island is underlain by Pre-Cambrian rocks consisting of a complex series of high-grade metamorphic rocks, most of which have been derived from sediments and altered by one or more metamorphişms. Associated with these metamorphic rocks are granites and granitoid rocks of igneous origin. Figure 2 shows the outcrops of the main geological formations in the Island and Table 1 is presented to show the general succession of geological formations in Sri Lanka.

The Pleistocene deposits which are developed in the western and north-western parts of the Island are mainly gravels and red earths while laterite is mainly developed in the south-west sector of the Island and is clearly a residual deposit. The most extensive sedimentary formation is the Miocene limestone in the north-western area. Rocks of Jurassic age occupy a restricted outcrop area in the north-west. They are shallow water non-marine deposits, consisting mainly of shale and arkosic sandstone. The Pre-Cambrian crystalline complex which covers the major part of the Island consists essentially of three sub-divisions:

1. Highland Series — metasediments and charnockitic rocks.

2. South Western Group — similar to Highland Series but with thin quartzites, wollastonite bearing rocks, cordierite gneisses and chert including coarse charnockites.

3. Vijayan Series — complex of gneisses, granites and migmatites.

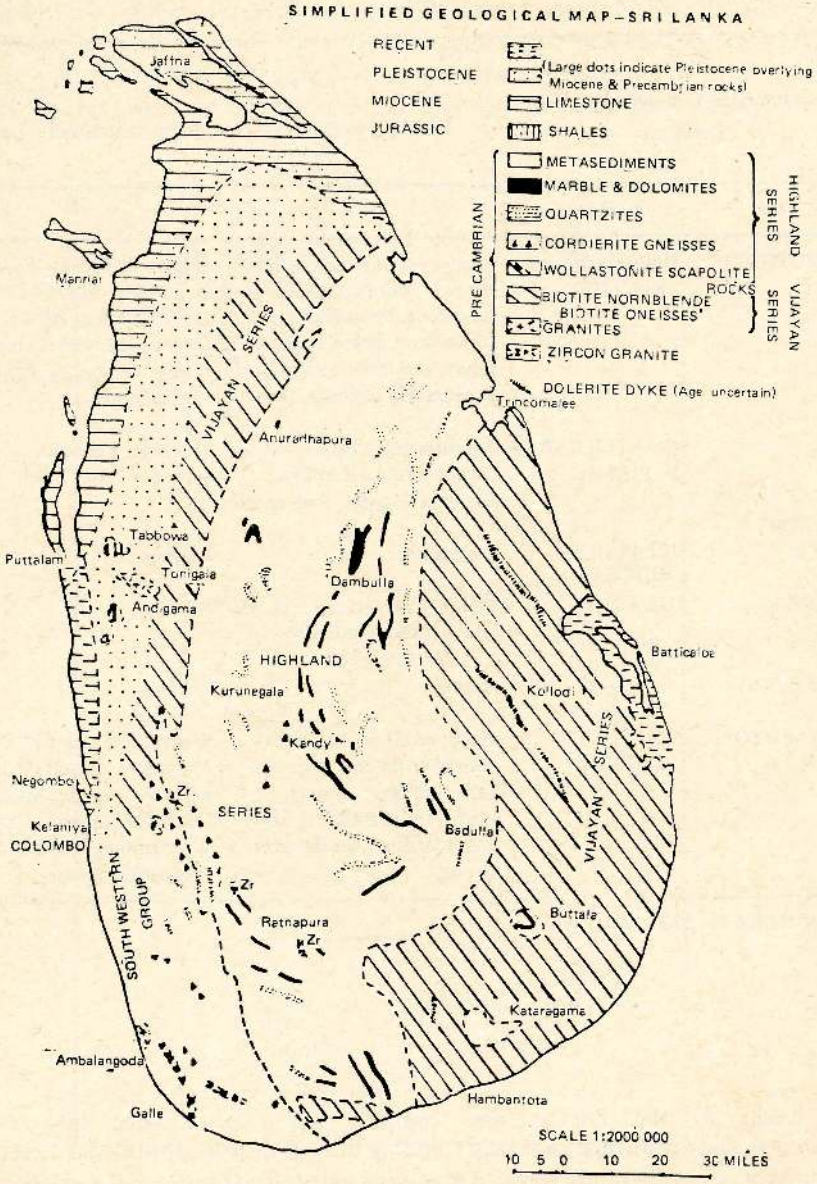

Figure 2. Geological Map of Sri Lanka.

Table 1. General Succession of Geological Formations in Sri Lanka.

Principal Geological Divisions		Principal Formations	Important Mineral Deposits
Era	Period		
ANTHROPOZOIC	HOLOCENE (RECENT)	Recent residual and alluvial deposits, blown sand, coastal sandstone, coral and shell formations, beach mineral sands, gem gravels, lagoonal & estuarine deposits, peat.	Kaolin, Ball Clay, Refractory Bond Clay, Alluvial Clay, Silica sand, Ilmenite, Rutile, Monazite, Zircon, Baddyleite, Garnet, Gems, Thorianite, Coral, Shell, Clay ochers.
	(QUATERNARY) PLEISTOCENE	Laterites (may extend from recent to Tertiary Periods) Gravels. Red earths.	Laterites, Limonitic Iron ore, Red sands.
CENOZOIC	TERTIARY) MIOCENE	Limestone.	Limestone.
MESOZOIC	JURASSIC	Shales, Carbonaceous shales and Arkosic sandstone.	Shales.
PALAEOZOIC	—	Absent	—
ARCHAEOZOIC	PRE-CAMBRIAN	Highland Series metamorphosed sediments. Vijayan Series gneissic complex Intrusives granites, dykes and dolorites. Southwestern Group.	Serpentinite, Marble, Dolomite, Magnesite, Quartz, Allanite, Felspar, Graphite, Mica, Cordierite Apatite, Chert, Wollastonite, Sillimanite, Magnetite, Copper.

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Rocks, of the Pre-Cambrian complex have been folded into a series of synforms and antiforms, generally trending in a north-west, south-east direction. A good deal of controversy still remains about the nature and indeed of the philosophy of the sub-division of the Sri Lanka Pre-Cambrian. What can be generally agreed however, is that the structures are everywhere complex.

3. Nature and Geological Environment of Laterites

The whole of the Island with the exception of the Jaffna Peninsula and the north-west coast, the Jurassic of Tabbowa and Andigama and small coastal strips elsewhere consists of Pre-Cambrian crystalline rocks. These rocks contain essential quantities of amphiboles, pyroxenes and other ferromagnesium minerals. Due to prevailing physical and chemical environments the rocks have undergone a lateritic type of weathering. The thickest laterite in Sri Lanka occupies a surface about 30 metres

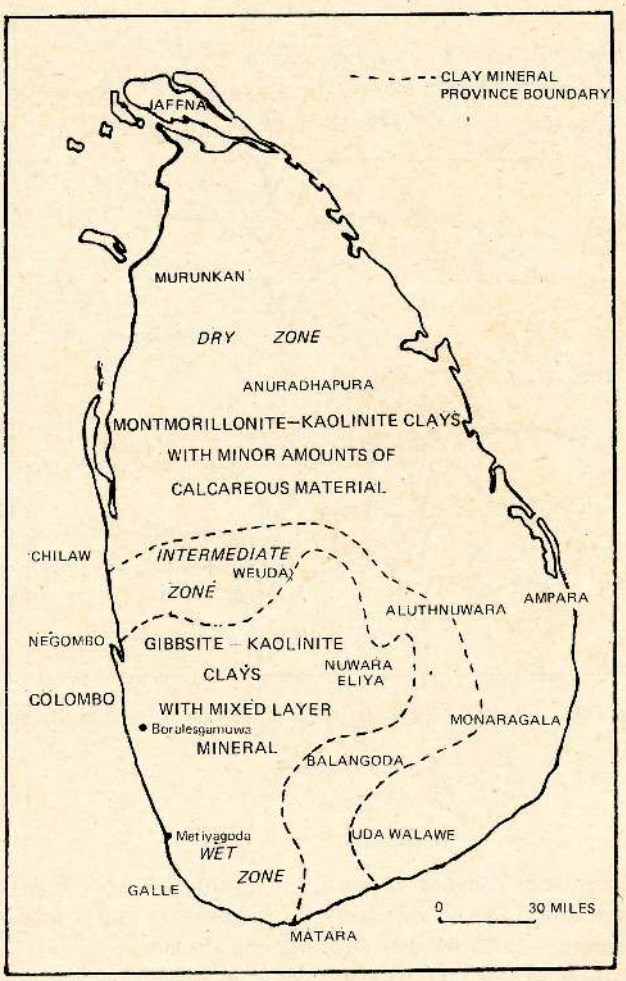

Figure 3. Clay Mineral Provinces – Sri Lanka.

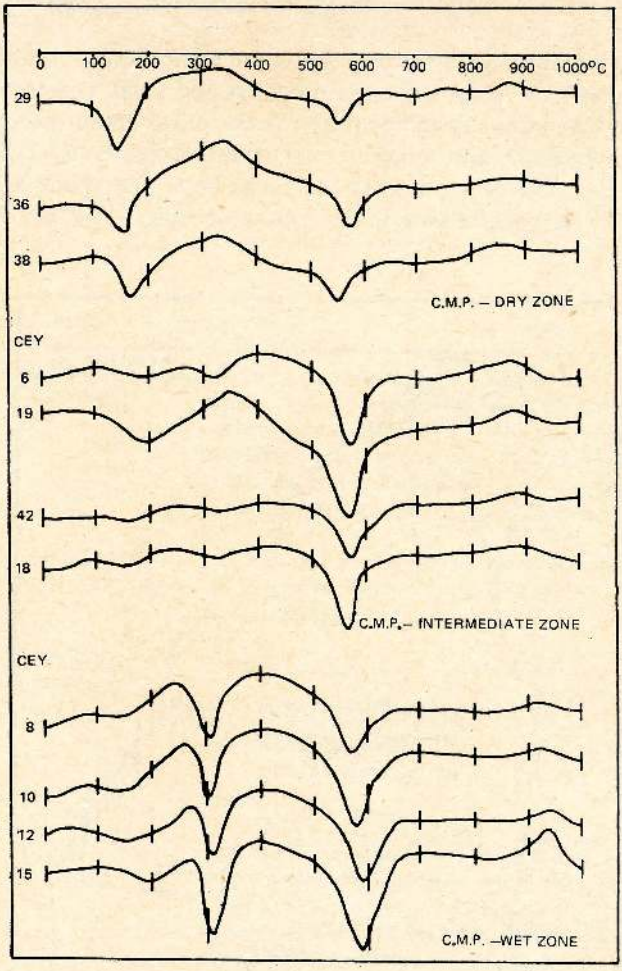

Figure 4. Differential Thermal Curves of the Clay Mineral Provinces.

above sea level between Negombo, north of Colombo and Kalutara south of Colombo. Inland it thins out and with increase of elevation passes into lateritic soils? Figure 3 is presented to show the Clay Mineral Provinces of Sri Lanka.[11] The characteristic features of this classification are:-

(a) the progressive development of montmorillonite from wet to dry zone areas;

(b) the progressive development of gibbsite from dry to wet zone areas and

(c) the progressive disappearance of calcareous material from dry to wet zone areas.

The presence of the mineral gibbsite indicating a lateritic type of weathering, is highly diagnostic and has been used as the main indicator mineral for purposes of this study (see Differential Thermal Analyses Curves Figure 4).

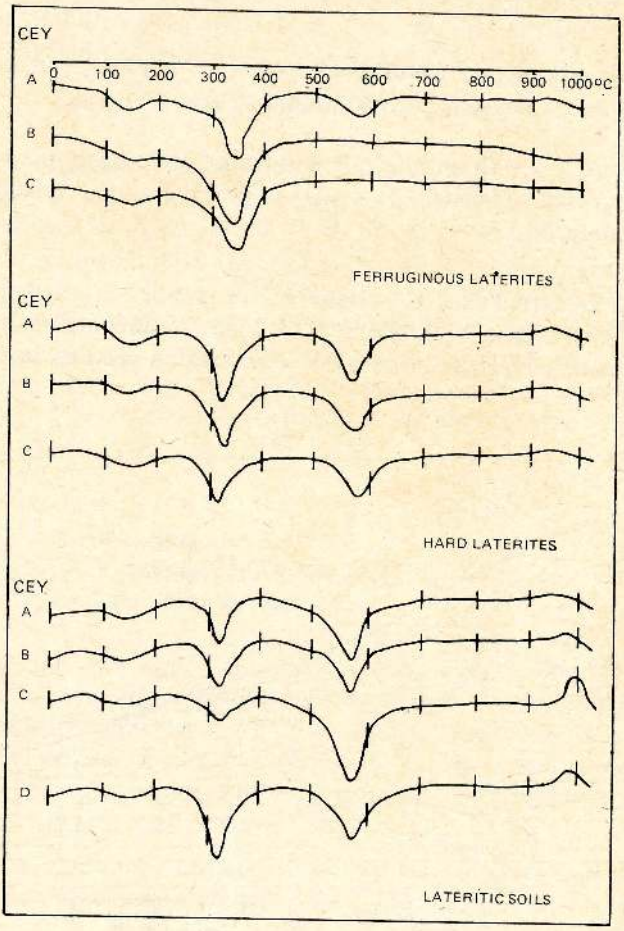

Figure 5. Differential Thermal Analyses Curves of Laterites and Lateritic Soils.

In Sri Lanka laterites overlie a variety of rock types and are largely laterites developed *in situ*. The laterites appear to have been more extensively distributed in the south-west low-lands in former geological periods than that which is observed at the present day. Absolute certainty as to the identity of the rock which has given rise to a particular laterite deposit is not always possible as outcrops of rock are rare and the heterogenity of rocks composing the basement complex makes the problem more difficult.

Herath[7] divided the laterites into 3 broad groups on the basis of differential thermal curves (DTA) Figure 5:

1. Massive highly ferruginous laterites rich enough in iron hydroxide (mainly goethite) to constitute iron ore;

2. Laterites with a vesicular appearance and widely used as a building material (gibbsite - kaolinite or gibbsite and/or goethite - kaolinite mixtures);

3. Lateritic red earths — relatively rich in gibbsite together with goethite and kaolinite. Soils mainly associated with the intermediate slopes and the highlands, (mineralogical composition same as laterites in 2).

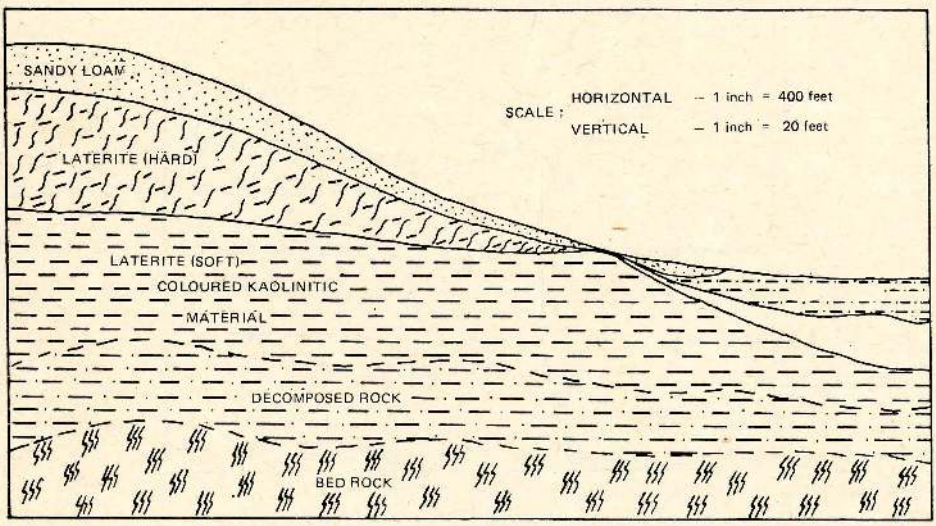

Figure 6. Diagrammatic Section – Laterite and Kaolin Deposits – Boralesgamuwa.

The typical laterite is usually separated from its parent rock by a considerable thickness of intermediate decomposition products. The laterite layer may vary in thickness from a few metres to 12 metres or more. The lower beds are soft lithomarge-like materials whilst the upper layers are more hard and compact and suitable for building material. In the upper most layers iron oxides get segregated to form surface ferruginous crusts. Normally the laterite layer is close to the present surface. In certain areas the laterite may be buried under varying thickness of later sediments that conceal the lateritization surface. Variations from the typical laterite profile have been observed. The hard laterite layer is normally absent in low lying areas. The soft laterite layer may also be missing. In some parts the soft layer has been almost entirely converted into kaolinite (Figure 6).

4. Samples Examined and Mineral Determinations

No systematic studies have been made on the laterites of Sri Lanka. A very large number of samples have been involved in the present study and all the locations of the sampling sites cannot be listed here. A range of typical laterites have been selected from a number of deposits and the lateritic materials are considered representative of the Island as a whole. The selection of the lateritic material was largely based on the changing stages of the weathering profile or on any other physical differences which were visually apparent. The samples collected whilst not representing all the lateritic occurrences of the Island certainly provide a cross section of those that may be called typical laterites of the Island. The locations of samples examined are presented in Figure 1.

Samples examined:
Ferruginous Laterites
Dela 3, Noragolla 3, Poronuwa 3
Kalawana 4, Rakwana 6, Balangoda 2
Kosgoda 2, Ambalangoda 4, Deniyaya 3.

These samples are mainly the highly ferruginous lateritic types sometimes approaching the composition of iron ore. This ore type is non-crystalline in texture and is comparatively soft and porous. The material occurs as surface cappings and occasionally as embedded lenses or pockets. The cappings are not continuous but consist mainly of detached masses and boulders on the crest of a hill as can be seen at Noragolla, or on hill slopes as at Dela.

The lower grade ores are vesicular, they have a lower specific gravity and contain both clay and siliceous matter.

Samples examined:
laterites
Ragama 6, Hunupitiya 6, Ja-Ela 3, Kalutara 2,
Beruwela 2, Kesbewa 3, Maharagama 2,
Ratmalana 2, Pannipitiya 4.

These are the typical laterites which could be used to cut bricks for the building industry. The laterites are seen exposed in well cuttings. The lateritic material is purplish or brick red and is porous. It has numerous cavities, filled or partially filled with coloured clay (reddish, yellow or lilac tinted). The sides of the cavities are usually ferruginous. In well exposed areas the hard layers and soft layers of the material can be easily recognized. Wells are sometimes dug in lateritic material of this nature to depths of over 15 metres without any side supporting mechanism. The typical laterites are well exposed around Colombo and the suburbs.

The chemical composition of a number of samples has been determined. X'Ray examination has been undertaken although the method was not suitable for quantitative determinations. The differential thermal analysis method (D.T.A.) was used to gather information on the mineralogy of laterites. In attempting to make a systematic study of a large number of materials it is important to examine the possibility of classifying them into broad mineralogical groups. Type samples from each group can then be selected for detailed examination. The (D.T.A.) method provided a useful technique for a rapid study of lateritic materials.

Results of the examination of Sri Lanka laterites revealed the presence of a number of clay and non-clay minerals, showing a marked similarity, in mineralogical composition. Quartz identified by chemical, X'Ray and D.T.A. methods was the most prevalent non-clay mineral. Kaolinite as shown by X'Ray, D.T.A. and the electron microscope was the dominant clay mineral. Halloysite was present in some of the soft lateritic materials while gibbsite (trihydrate of alumina) was invariably associated with goethite (hydrate of iron) and both have been identified by X'Ray, D.T.A. and selective chemical analysis methods. Gibbsite — boehmite bearing soft lateritic materials have also been identified. The main resistant primary minerals identified include, mica, ilmenite and quartz. The clay mineral montmorillonite was not identified in any sample.

For purpose of this study only the typical laterites including the ferruginous varieties (iron ore) are considered. Mention is however, made of lateritic soil where necessary. Table 2 is presented to show the chemical analyses of some ferruginous laterites found in Sri Lanka and Table 3 lists the analyses of some type laterites from the Island.

The ferruginous laterites are mainly composed of the mineral goethite (poorly crystallised), clay minerals are absent. (See Figure 5 for D.T.A. curves). The typical laterites on the other hand are composed of the minerals gibbsite, goethite, kaolinite together with quartz and ilmenite (See Figure 5). D.T.A. curves for laterites (hard laterites) are similar to the D.T.A. curves for lateritic soils developed in the Intermediate slopes and the central highlands of the Island. Mineralogically the two types are similar. It is also interesting to note that gibbsite is totally absent

Table 2. Chemical Analyses of Ferruginous Laterites.

	Dela	Noragolla	Ambalangoda	Deniyaya
SiO_2	6.57	4.25	13.16	11.58
F_2O_3	73.35	80.11	64.48	69.98
Al_2O_3	2.10	2.22	7.99	2.15
Mn	1.14	0.94	N.A.	1.03
TiO_2	Trace	Trace	N.A.	0.15
P_2O_5	1.62	1.75	0.09	0.87
CaO	0.14	0.11	N.A.	0.97
MgO	Trace	Trace	N.A.	0.01
S	0.17	0.19	N.A.	0.17
Loss on ignition	11.48	11.02	11.19	11.76
TOTAL	99.51	100.59	96.91	99.67

Table 3. Chemical Analyses of Laterites.

	RAGAMA	HUNUPITIYA	JA-ELA	MORATUWA	COLOMBO
SiO	46.0	47.7	41.23	46.23	42.31
Fe_2O_3	6.2	7.4	26.25	22.10	28.58
Al_2O_3	36.6	32.00	20.78	20.26	19.01
Loss on ignition	11.0	12.00	10.20	9.25	8.76
TOTAL	99.8	98.1	98.46	97.84	98.66

Table 4. Mineralogical Composition of Sri Lanka Laterites.

Mineral Group	Minerals Invariably Present	Others
Ferruginous Laterites	Goethite	Quartz, Kaolinite Graphite (flakes)
Laterites	Gibbsite, Goethite, Kaolinite, quartz	Ilmenite, mica, Other primary resistant minerals
Lateritic Soils	Gibbsite, Goethite, Kaolinite, Quartz	Ilmenite, mica, interstratified mineral, vermiculite. Other primary resistant minerals

in dry zone soils (See Figure 4). Table 4 is presented to show the mineralogical constitution of Sri Lanka laterites, the composition of lateritic soils[11] is also listed in this Table.

5. Summary and Conclusions

In Sri Lanka laterites are best developed in and around the Colombo District. It is a residual deposit representing the alteration products of the subjacent granites and gneisses, the genetic connection between the two being clearly evident in numerous exposures where laterite is developed. Field work indicates that the laterites are formed by the alteration of a parent rock in two distinct stages. First, the alteration to a clay material (lithomarge) consisting essentially of hydrated silicate of alumina (kaolinite). This first stage may be conveniently termed Kaolinization. In Sri Lanka kaolinitic formations are invariably present beneath lateritic formations as is well exposed in the Boralesgamuwa area. In low lying areas under swampy conditions the lithomarge is usually converted to beds of pure kaolinitic material which could be used in the ceramic industry (Figure 6). Sri Lanka obtains most of her kaolin from deposits of this nature.

After the first stage of the formation of lithomarge, laterite is formed. This second stage may be termed lateritization which is essentially a desilication process. Laterite is formed by the decomposition of the hydrated silicate of alumina accompanied by the elimination, in solution of the silica which is freed. The residual alumina takes up as much additional water to form the trihydrate of alumina, gibbsite ($Al_2O_3 3H_2O$). In Sri Lanka this process has not continued to completion and aluminous laterites approaching the composition of bauxites have not been developed. A sample containing 63.5 per cent gibbsite from Nuwara-Eliya has been reported (GEOMINCO–HUNGARY), these are isolated pockets of aluminous material and cannot be considered as representative samples from the area.

The ferruginous forms of laterite in Sri Lanka although not extensively developed approaches the composition of iron ores. It has been observed in various parts of the Island that this ore has been used in the indigenous smelting industry in ancient times. The ore is non-crystalline in texture, comparatively soft and porous and occurs largely as surface cappings which are not continuous but consist mainly as detached masses and boulders on crests of hills or on hill slopes. The iron ore deposits are very small, in point of fact they are insignificant compared to the well known iron ore deposits of the world. The total quantity of ore available is around two million tons, and the material is scattered in over 40 locations over the south-west quadrant of the island.

In Sri Lanka lateritization occurs in the residual soils of a variety of rocks. Lateritic deposits are well developed in the south-west sector of the Island. The predominant aluminous mineral in the soils analysed is the trihydrate gibbsite, the most common ferric oxide hydrate is goethite. The clay mineral is kaolinite. The

aluminous and ferruginous varieties of laterites are encountered in Sri Lanka. The highly aluminous varieties approaching the composition of bauxite have not been observed to be present in appreciable amounts.

Laterites are used (as cut bricks) in the building industry. The coloured varieties are used as clay ochers and the yellow variety is termed 'samara'. Samara is used extensively in rural areas for colour-washing dwellings. The porous nature of laterite is also a highly favourable factor for re-charge of groundwater. The lithomarge clay below the laterite acts as impervious strata and helps in building up the groundwater storage within the laterites.

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Characterization of the Xylanolytic Activity of *Cellulomonas*

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Abstract: Maximum production of xylanolytic enzymes by *Cellulomonas* CS1-17 required aerobic conditions, a temperature of 30°C and a pH between 6.2 and 7.2. Under these conditions, maximum levels of xylanolytic activity were reached within 48 hr; addition of further mineral salts and yeast extract to the growth medium decreased the time to 24 hr.

At pH values between 5.4 and 8.4 the xylanase was stable up to a temperature of 30°C, for at least 48 hr after harvest; over the same temperature range, the β-xylosidase was stable only at the higher end of this pH range.

The culture filtrate was similar to the growing cells in its ability to hydrolyse xylan whilst the growing cells metabolized the bulk of the hydrolysis products, the latter accumulated as soluble reducing sugars when the culture filtrate was used as the enzyme source.

1. Introduction

A highly cellulolytic *Cellulomonas* mutant CSl-17[4] has been shown to be improved over the original parent strain CSl-1, with respect to hemicellulolytic (including xylanolytic) activity.[8, 11] The hemicellulolytic activity was shown to be directly proportional to the xylose content in the hemicellulose substrate. From induction studies during growth on xylan, crystalline cellulose and carboxymethylcellulose, it has been shown that although both cellulolytic and xylanolytic activities have been similarly effected by the mutation, xylanolytic activity is distinct from cellulolytic activity.

Peiris[8], demonstrated that when the *Cellulomonas* mutant, CSl-17, was grown under aerobic conditions at 30°C in an unbuffered medium containing 0.5% xylan, 1% of each Dubos mineral salt and 0.02% yeast extract, maximum xylanolytic activity was attained within two days. The current investigation sought to improve enzyme production by varying the pH, temperature, aeration and the concentrations of mineral salts and yeast extract.

Choudhury[1], showed that non-growing cultures of *Cellulomonas* CSI-17 are effective in hydrolysing pretreated sugar cane bagasse. In the current investigation

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the hydrolysis of xylan by growing cultures *(in vivo)* and non-growing cultures *(in vitro)* was compared. The xylan used as substrate for digestion was an arabinoxylan obtained from oats and was similar in sugar composition to the hemicellulose fraction of sugar cane bagasse.

2. Materials and Methods

2.1 Bacterial Strain.

The *Cellulomonas* strain was CSI—17, a mutant previously shown to be highly cellulolytic[4] and xylanolytic.[8]

2.2 Growth and Assay Substrate.

Xylan, a commercial preparation, obtained from oats and supplied by Fluka AG, Buchs SG, Switzerland was used as growth and assay substrate. High performance liquid chromatographic (HPLC) analysis of an acid hydrolysate showed its neutral sugar composition to be xylose, arabinose and hexose in the ratio of 73:12:15. The hexose was found by thin layer chromatography to be mainly glucose with a trace of galactose. (The sugar composition was therefore similar to that of hemicelluloses A and B isolated by Rickard and Peiris[11] from sugar cane bagasse. In all three cases xylose was the major component). As a growth substrate it was used as supplied; for enzyme assay the fraction containing particles between 63 and 250 μ in size was used.

2.3 Growth and Fractionation of Cultures.

The cultures were grown as described by Peiris.[8] They involved growth at 30° C in shake flasks with unbuffered medium (initially pH 7.2) containing 0.5% xylan, 1% of each Dubos mineral salt[3] and 0.02% yeast extract. After growth for two days, the cultures were harvested, separated into cellular and extracellular (culture filtrate) fractions and the cellular fraction homogenized.

The following deviations from standard conditions described by Peiris[8] were made: (a) the shake flask cultures were buffered at various pH values by the inclusion of either 40 mM 3-(N-morpholino)—propanesulphonic acid (MOPS), Calbiochem, San Diego, U.S.A. or 40 mM 2-(N-morpholino) ethanesulphonic acid (MES), Sigma, St. Louis, U.S.A. in the medium and adjusting the pH to the desired value;[7] (b) shake flasks were substituted with a fermentor as the growth vessel; a stirred tank fermentor[9] with a working volume of 1*l* which was fabricated at the School of Biotechnology, University of New South Wales, Australia, was used; the air supply system consisted of an adjustable pressure reducing valve, a needle valve for control of air flow rate and a flow meter with a range of 100 to 1200 ml/min; the dissolved oxygen tension (DOT) in the medium was measured with a steam sterilizable amperometric probe which was connected to a meter calibrated between 0% and 100% saturation of the medium with oxygen; standard growth medium was employed except for a three-fold increase in the yeast extract and each Dubos mineral salt in one instance, as indicated; except where otherwise specified, temperature was maintained at 30°C and DOT between 60 and

100% saturation; (c) either soluble or insoluble xylan replaced the mixed product in some media; standard medium containing 0.5% xylan was prepared, autoclaved, cooled and centrifuged at 20,000g for 30 min; the supernatant served as the soluble xylan medium (0.34% carbohydrate); the residue was suspended in fresh medium to yield the insoluble xylan medium (0.4% carbohydrate); both media were resterilized; (d) the cellular fraction of the harvested cultures was not homogenized prior to assay of xylanolytic activity; the cells were collected by centrifugation, washed and suspended in buffer in the standard manner and used as an intact cell preparation.

2.4 Viable Cell Counts.

The culture was diluted 1 in 10^7 by serial dilution. 0.1 ml of each dilution was spread on nutrient agar plates in duplicate and incubated at 30°C until single colonies appeared. Viable cells were determined by counting the number of colonies on plates containing 50 to 200 colonies and taking the average value.

The nutrient agar plates were of the following composition (per l/ of distilled water): 25g nutrient broth No. 2 (Oxoid, CN 67), 5g yeast extract (Oxoid, L 21) and 12g Kobe agar. The diluent used for serial dilutions of the culture was 0·85% (w/v) sterile sodium chloride (B.D.H., A.R.).

2.5 Assay Procedures.

Xylanase, β-xylosidase, reducing sugar and total carbohydrate were assayed as described by Peiris.[8] All enzyme activities, including those in the cellular fraction, are expressed in milliunits (mu)/ml of culture, where one International Unit releases one μmole of product/min. Reducing sugar (RS) and total carbohydrate (TC) are expressed in μg/ml; the percentage hydrolysis was calculated as the (RC/TC) x 100.

3. Results and Discussion

3.1 Effect of Growth Parameters on Xylanolytic Activity

3.1.1 pH.

When the *Cellulomonas* strain was grown for two days in culture media buffered between pH 5.8 and 7.2, maximum levels of both xylanase and β-xylosidase activity were recorded at pH 7.1 (Table 1). The enzyme levels were, however, virtually constant between pH 6.2 and 7.2, the variation being considered to be within the limits of accuracy of the enzymic assays. The xylanase activity was less than that recorded in a standard (unbuffered) culture. Other growth parameters were tested in unbuffered cultures, initially adjusted to pH 7.2.

3.1.2 Temperature.

When the temperature was varied between 23°C and 40°C, maximum enzyme activity at the end of the first day was recorded in the culture grown at 35°C (Table 2). However, at the end of the second day, maximum xylanase activity was recorded in the culture grown at 30°C; similar levels of β-xylosidase activities were recorded in the cultures grown at 23°C and 30°C.

Table 1. Effect of pH on Production of Xylanolytic Activity by CSI-17 Grown for Two Days on 0.5% Xylan

pH	Buffer	Viable Counts/ml (cells x10⁹)	Enzyme Activity (mu/ml of culture)			
			Xylanase		β−Xylosidase	
			Total	% Extra-cellular	Total	% Extra-cellular
5.8	MES	0.7	603	21	1.5	<10
6.2	MES	2.6	11002	87	10.4	3
6.4	MES	1.8	11398	85	9.6	2
6.4	MOPS	2.0	10159	87	11.3	< 1
7.1	MOPS	2.4	13122	87	12.2	3
7.2	MOPS	2.6	12942	88	10.7	3
7.2	(unbuffered)	4.0	18630	90	11.3	5

Table 2. Effect of Temperature on the Production of Xylanolytic Activity by CSI-17 Grown on 0.5% Xylan in a Fermentor

Culture Time (days)	Temperature (°C)	Viable Counts/ml (cells x 10⁹)	Enzyme Activity (mu/ml of culture)			
			Xylanase		β-Xylosidase	
			Total	% Extra-cellular	Total	% Extra-cellular
1	23	0.1	48	60	0.9	86
	30	3.4	4716	68	4.5	1
	35	0.9	6660	54	7.2	1
	40	0.03	2250	61	0.8	12
2	23	1.7	8226	51	12.8	1
	30	1.9	14040	83	12.2	2
	35	3.3	10485	88	8.7	2
	40	0.00	1054	78	0.3	28

3.1.3 Dissolved Oxygen Tension (DOT).

Growth and enzymic activity was very low in cultures grown under anaerobic conditions (DOT 0% saturation, maintained by bubbling sterile nitrogen gas into the medium) (Table 3). Although high aeration (DOT 60-100%, maintained by bubbling sterile air into the medium) promoted enhanced growth, xylanase production was maximized at moderate aeration (DOT 10-30% saturation, maintained by regulating the inflow of sterile nitrogen gas and air into the medium). Moderate aeration probably is comparable to standard shake flask conditions. The differences in β-xylosidase production at high and moderate aeration were minimal.

3.1.4 Mineral Salts and Yeast Extract.

Supplementation of the culture medium with a three-fold increase in the yeast extract and all the Dubos mineral salts had a marked effect on the rate of production of the xylanolytic enzymes, which were increased approximately three-fold over their levels in the culture containing the standard medium by the end of the first day (Table 4). By the end of the second day, however, the activities in the standard culture had virtually equalized with those in the supplemented culture.

Choudhury,[1] found that increased concentrations of Dubos salts and yeast extract in a growth medium containing 2% pretreated bagasse enhanced the viable count and the hydrolytic activity of CSl-17 cultures. They suggested that the increased activity was a direct result of the increased biomass. In the current study, where the growth substrate was 0.5% xylan, the effect of the salts and yeast extract on the rate of production of xylanolytic activity over the first day appeared not to be dependent on increased biomass but rather a direct effect on enzyme production per unit cell number.

It appears that, the addition of yeast extract and Dubos mineral salts to the growth medium had been effective in improving xylanolytic enzyme production by CSl-17 beyond that obtained in standard cultures. The variation of temperature, pH and DOT virtually had no effect on the enzyme production.

Under all the growth conditions tested, xylanase activity (at its maximum levels) was mainly present in the culture filtrate (extracellular fluid), whilst the β-xylosidase remained associated with the homogenized cells.

3.2 β-Xylosidase Location

It was conceivable that the association of the β-xylosidase in the cellular fraction of the cultures was the result of its adsorption to unutilized insoluble xylan substrate present in this fraction. In order to eliminate this possibility, an experiment was conducted where soluble xylan replaced the mixture of soluble and insoluble xylan as the growth substrate. After growth for two days by the standard procedure, the culture was fractionated into its cellular and extracellular (culture filtrate) fractions. The cells were washed twice with saline, resuspended in 25ml of dilute (1:10) McIlvaine's buffer[2] and a sample (intact cells) taken for assay. The remainder was homogenized according to the standard procedure and a sample taken for assay. The remainder of the

Table 3. Effect of Dissolved Oxygen Tension (DOT) on the Production of Xylanolytic Activity by CSI-17 Grown on 0.5% Xylan in a Fermentor

Culture Time (days)	DOT (% saturation)	Viable Counts/ml (cells x 10^9)	Enzyme Activity (mu/ml of culture)			
			Xylanase		β-Xylosidase	
			Total	% Extra-cellular	Total	% Extra-cellular
1	60 - 100	3.4	4716	68	4.5	1
	10 - 30	0.6	4608	41	2.3	0.1
	0	0.4	211	34	0.7	4
2	60 - 100	7.8	14040	83	12.2	2
	10 - 30	2.9	18396	78	11.3	2
	0	0.1	217	31	0.7	13

Table 4. Effect of Increased Concentrations of Dubos Salts and Yeast Extract on the Production of Xylanolytic Activity by CSI-17 Grown on 0.5% Xylan in a Fermentor

Culture Time (days)	Dubos Salts and Yeast Extract Concentration	Viable Count/ml (cells x 10^9)	Enzyme Activity (mu/ml of culture)			
			Xylanase		β-Xylosidase	
			Total	% Extra-cellular	Total	% Extra-cellular
1	Standard	3.4	4716	68	4.5	1
	x 3	3.7	13086	63	17.6	0.5
2	Standard	7.8	14040	83	12.2	2
	x 3	11.8	15732	80	13.8	1

homogenate was centrifuged at 17,000g for 15 min and the supernatant was designated the intracellular fraction. The pellet, after resuspension in 10ml of dilute McIlvaine's buffer, was designated the cell wall fraction. The intact cells, homogenized cells, the intracellular fraction, the wall fraction and the culture filtrate were all assayed for β-xylosidase activity. Results (Table 5) were all corrected for volume changes and in common with other results, are reported in m units/ml of original culture.

Only 2% of the activity was located in the extracellular fraction, the remainder being associated with the intact cells. 37% of the cellular activity was 'lost' during homogenization, presumably as a result of enzyme inactivation. 69% of the residual activity in the homogenized cells was associated with the wall fraction while 31% was intracellular. The activity of the intact cells suggests that either the β-xylosidase is located on the outside of the cells or that the synthetic substrate used in this investigation readily passes into the cells and the nitrophenol product is readily excreted. The fact that the cell wall fraction possessed more than twice the activity of the intracellular fraction supports the concept of the enzyme's location on or in the cell wall.

As soluble xylan was the substrate, the results minimize the possibility that the location of the enzyme in the standard cellular preparations (containing homogenized cells plus unutilized insoluble xylan) is due to its adsorption on to the insoluble xylan.

3.3 Enzyme Stability

This study was part of an overall aim to maximize the ability of preparations from *Cellulomonas* cultures to hydrolyse pretreated bagasse. It was therefore necessary to ensure that the enzymes, including the xylanolytic enzymes, were stable after harvest. The enzymes tested were the β-xylosidase of intact cell preparations and the extracellular xylanase of a culture of CS1-17 which had been grown for two days on 0.5% xylan under standard conditions.

In order to test the effect of pH on storage stability, portions of the culture filtrate and intact cell preparations were adjusted to specified pH values by the addition of dilute (1:10) McIlvaine's buffer.[2] These were then stored at specified temperatures and the extracellular xylanase and cellular β-xylosidase activities

Table 5. Distribution of β -Xylosidase in a CSI-17 Culture Grown for Two Days on Soluble Xylan

Fraction	β-Xylosidase Activity (mu/ml of culture)
Extracellular (culture filtrate)	0.2
Cellular	
Intact cells	10.1
Homogenized cells (standard preparation)	6.4
Intracellular fraction	2.0
Wall fraction	4.4

determined at zero time and after one and two days storage. 0.2% azide was present, as a preservative and metabolic inhibitor, in all portions. Just prior to assay of each portion for enzyme activity the pH was adjusted to 7.0 by the addition of either 0.1M citric acid or 0.2M disodium hydrogen phosphate, the components of McIlvaine's buffer. Volume changes were accounted for in the calculation of activity per ml of original preparation.

Initial pH values had been adjusted to 5.0, 6.0, 7.0 and 8.0. During storage, however, pH changes occurred, presumably as a result of certain metabolic reactions which had not been inhibited by 0.2% azide. In all cases mean values between initial and final pH are recorded.

The results, recorded in Table 6, revealed that, at least for two days, the extracellular xylanase was stable at pH values between 5.4 and 8.4 and temperatures up to and including 30°C. At 42°C, it was unstable at all pH values tested and lost at least 50% of its initial activity within one day.

The stability of the cellular β-xylosidase was pH and temperature dependent. At all pH values tested, it was relatively stable at 4°C, but at likely process temperatures (25°C, 30°C and 42°C) it lost more than 50% of its activity during storage for two days at pH 5.3 and 6.1. At the higher pH values tested (6.9 and 7.4) it retained at least 70% of its activity at 25°C and 30°C and 50% at 42°C. This suggests that to maintain this enzyme in an industrial process the pH should not be allowed to decline below 6.9 (or perhaps a lower, untested, value between 6.1 and 6.9)

3.4 Extent of Hydrolysis of Xylan

In order to determine whether non-growing cultures of *Cellulomonas* were as effective as growing cultures in hydrolysing xylan, *in vivo* and *in vitro* tests were conducted. Both soluble and insoluble xylan were used as substrates for digestion in each case. The extent of hydrolysis during growth over two days under standard conditions was compared with that obtained over a further two days after addition of fresh substrate.

Each *in vitro* digest contained 15ml of enzyme (culture filtrate from the standard culture) plus 15ml of fresh xylan medium and 0.2% sodium azide. Incubation was carried out at 40°C. Zero time samples were prepared by mixing enzyme which had been boiled for half an hour with an equal volume of fresh xylan medium.

In the case of both the *in vivo* and the *in vitro* tests, the zero time samples and those collected after incubation for two days were boiled for 15 min and reducing sugar (RS) and total carbohydrate (TC) measured. The percentage hydrolysis of the residual carbohydrate was calculated from the values for the two day samples, using the expression (RS/TC) x 100. In addition, the difference between the initial and final TC values was considered to be metabolized and therefore fully hydrolysed carbohydrate. Its percentage of the initial TC was added to the percentage hydrolysis of the residual carbohydrate (corrected for the fraction of the initial carbohydrate which it represented) to give the total percentage hydrolysis. The initial RS was comparatively high in the *in vitro* tests due to 'carry over' with the enzyme preparation.

Table 6. Storage Stability of Xylanolytic Activity of CSI-17 Preparations

Storage Temperature	Storage pH		Storage Time (days)	Relative Xylanase (culture filtrate)	Relative β-Xylosidase (Intact cell preparation)
	Culture Filtrate	Intact cell Preparation			
			0	100	100
4°C	5.4	5.3	1	130	110
			2	120	100
	6.2	6.1	1	95	96
			2	94	78
	7.1	6.9	1	84	103
			2	101	101
	8.4	7.4	1	120	80
			2	118	81
25°C	5.4	5.3	1	108	80
			2	105	43
	6.2	6.1	1	85	77
			2	85	35
	7.1	6.9	1	84	96
			2	84	99
	8.4	7.4	1	105	84
			2	102	72
30°C	5.4	5.3	1	117	58
			2	109	22
	6.2	6.1	1	89	63
			2	88	28
	7.1	6.9	1	84	96
			2	94	90
	8.4	7.4	1	98	80
			2	98	81
42°C	5.4	5.3	1	43	13
			2	34	3
	6.2	6.1	1	43	17
			2	46	13
	7.1	6.9	1	44	75
			2	34	54
	8.4	7.4	1	40	58
			2	11	52

The values for percentage hydrolysis can be considered as approximations only. Use of the DNS method for measurement of reducing equivalents was based on the fact that it is widely used for the determination of reducing sugars liberated by α-amylase[13] and by carboxymethylcellulase.[6] Since the reducing power (on a molar basis) of an oligomeric series increases with chain length, falsely high values are given for percentage hydrolysis when dimers and oligomers are present in the digest. The discrepancy does however decrease with chain length; this is evident when the ratio (1.0:1.4) of reducing powers of glucose and maltose[5] is compared with the ratio of (1.0:1.95) of reducing powers of maltose and maltoheptaose.[12] The method therefore provides a relatively simple semi-quantitative means of comparing the abilities of different enzyme preparations to hydrolyse polysaccharides.

The results (Tables 7 and 8) reveal that neither the *in vivo* nor the *in vitro* system was capable of hydrolysing soluble or insoluble xylan completely. The total percentage hydrolysis values indicated that *in vitro* the cell free culture filtrate was just as effective as a living culture in hydrolysing about 75% of the soluble xylan. Only when the cell free system was obtained from a culture grown on insoluble xylan was there an apparent decrease (from 67% to 50%) in the ability of the culture filtrate to match that of the living culture to hydrolyse insoluble xylan. (This may perhaps indicate that a factor (or factors) required for effective hydrolysis of insoluble xylan remained associated with the residual insoluble xylan of the culture; this was a significant proportion of the initial carbohydrate and was discarded when the cell free culture filtrate was separated and used as the enzyme source). Minimization of carbohydrate metabolism *in vitro* resulted in the products of hydrolysis accumulating as soluble reducing sugars.

A further experiment was undertaken to determine whether inclusion of cells in the *in vitro* enzyme digest would improve the rate and extent of soluble xylan hydrolysis. A standard culture of CSI-17, grown on soluble xylan, was divided into two portions; one was centrifuged and the cell-free culture filtrate collected, whilst the other was left untreated. Both preparations served as enzyme preparations for *in vitro* digestion of a soluble xylan. In contrast to the previous test, the reaction mixture was buffered at pH 7.0 to ensure maximum enzyme stability (see above) and enzyme activity.[10] Enzyme stability was also improved by incubating the digests at 30°C, rather than at the optimum (40°C) for enzyme activity[10] as in the previous test.

Flasks containing 40ml of soluble xylan, 40ml of McIlvaine's buffer (pH 7.0), 40 ml of enzyme and 0.2% sodium azide, were incubated at 30°C for two days. Samples, taken at various time intervals, were boiled for 15 min and the reducing sugar (RS) and the total carbohydrate (TC) determined (after removal of cells by centrifugation, where appropriate). Controls were prepared using enzyme sources which had been boiled previously for 1hr before mixing them with soluble xylan solution and buffer in the ratio 1:1:1. The controls were assayed in the same manner as the samples. In all cases, the approximate degree of polymerization (DP) was

calculated by dividing the TC by the RS; the same limitations in accuracy apply to calculation of DP as to calculation of percentage hydrolysis (see above).

Results are recorded in Table 9. Their control values reveal that the introduction of relatively low molecular weight fragments with the enzyme preparations made interpretation difficult. They do demonstrate however that an initial rapid rate of hydrolysis, detected even at zero time and continuing over 5 hr was followed by minimal further activity. Neither digest was capable of completely hydrolysing the soluble xylan; even at the end of two days, the DP was still 1.5 (67% hydrolysis) in both cases.

Addition of fresh xylan at 5 hr to the culture filtrate resulted in it too being hydrolysed to the same extent as the original material. This indicated that the cessation of activity was not due to enzyme inactivation but rather to resistance of the substrate to complete hydrolysis by the enzyme preparation. A possible explanation is that CSI-17 produces xylanolytic activity which is inversely proportional to chain length and which fails to hydrolyse the low molecular weight xylose oligomers.

The investigation suggested that cell-free preparations of *Cellulomonas* CSI-17 are similar to growing cultures of the strain in their ability to hydrolyse xylan. In comparsion to the *in vivo* conditions, where the products were metabolized, relatively high levels of reducing sugars accumulated in the soluble fraction of the *in vitro* digests. This suggests that the latter system is one which is appropriate for saccharification of the hemicellulose fraction of lignocellulose.

Table 7. *In Vivo* Hydrolysis of Soluble and Insoluble Xylan by CSI-17 Cultures

Xylan Medium	Time (days)	Soluble Reducing Sugar (μg/ml)	Total Carbohydrate μg/ml			% Hydrolysis of Residual Carbohydrate	% Total Carbohydrate Metabolized	% Total Hydrolysis
			Soluble	Insoluble*	Total			
Soluble	0	110	3350	66	3416			
	2	340	1020	177	1197	28		
	Δ	+230	-2330	+111	-2219		65	75
Insoluble	0	70	1600	2400	4000			
	2	50	155	1222	1377	4		
	Δ	-20	-1445	-1178	-2623		66	67

* Includes microbial cells

Table 8. *In Vitro* Hydrolysis of Soluble and Insoluble Xylan by a CS1 - 17 Extracellular Enzyme Preparation (Culture Filtrate)

Xylan Substrate	Extracellular Enzyme Source	Incubation Time (days)	Soluble Reducing Sugar (μg/ml)	Total Carbohydrade (μg/ml) Soluble	Insoluble	Total	% Hydrolysis of Residual Carbohydrate	% Total Carbohydrate Metabolized	% Total Hydrolysis
Soluble	Soluble	0	225	1900	33	1933			
	Xylan	2	1495	2050	0	2050	73		
	Culture	Δ	+1265	+150	-33	+117		0	73
	Insoluble	0	80	1700	33	1733			
	Xylan	2	1260	1650	0	1650	76		
	Culture	Δ	+1180	-50	-33	-83		5	77
Insoluble	Soluble	0	205	980	1200	2180			
	Xylan	2	1080	1220	580	1800	60		
	Culture	Δ	+875	+240	-620	-380		17	67
	Insoluble	0	60	720	1020	1740			
	Xylan	2	840	1080	640	1720	49		
	Culture	Δ	+780	+360	-380	-20		1	50

Table 9. *In Vitro* Time Course of the Decrease in the Degrees of Depolymerization (DP) of Soluble Xylan (DP.24.4) by CSI-17 Preparations

Time	DP*	
	Total Culture	Culture Filtrate
Control - 0 min	4.7	5.8
0 min	3.2	4.0
7 min	2.4	2.7
18 min	2.0	2.4
22 min	2.0	2.0
45 min	1.7	2.2
1 hr	1.9	2.0
2 hr	1.8	1.9
5 hr	1.7	1.6
20 hr	1.5	1.6
30 hr	1.5	1.5
48 hr	1.5	1.6

* Degree of polymerization = TC/RS

Although the initial *in vitro* rate was rapid, the reaction ceased before complete hydrolysis was reached. Even when the digestion was carried out under conditions which maximized enzyme stability, only about 67% hydrolysis was attained by the cell-free extracts. As the β-xylosidase activity is located in the *Cellulomonas* cells and since this enzyme could be necessary for hydrolysis of the oligomers released by xylanase activity, it was considered that inclusion of cells in the digest may improve the degree of hydrolysis; this proved not to be the case.

Investigations are in progress to identify the products of enzymic digestion of xylan and to improve conditions for their further hydrolysis.

Acknowledgements

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The Kelaniya-Negombo Coastal Zone and its Geological Resource Potential

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Abstract: Recognizing the importance of the marine sciences, an Oceanography and Survey of Off-shore Area Unit has been set up within the newly established National Aquatic Resources Agency (NARA) of Sri Lanka. Work programmes initiated by NARA include the investigation of the coastal regions of the island which would be integrated with the proposed hydrographic and oceanographic surveys to be undertaken in early 1984. The present study is confined to the Kelaniya - Negombo coastal zone and is the first phase of the survey. An account is given of the general coastal features and the geological resource potential of the area. Substantial amounts of ilmenite occur at several localities along the beach. At some points bulk samples of beach sands contain over 65 per cent of the mineral ilmenite. A low grade peat deposit is described which occurs in the silted up lagoon—the Muthurajawela swamp. The importance of the rational management of the coastal zone is also discussed as coastal areas and the coastal environment are important resources for socio-economic development.

1. Introduction

In regard to mineral resources, the sea can be divided into five regions: marine beaches, sea water, the continental shelves, surficial sediments and the hard rock beneath the surficial sea floor sediments. A variety of minerals are extracted from the first three regions of the ocean. Some minerals mined from marine beaches include the heavy minerals resistant to chemical weathering, diamonds (southwest Africa), gold (Alaska), magnetite sands (Japan), shell sands (USA), Ilmenite-Rutile-Zircon (Sri Lanka, Australia, India, USA, Brazil and other countries). In addition to common salt, bromine, magnesium and magnesium compounds, several other minerals are extracted from sea water. Important minerals on the continental shelves include, phosphorite, glauconite and calcareous shell deposits. Barium sulphate concretions have been dredged from about 1235 m off Colombo.[3] The oil reserves of the continental shelves of the world have been estimated to be about equal to the resources of onshore areas of the continents. From an economic standpoint, manganese nodules are the most important on the floor of the three major oceans. Very little is known about the fifth region that of the hard rock under the ocean floor sediments. These are the better known mineral occurrences of the sea.[4]

A great potential therefore lies in developing marine resources and the application of marine science to development can only be undertaken by people trained accordingly. Recognizing the importance of the marine sciences, Sri Lanka has

established a new organization (1981) named the National Aquatic Resources, Research and Development Agency (NARA), charged with the responsibility of carrying out and co-ordinating research, development and management activities on the subject of aquatic resources (living and non-living). The establishment of NARA also satisfies a long felt need for a National Oceanography Institute for Sri Lanka.

Under the terms of the Law of the Sea Convention which was signed in Jamaica (December 1982), Sri Lanka has control of an off-shore territory approximately 20 times as large as the country's total land area and comprises the 320 km Exclusive Economic Zone and Sea Bed rights beyond.

Work programmes initiated by the Oceanography Unit of NARA include the investigation of the coastal regions of the Island which would be integrated with the proposed geological and geophysical off-shore surveys to be undertaken in early 1984. The present study is confined to the Kelaniya-Negombo coastal zone and is the first phase of the survey. An account is given of the general coastal features and the geological resource potential of the area. The Muthurajawela swamp is described as it occurs in the area under investigation and the importance of the rational management of the coastal zone is discussed.

2. General Geography and Geology

Sri Lanka which is a tropical island has an area of 65,000 sq.km (25,332 sq. miles) and the island may be divided into two main physiographic divisions.

1. The low lying coastal plain with little relief and traversed by rivers which have almost reached their base level of erosion in the coastal plain.
2. The central highlands with immature drainage pattern and marked relief abounding in numerous strike ridges, hills and mountains.

The coastal plain is narrow in the western and southern parts of the Island and the highlands towards the south rise steeply from the coastal plain. Sri Lanka lies in the monsoon region of south-east Asia and the mean rainfall for the Island is 203 cm (80 inches). The rivers have a radial distribution, the upper reaches are mainly confined to the central hill country. The radial pattern is the dominant element in the drainage pattern of Sri Lanka.

The two main rivers, draining the area under investigation include the Kelani Ganga with its mouth immediately north of Colombo and the Maha Oya with its mouth north of Negombo. Crystalline rocks of Pre-cambrian age occupy the greater part of the Island. They consist of a gneissic complex (Vijayan Series)

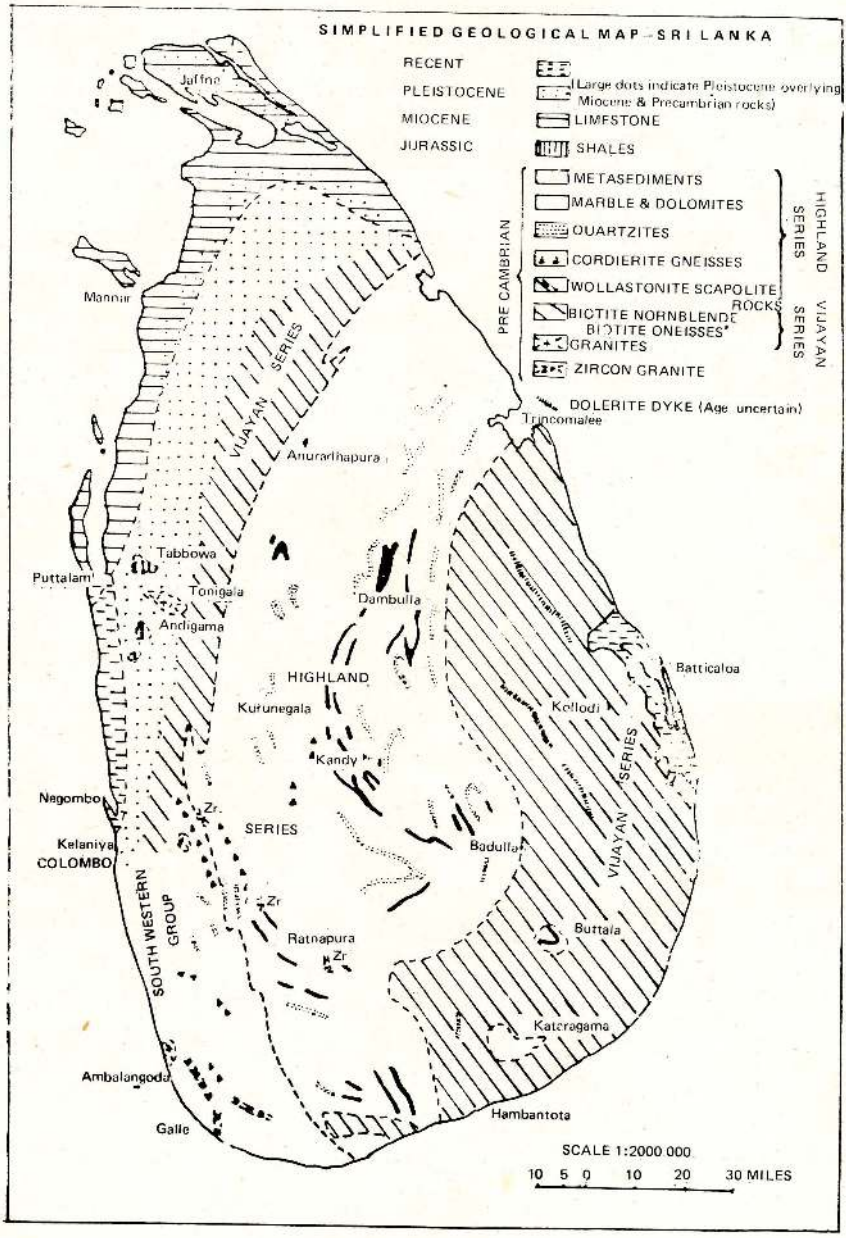

Figure 1. Geological Map of Sri Lanka.

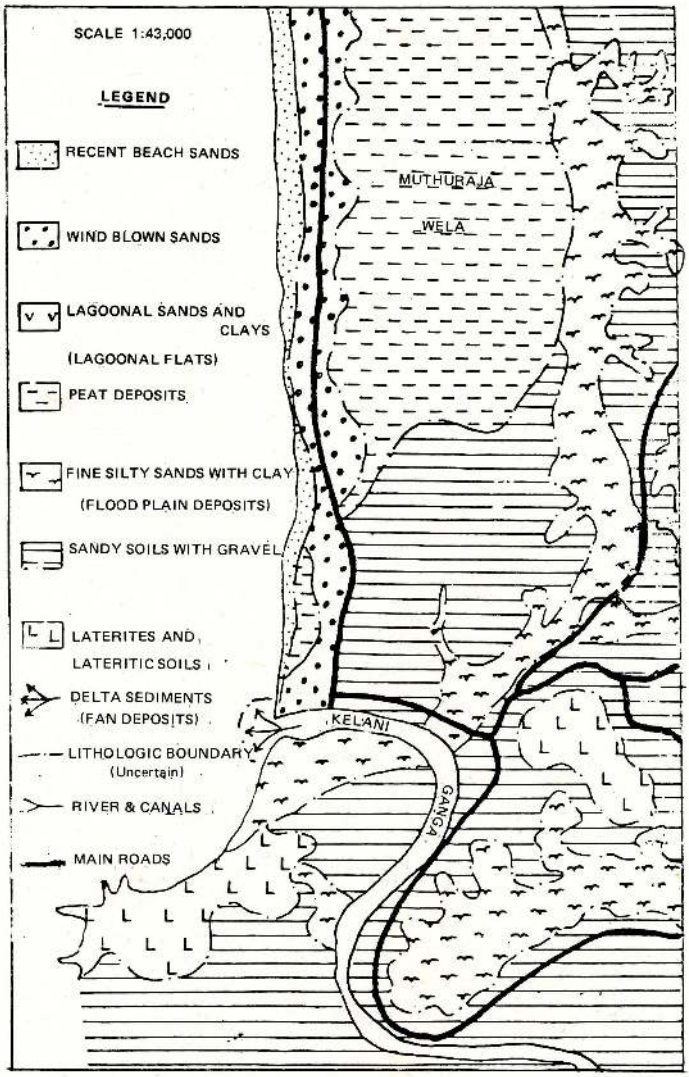

Figure 2. Coastal Features of the Country North of the Kelani River Mouth.

mainly under paddy cultivation and these deposits consist of fine silty sands with clays. The Muthurajawela swamp covers an area of 35 sq km. Marshy vegetation is common in the swamp which is a silted up lagoon, presently a peat deposit. Laterites are well developed in the area examined and they are confined to slightly elevated land with mixed vegetation. The laterites are mainly used as a building material and they are also ideal formations for storage of underground water. Sandy soils with gravel cover areas mainly under coconut cultivation. Fan type deposits of delta sediments are at the mouths of the two major rivers (Kelani and Maha Oya).

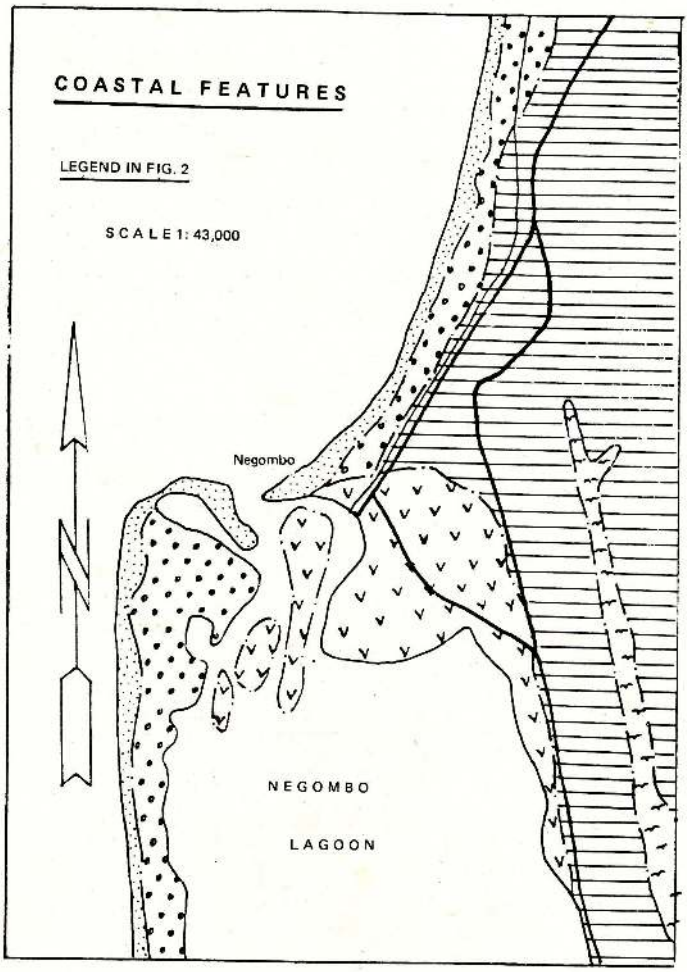

Figure 3. Coastal Features of the Negombo Area.

sideration in the event a decision is taken to mine the deposit. The stability of the developed area (areas of the peat deposits reclaimed by filling) may be affected over the years if the deposit is mined.

5. Geological Resource Potential

The sampling undertaken was from an area between the mouth of the Kelani river (near Crow Island) to about the area immediately north of the mouth of the Maha Oya. Forty nine auger holes were put down and 260 samples were collected. Twelve (12) samples of beachrock (sandstone) were also collected during the survey. The area about 2 kilometers north from the mouth of the Kelani river was examined in detail to gather information on lenses and pockets of ilmenite concentrations which may occur below the surface sands (see Figure 4). Some samples of sands appeared to be almost black in colour and these sands invariably contain very high percentages of ilmenite. The highest concentration of ilmenite occurs on the beach near the mouth of the Kelani river. Analyses of the samples were carried out in the laboratories of the Geological Survey Department. Fifty samples of beach sands were closely examined, 28 samples were analysed to determine the mineral content and 3 samples of beach rock were examined in detail. The sampling area is shown in Figure 1. (Colombo to Negombo).

A current bedded beach rock of recent age forms a conspicuous feature of the coast north of Colombo (Figure 4). It is a coarse to medium grained rock and consists of ilmenite, quartz grains and shell fragments held together by a calcareous cement or ferruginous material.

The ilmenite is arranged in bands, the beach rock then has a banded appearance (Figure 5). The ilmenite content of the rock varies from place to place. At certain points the ilmenite content may so increase that the rock becomes an ilmenite rock with a specific gravity as high as 3.8.

Other minerals present in the sandstone include monazite, zircon, garnet, magnetite and rutile. These minerals which occur in varying amounts are usually present in quantities less than 5 per cent and the monazite content seldom rises above 3 per cent. Similar current bedded beach rocks are exposed on the east coast and are well developed between Batticaloa and Arugam Bay.

Table 3 is presented to show the results of analyses of some samples of beach sands. Most of the minerals present are the heavy minerals resistant to chemical weathering. There is no pattern whatsoever as far as the percentages of minerals are concerned in the mineral assemblages in the beach sands. The character of the deposits vary considerably and the mineral contents vary both with depth and within a few metres along the beach. Figure 4 is presented to show a generalized cross-

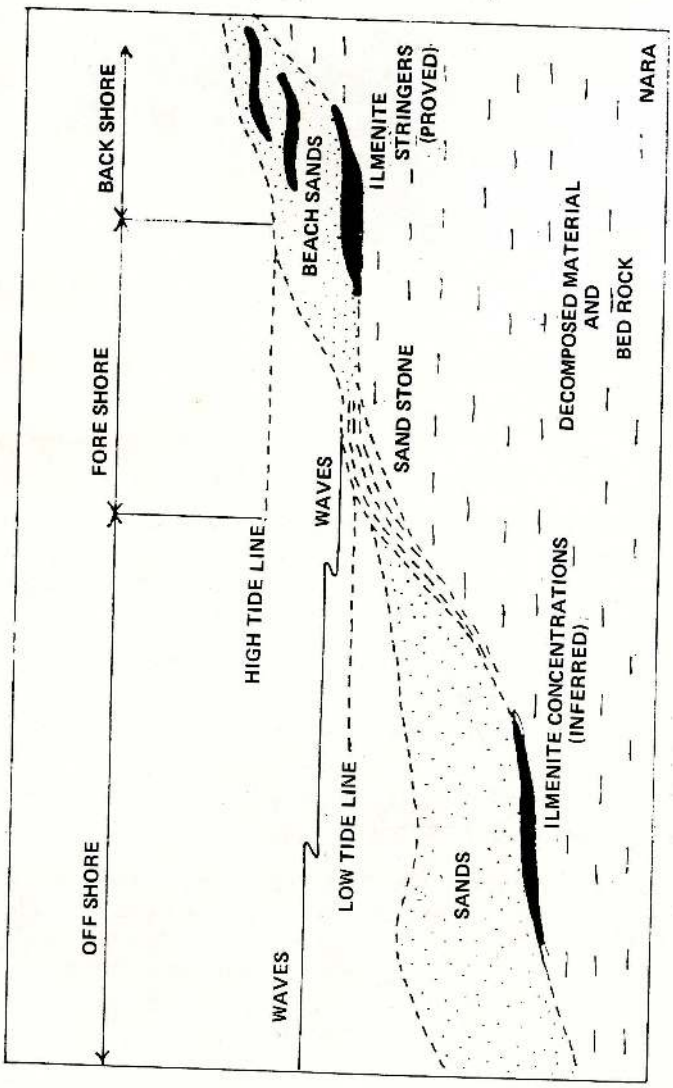

Figure 4. Generalized Cross-section view of the Beach North of the Kelani River Mouth

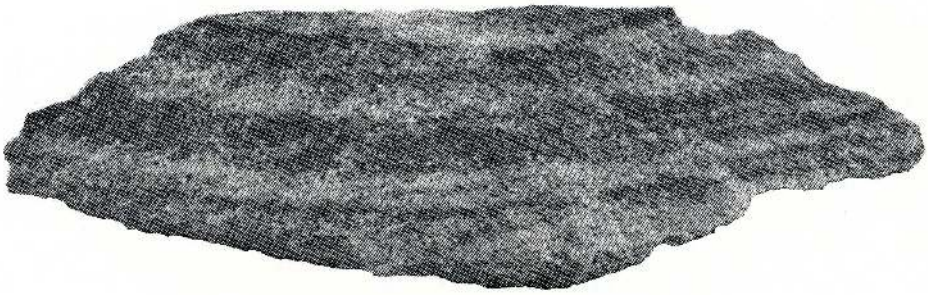

Figure 5. Beach Rock showing Bands of Ilmenite.

sectional view of the beach about 2 kilometers north of the mouth of the Kelani river. There are a series of ilmenite stringers at depth. The jigging action of the waves may have been responsible for concentrating the heavy minerals in certain zones of the beach.

Ilmenite is the main heavy mineral present within the area studied. At some points over 75 per cent ilmenite is present in the beach sands. These concentrations are close to the mouth of the Kelani river (Figure 6). All other minerals occur in negligible amounts and are of no economic value at the moment. At some points along a distance of about 3 km (immediately north of the mouth of the Kelani river) over 25,000 tons of ilmenite could be recovered annually.

According to Wadia and Fernando[5] "the beach for several miles north of the Kelani river is formed of sand rich in ilmenite. Wave action produces a clean concentrate at certain seasons. The concentrate forms most rapidly in the period between the two monsoons. The Kelani black sands contain 2 to 3 per cent of monazite, as much as 14 per cent has been reported on one occasion from the coast near Pamunugama and in the sand bars at the mouth of the Maha Oya, 7 per cent of monazite has been recorded."

The present investigation reveals that ilmenite is the only mineral of economic value which could be recovered from the area investigated.

Table 3. Analyses of some beach sands Kelaniya - Negombo area

	A 1		A 2		A 5		A 7		A 9		A 11		A 13	
	0-40	40-60	0-54	54-107	0-46	46-82	0-40	40-89	0-47	47-72	0-44	44-67	0-51	51-103
Ilmenite	42	14.00	73.00	72.80	78.00	76.00	38.00	61.00	23.00	15.00	5.32	5.66	15.00	43.60
Quartz	44	73.30	12.60	8.23	6.50	6.82	53.50	32.00	76.30	76.96	85.60	84.44	80.60	52.80
Garnet	<5	<5	<4	<3	<5	<5	<3	<4	<2	<3.00	<2	<2	<3	<3
Monazite	4.12	3.10	0.92	2.76	1.64	0.74	—	—	—	3.90	—	—	—	—
Magnetite	1.23	12.00	4.00	5.32	4.34	3.10	0.64	1.54	—	0.22	5.40	5.30	—	—
Zircon	3.00	<5	<5	<6	<2	<3	<3	<2	—	<2	<2	<2	<1	<1
Rutile	—	—	1.38	1.02	1.24	3.00	—	—	—	—	—	—	—	—

	A 15		A 17		A 23		A 28		A 33		A 38		A 47	
	0-56	56-106	0-47	47-65	0-50	50-86	0-40	40-90	0-52	52-100	0-40	40-90	0-40	40-92
Ilmenite	46.64	56.80	65.50	67.50	12.60	14.80	35.80	37.00	42.50	38.00	26.80	32.00	13.25	15.65
Quartz	45.60	33.76	23.16	22.76	81.00	78.60	58.65	53.50	47.65	50.65	64.25	56.50	79.00	77.50
Garnet	<3	<3	<5	<5	<3	<3.00	<2	<2	<5	<5	<3	<3	<5	<5
Monazite	1.76	1.48	3.23	2.72	—	—	1.45	1.80	—	—	2.359	2.85	—	—
Magnetite	0.96	1.16	1.20	1.52	—	—	—	1.45	0.82	1.85	1.23	1.76	0.80	1.20
Zircon	<2	<2	<2	<2	<5	<5	<2	<5	<5	<5	<2	<5	<2	<2
Rutile	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Figure 6. Black Sands (Ilmenite) near Mouth of Kelani River.

6. Importance of the Rational Management of the Coastal Zone

The importance of the marine environment is clearly indicated by the fact that the seas cover 71 per cent of the world's surface. Some two-thirds of the world's population are now considered to live near the coast. The coastal areas and environment are therefore considered to be a resource and wherever possible the coastal zone should be developed according to an overall plan. This has important implications for developing countries in which coastal settlements are still in the process of evolving.

There are distinct advantages in living where land and sea meet and interact in the coastal area. The modern rise of coastal communities in developing countries is linked to the commercial use of the oceans. The sea coast has been recognized as a venue for relaxation and recreation. Many countries today have a highly developed tourist industry. Coastal areas and therefore the sea in general receive ultimately by far the greatest part of man's waste materials. The resulting marine pollution has focussed the attention of nations on this problem.

In the management of the coastal zone, problems cannot be solved by allocating different parts of the coast for different functions. A port loading facility if established without considering coastal winds and currents can result in destruc-

tion of surrounding marine life. Similarly, by ignoring prevailing oceanographic conditions improper siting of a submarine sewage out-fall can result in destruction to marine life and in contamination of beaches. If the sea is allowed to encroach on the land, damage can result sometimes on a considerable scale (see Figure 7). Indiscriminate mining of coral reefs (as in Sri Lanka) barriers which have taken thousands of years to build up may cause severe coastal erosion. Mining activities along coastal areas if not done systematically may also result in coastal erosion. The Vallaichenai lagoon on the east coast is today completely devoid of marine life as a result of effluent from the paper factory being drained into the lagoon. Any development affecting the marine environment and the sea coast, is therefore potentially harmful if considered in isolation and without a proper plan. Integrated surveys are therefore of great value in the management of coastal areas and scientists from various disciplines may have to be consulted when work programmes in the coastal environment are undertaken.

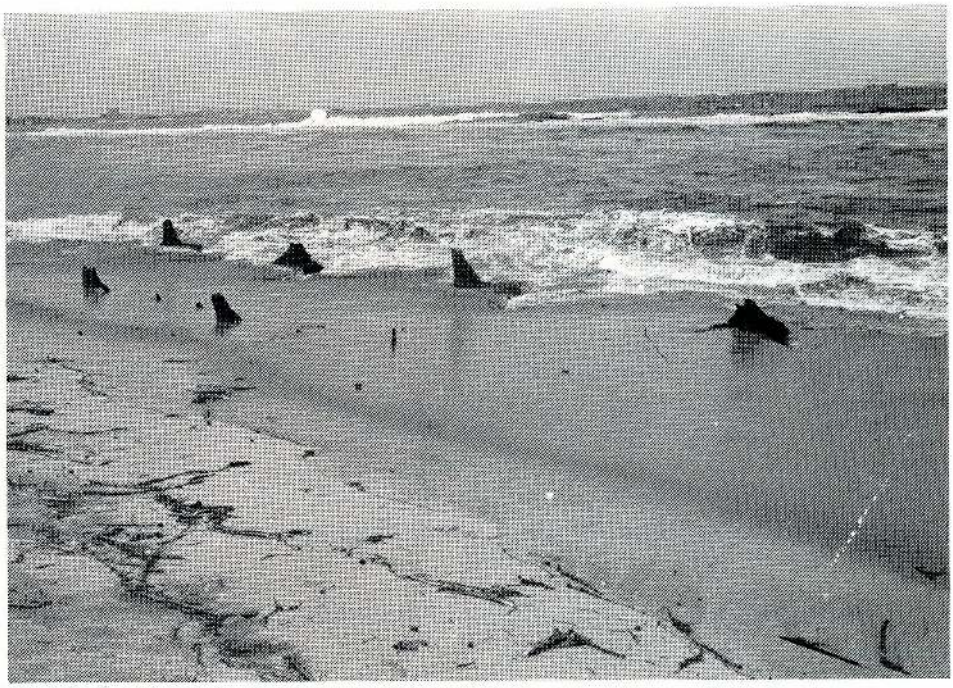

Figure 7. Sea Erosion near Pegasus Reef Hotel.

7. Summary and Conclusions

The potential of the seas is extraordinary and is destined to shape the future of mankind in a very particular way. The coastal areas and the coastal environment are important resources for socio-economic development. With respect to mineral resources the same type of minerals can be expected to be found in beach deposits that are found in placer deposits onshore. A study of the geology and mineralogy of the rocks in the drainage areas of rivers providing sediments for a particular beach will normally indicate whether valuable minerals can be expected to be found in the beach.

It is generally safe to assume that similar deposits of minerals exist in the off-shore areas as in those beaches onshore. The technology of exploring off-shore deposits is already developed in the systems used to sample off-shore sediments for oil. At present Sri Lanka is devoid of capabilities to assess the mineral resources of off-shore areas—the continental shelves and surficial sediments. It is proposed however, to commence as early as possible hydrographic and oceanographic surveys with assistance from a number of foreign organizations. The present surveys of coastal areas would eventually be integrated with the proposed geological and geophysical surveys of off-shore areas. These surveys are to be undertaken by the National Aquatic Resources Agency.

The current investigation has shown that the beach deposits vary widely in character. The mineral ilmenite occurs in appreciable amounts and is the only mineral present which is of economic importance, provided markets are available for the sale of this material. Samples containing over 75 per cent ilmenite have been observed near the mouth of the Kelani river and over 25,000 tons of ilmenite can be recovered from this area each year. The other deposits of interest are the Muthurajawela peat deposits. At present they do not seem to be of any value. Further surveys have to be undertaken to locate areas with good quality peat deposits, after all available reports have been studied. The swamp however, could be developed for purposes of aquaculture. Mention may also be made that extensive alluvial deposits occur along the Kelani river course east of Colombo. Next to these deposits those along the course of the Maha Oya are the most exploited clay deposits of Sri Lanka for the brick and tile industry.

The rational management of the coastal environment includes respect for an enhancement of, the quality of life in the broadest sense. Among the most important activities in the coastal areas, we may mention fishing, aquaculture, prospecting for hydrocarbons, production of mineral raw materials, town planning, recreation, industry, sports and other activities. This variety of activities makes it necessary that they should be co-ordinated and harmonised in a suitable framework so as to avoid discordances between them and the hinterland activities. Surveys of an

integrated nature are therefore of value in the management of coastal areas and scientists from various disciplines may have to be consulted when necessary, where coastal development is concerned.

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Cross breeding trials with Sheep—Effect of dam Factors

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Abstract: The data for this analysis was obtained from the Government livestock farm at Wirawila. The objectives of the study were to determine firstly, the performance of the Wiltshire Horn × Local (WL) sires crossed to Bikaneri (B) and Wiltshire Horn - Local × Bikaneri (WLB) ewes, based on the birth weight, 3-month and 6-month body weights of their cross bred progeny. Secondly, the effect of the breed of ewe, age of ewe, lambs' year of birth and sex of lamb on birth, 3 and 6-month weight was analysed. Two analytical models were used for the purpose. The WL sires combined better with WLB ewes and their cross bred progeny were significantly heavier than the WL × B cross breds at all ages. One model showed that the breed of ewe, lambs' year of birth and sex of lamb had a significant effect on birth, 3 and 6-month body weights. In the other model, breed of ewe was significant only for 3 and 6-month weight while sex of lamb was significant at all ages.

1. Introduction

The improvement of the overall efficiency of mutton production must come by achieving higher reproductive rates among breeding stock and growth rates of lambs and young stock. By the use of selected breeds in cross breeding programs, increased efficiency could be partly achieved. Good management of the breeding and market stock will also help to improve performance and increase profits.

The objectives of the present study were to determine firstly, the performance of Wiltshire Horn - Local (WL) sires crossed to Bikaneri (B) ewes and Wiltshire Horn - Local Bikaneri (WLB) ewes, on the basis of their progeny body weights at birth, 3 months and 6 months. The second part of the study analysed the effects of factors such as breed of ewe, age of ewe, lamb's year of birth and sex of lamb on birth, 3-month and 6-month weights. Two models were assumed for the study, the first using all the lamb weight information during the years 1974 and 1976 (Model 1) and the second using information on the lambs born in 1976 (Model 2).

2. Materials and Methods

The data for this analysis were obtained from the records of the Government livestock farm at Wirawila, during the years 1974 and 1976. The farm is situated in the south east region of Sri Lanka and receives an average annual rainfall of 109 cm and experiences a temperature of 27.2° C. The rainfall is high during the Maha season (October to January) and pasture growth and availability is dependent on the rainfall.

During the years from about 1969 to 1973, a population of Wiltshire Horn × Local sheep was established at Wirawila[2] and from this population, rams were used to sire the ewes in this analysis. Similarly, Wiltshire Horn × Local ewes were also available and these were bred to Bikaneri rams to produce a three breed cross WLB. These females were used for the study. Ewes were bred during July/August of the year by allowing the rams to run with the herds and lambing occurred from November of each year. A ratio of about 1 ram to 12 ewes was maintained.

Local sheep, also called Jaffna sheep which have hair rather than wool, range in colour patterns from black to white, weight approximately 1.9 kg at birth, 6.35 kg at 4 months of age and 18.14 kg at 1 year of age.[1,6] Buvanendran[2] estimated adult body weights for males and females at 23 kg and 18 kg respectively, and gave breed descriptions and body weights for Bikaneri, Wiltshire Horn and their crosses.[2,3]

The data used for the study in model 1 included 260 lambs of B and WLB ewes bred to WL rams. There were 78 lambs out of Bikaneri ewes crossed to WL sires in 1976 of which 51 lambs were from yearling ewes and 27 from 2-year olds. The rest of the sample consisted of 182 WL × WLB lambs in 1976, of which 36 were from yearling ewes, 74 from 2-year old ewes and 72 lambs from yearling ewes in 1974. A part of the same data which included only the year 1976 was used for the analysis in model 2. This study included a total of 188 lambs of which 78 were out of B ewes and 110 out of WLB ewes crossed to WL sires.

The progeny of each cross was numbered, color tagged and maintained in one herd along with their mothers. No twins were used for the present study. All lambs were weaned at 3 months. The sheep were allowed to graze on an established field of *Brachiaria brizantha* during the day and housed in open sheds for the night where limited grazing was available. The availability and nutritive value of the pasture depended entirely on the rainfall and the prevailing farm practices. No concentrates were fed to the lambs. Water was provided for the sheep at noon each day and again in the evenings. The usual farm management practices were followed.

The body weights of the young cross breds were recorded in kg at birth and then at monthly intervals up to 12 months. The body weights used for this analysis were those at birth, 3 months and 6 months.

In model 1, the sources of variation breed of ewe, age of ewe, year of birth were combined (BAY)* along with sex of lamb and their effect on birth, 3-month and 6-month weight was determined. BAY was put in with 4 degrees of freedom while sex was associated with a single degree of freedom. In model 2, the effect of the breed of ewe and sex of lamb on birth, 3-month and 6-month weight for one and two-year old ewes combined for the year 1976 was determined. A least squares program was used to derive least squares means, analysis of variance and simple correlations between the weights at different ages.[9] A F-statistic was used to test the significance in each analysis of variance while a t-statistics tested whether the simple correlations were significantly different from zero.[16]

3. Results and Discussions

The analysis of variance for model 1 in which the variation was partitioned into Breed-Age-Year and sex of lamb is shown in Table 1, and the analysis of variance for model 2 is shown in Table 2.

Table 1. Analysis of variance for Model 1

Source of variation	*df*	*Mean Squares*		
		Birth weight	*3-month weight*	*6-month weight*
BAY	4	7.97**	1261.29**	1701.33**
Sex	1	6.07*	152.34**	850.46**
Residual	254	1.05	15.74	17.41

** $P < 0.01$
* $P < 0.05$

Table 2. Analysis of variance for Model 2

Source of variation	*df*	*Mean Squares*		
		Birth weight	*3-month weight*	*6-month weight*
Breed of ewe	1	2.95	722.60**	1622.36**
Sex	1	6.21**	136.29**	720.12**
Residual	185	1.14	18.50	27.33

** $P < 0.01$
* $P < 0.05$

* Abbreviated for Breed-Age-Year.

The sources of variation BAY had a highly significant effect on lamb birth weight, 3-month and 6-month weight (Table 1). In model 2, breed of ram had no significant effect on birth weight but was significant for weight at 3 and 6 months of age. Daflapurkar[6] reported significant breed of ewe effects for birth weight while, Farid[6] reported significance of this source of variation for birth and weaning weight. The significance of the age of ewe on birth and weaning weight was reported [14] among Corriedale sheep, while Farid[6] recognised the age of ewe as being significant for birth weight only. Chang and Rae[4] reported that the age of ewe accounted for 2.1 per cent of the total variation in weaning weight among Romney Marsh lambs in New Zealand. Significant year of birth effects on birth and weaning have been reported in the literature supporting this analysis.[10,14] Chang and Rae[4] reported that the effect can account for 2.0% of the total variation in weaning weight, among Romney lambs. The sex of lamb was significant for all ages in the present study in models 1 and 2. Similar findings where male lambs were heavier than females have been reported [6, 7,11,12,13] among other sheep breeds.

Least squares means and standard errors for birth, 3-month and 6-month weight, by breed of ewe, age of ewe, lamb's year of birth and sex are shown in Table 3.

Table 3. Least squares means and standard errors for Model 1

Breed of ewe	*Age of ewe*	*Lamb's year of Birth*	*Sex of Lamb*	*n*	*Weight (Kg) ± Se*		
					Birth	*3-month*	*6-month*
B	1	1976	M & F	51	2.96 ± 0.06	11.40 ± 0.25	16.24 ± 0.26
B	2	1976	M & F	27	3.20 ± 0.09	12.76 ± 0.34	19.54 ± 0.36
WLB	1	1976	M & F	36	3.13 ± 0.08	12.88 ± 0.29	18.53 ± 0.31
WLB	2	1976	M & F	74	3.32 ± 0.05	14.46 ± 0.21	21.10 ± 0.22
WLB	1	1974	M & F	72	3.33 ± 0.05	16.77 ± 0.21	22.50 ± 0.22
B & WLB	1 & 2	1974 & 76	M	133	3.27 ± 0.04	14.00 ± 0.16	20.39 ± 0.17
B & WLB	1 & 2	1974 & 76	F	127	3.13 ± 0.04	13.31 ± 0.16	18.77 ± 0.17

M — Male
F — Female

The WL × WLB cross bred which contained approximately 37.5 per cent Wiltshire Horn, 31.5 per cent Local and 25 per cent Bikaneri breeding had higher birth, 3-month and 6-month weights compared with the WL × B cross which was composed of approximately 25% Local and 50% Bikaneri breeding. This trend was observed within each age of ram class during the year 1976. Combining the weights of the lambs born from 1 and 2-year old ewes, in 1976, WL × WLB cross breds were 4.7 per cent, 13.2 per cent and 10.8 per cent heavier than the WL × B cross breds

at birth, 3 months and 6 months of age respectively. The results seem to indicate that the higher weights which were obtained in this analysis may be due to the slight increase in the Wiltshire Horn breeding component among the WL × WLB cross breds. In each cross bred group, lambs from 2-year old ewes were heavier than lambs from 1 year olds, reflecting a strong influence of the age of ewe. The year 1974 was a particularly good year for the WL × WLB cross breds as the body weights of all lambs were higher compared with lambs born in 1976. In fact, the lambs from 1 year old ewes in 1974 were heavier than lambs out of 2-year olds in 1976. Male lambs were heavier than females by about 0.14, 0.69 and 1.62 kg at birth, 3 months and 6 months respectively.

The weights of all cross bred sheep reported in this analysis were higher than for pure bred Bikaneri from the same farm as reported in an earlier paper by Goonewardene.[8] However, the weights of the WL × B and WL × WLB cross breds were lower than for Wiltshire Horn × Bikaneri cross breds from yearling ewes in their study. It could therefore be concluded that an improvement in weight was due to the influence of improved breeds such as the Wiltshire Horn in this program of cross breeding together with some maternal heterosis.

The assumed model 1 did not adequately adjust for year effects as the breeds and ages of rams did not overlap sufficiently across years.

Least squares means for Model 2 are shown in Table 4.

Table 4. Least squares means and standard errors for Model 2

Breed of ewe	*Sex of Lamb*	*n*	*Weight (kg) ± Se*		
			Birth	*3-month*	*6-month*
B	M & F	78	3.04 ± 0.05	11.87 ± 0.22	17.37 ± 0.26
WLB	M & F	110	3.26 ± 0.05	13.94 ± 0.18	20.26 ± 0.22
B & WLB	M	99	3.22 ± 0.05	13.24 ± 0.19	19.72 ± 0.23
B & WLB	F	89	3.09 ± 0.05	12.57 ± 0.20	17.91 ± 0.24

M — Male
F — Female

The results show similar trends to the results of model 1 where the WL × WLB crosses were superior to WL × B cross breds at all ages. This may again be attributed to the advantage gained in having more Wiltshire Horn breeding among cross breds along with some maternal heterosis. Males were heavier than females at all ages; the differences were 0.13, 0.67 and 1.81 kg in favour of males, at birth, 3 months and 6 months of age respectively.

The correlations between weight at different ages obtained from the two models are shown in table 5.

Table 5. Correlations between weights at different ages (Model 1 above diagonal Model 2 below diagonal)

	Birth	*3-month*	*6-month*
Birth	—	0.32**	0.40**
3 months	0.25*	—	0.76**
6 months	0.36**	0.67**	—

**P < 0.01
*P < 0.05

Model 1 used 260 pairs of observations.
Model 2 used 188 pairs of observations.

The correlations between adjacent weights were always positive. The weight at 3 months was a better indicator of the weight at 6 months compared to birth weight. Furthermore, birth weight was not a very good indicator of 3-month weight as the correlations although positive in both models were lower than what was expected. The results of this study correspond with correlation between weights[1,7].

4. Conclusions

The WL sires combined better with WLB ewes than with B ewes as the cross breds were heavier at birth, 3 months and 6 months. The superiority of the cross bred based on progeny performance may be attributed to the higher percentage of Wiltshire Horn breeding. Furthermore, the improvement in lamb weaning weights among the progeny of the WLB ewes may suggest that material heterosis is expressed among the cross bred ewes.

Under field conditions one could therefore advocate the use of cross bred ewes in order to achieve higher lamb weaning weights. The study also showed that the breed of ewe, age of ewe, and sex of lamb had a very significant effect on birth weight 3-month and 6-month weight in model 1. In model 2 however, sex of lamb was significant for all age groups but breed of ewe was significant only for 3 and 6-month weight. Selection for large weaning weights among lambs lead to higher weights at 6 months of age.

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A Route to the Synthesis of Aluminium Sulphate from Local Raw Materials

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Abstract: The annual requirement of aluminium sulphate in Sri Lanka is about 15,000 metric tons and this is totally imported. Since bauxite is not available in Sri Lanka, Dediyawela ball clay containing about 36% Al_2O_3 and lateritic clays containing about 20% Al_2O_3 were used as sources of alumina for the synthesis of aluminium sulphate. Treatment of calcined ball clay with H_2SO_4 results in the formation of aluminium sulphate. The recyclic process of treatment reduced the free acid content in the product. By recrystallisation the excess iron was removed.

1. Introduction

Aluminium sulphate is available in three different forms as anhydrous $Al_2(SO_4)_3$, $Al_2(SO_4)_3 . 14H_2O$ and $Al_2(SO_4)_3 . 18H_2O$.[1] Commercially available aluminium sulphate is $Al_2(SO_4)_3 . 18H_2O$ and it is mainly used in water purification and in the paper industry.

Commercial grade aluminium sulphate is available in two forms.[1]

(a) Iron Free (less than 0.003% Fe_2O_3)

(b) Commercial Grade (0.4% to 0.5% Fe_2O_3)

The annual requirement of aluminium sulphate in Sri Lanka is 15,000 metric tons and this is totally imported.

Bauxite is a mineral mainly consisting of $Al_2O_3.2H_2O$. By treatment of bauxite or China Clay with conc. H_2SO_4 aluminium sulphate is produced.[1,4]

Mineral bauxite is not found in Sri Lanka.[2] Investigations were carried out at the Minerals Technology Section of the CISIR to find out the possibility of using Dediyawela ball clay, kaolin and laterite as a source of alumina (Al_2O_3) for the production of aluminium sulphate.

Dediyawela ball clay is an alumino-silicate type of clay and it contains about 36% Al_2O_3.

Laterite is a weathered clay and it contains about 20% of Al_2O_3.

2. Experimental

2.1 Chemical Analysis of Ball Clay and Laterite

Determinations of SiO_2, Al_2O_3 and Fe_2O_3 of ball clay and laterite were carried out according to standard methods.[3] SiO_2 content was determined by HF treatment.

Al^{+++} and Fe^{+++} contents were determined by spectrophotometry method and the wave lengths of 370 nm and 700 nm, respectively.

2.2 Calcination of Ball Clay and Laterite

Calcination was done using a muffle furnace at different temperatures and periods. The temperature of furnace was measured to an accuracy of $\pm$ 5°K.

2.3 Grinding of Laterite and Ball Clay

A laboratory ball grinder was used for grinding laterite to pass 80 mesh sieve. Powdered ball clay was obtained from Dediyawela ball clay refining plant of the Ceylon Ceramics Corporation.

2.4 Acid Treatment

98% analytical grade sulphuric acid diluted to different strengths was used for treatment of ball clay and laterite.

2.5 Leaching

Slurry obtained from 2.4 was leached at different temperatures for varying periods, using a steam bath and a magnetic stirrer.

2.6 Concentration and Crystallization

Slurry obtained after leaching was filtered under vacuum and the filtrate was concentrated using a steam bath and crystallized by cooling.

2.7 X-ray Analysis of Samples

XRD patterns of the samples were taken by using "JEOL JDX-85" type X-ray Powder Diffractometer.

3. Results and Discussions

3.1 Dediyawela Ball Clay as a Source of Alumina

Dediyawela ball clay is a mixture of mineral kaolinite ($Al_2O_3.2SiO_2.2H_2O$) gibbsite ($Al_2O_3.3H_2O$) and boehmite ($Al_2O_3.H_2O$). The X-ray diffraction pattern of the Dediyawela Ball Clay (Figure 1) shows the presence of small amount of silica ($\propto$ quartz) as impurity. The total alumina (Al_2O_3) content in Dediyawela ball clay is 36% and the chemical composition of the Dediyawela ball clay is given in Table 1.

Table 1. Chemical Composition of Dediyawela ball clay

SiO_2	—	44.19
Al_2O_3	—	36.79
Fe_2O_3	—	0.93
TiO_2	—	1.30
MgO	—	0.62
Loss on Ignition	—	14.90

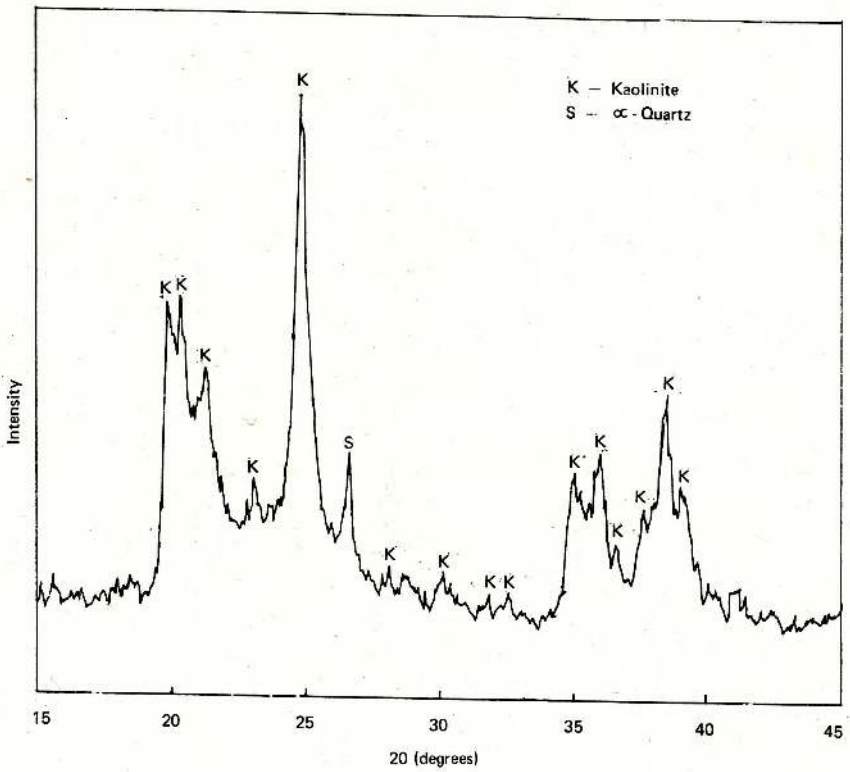

Figure 1. XRD OF BALL CLAY.

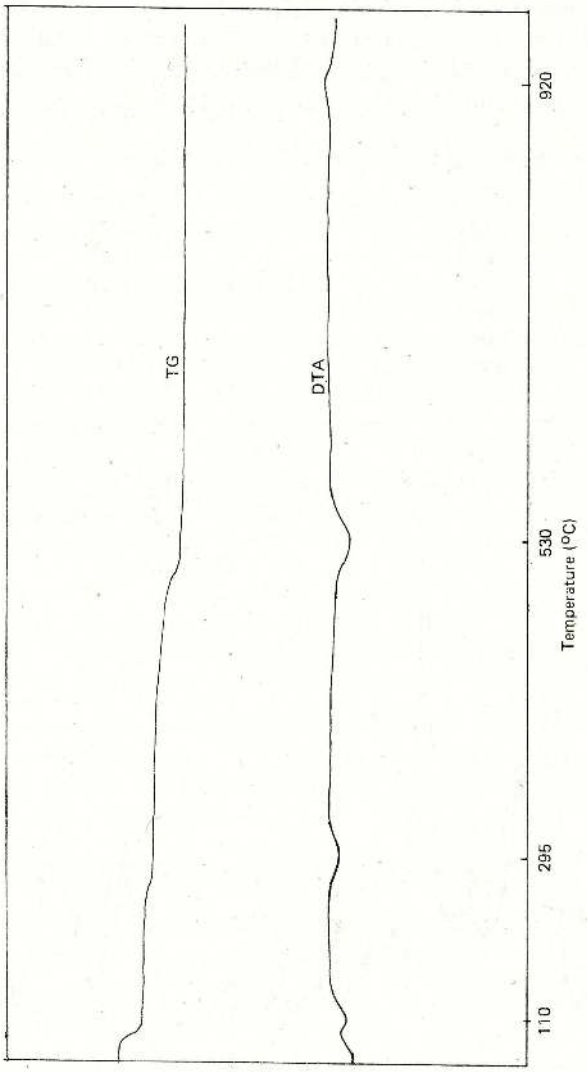

Figure 2. DTA OF BALL CLAY.

Calcination of ball clay at temperatures above 723°K shows the formation of meta-kaolin. The Differential Thermal Analysis curve of ball clay used in this investigation is given in Figure 2. At temperatures above 1198°K formation of silicon spinel ($2Al_2O_3.3SiO_2$) is favoured. The sequence of formation of different types of alumino silicate is given below.[5]

$Al_2Si_2O_8(OH)_4$ —(723° - 823°K)→ $Al_2Si_2O_7 + 2H_2O$ (meta-kaolin)

$Al_2Si_2O_7$ —(1198°K)→ $2Al_2O_3.SiO_2 + SiO_2$ (silicon spinel)

$2Al_2O_3.SiO_2 + SiO_2$ —(1373°K)→ $2(Al_2O_3.SiO_2) + SiO_2$

$2(Al_2O_3.SiO_2) + SiO_2$ —(1673°K)→ $3Al_2O_3.2SiO_2 + SiO_2$ (mullite, cristobalite)

Digestion of ball clay with conc. H_2SO_4 at a temperature of 353°K resulted in only a very low yield of aluminium sulphate. Treatment of calcinated ball clay with the same quantity of conc. H_2SO_4 at 353°K gave a better yield of aluminium sulphate.

This experiment clearly shows that the Al_2O_3 present in ball clay is in bound form and hence the solubility in conc. H_2SO_4 is very low. On calcination, formation of meta-kaolin which is a metastable phase enhances the solubility of Al_2O_3 in conc. H_2SO_4.

3.1.1 Effect of calcination temperature of ball clay on the solubility of Al_2O_3 in conc. H_2SO_4

Known quantities (50 g) of ball clay calcinated at different temperatures for a duration of 2 hours were digested with known quantities (40 ml) of 98% H_2SO_4 diluted to 400 ml with distilled water for a duration of 2 hours at a constant temperature of 338° K. The filtrate was concentrated and crystallized.

The yield of aluminium sulphate obtained from ball clay calcined at different temperatures was determined and variation of yield with temperature is shown in Figure 3. The results clearly show that the most suitable temperature for calcination of ball clay to yield soluble alumina is 1173° K.

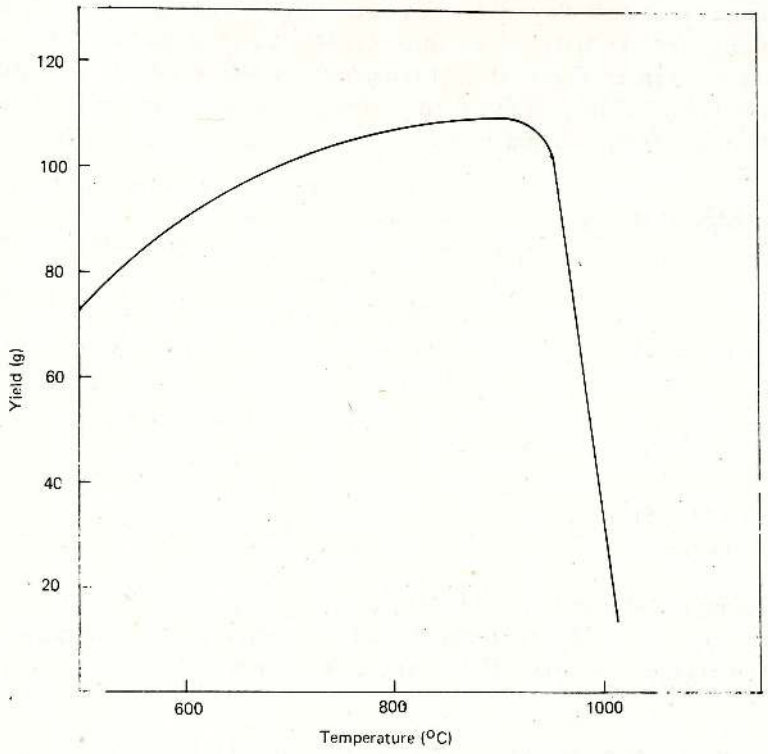

Figure 3. Effect of calcination temperature on the yield of aluminium sulphate.

3.1.2 Effect of duration of calcination of ball clay on the formation of aluminium sulphate

Known quantities (50 g) of ball clay calcined at 1173° K for different durations were digested with 40 ml of 98% H_2SO_4 for a duration of 2 hours. The aluminium sulphate formed was crystallized from the filtrate and the weight was determined. The results are shown in Figure 4. Maximum yield of aluminium sulphate was obtained from the sample calcined for a period of 2 hours.

3.1.3. Minimum quantity of conc. H_2SO_4 necessary for complete leaching of alumina from calcined ball clay

Dediyawela ball clay calcined at different temperatures was used in this investigation. Durations of calcination and leaching were kept constant throughout this investigation. The results obtained are plotted in Figure 5. In all the experiments the

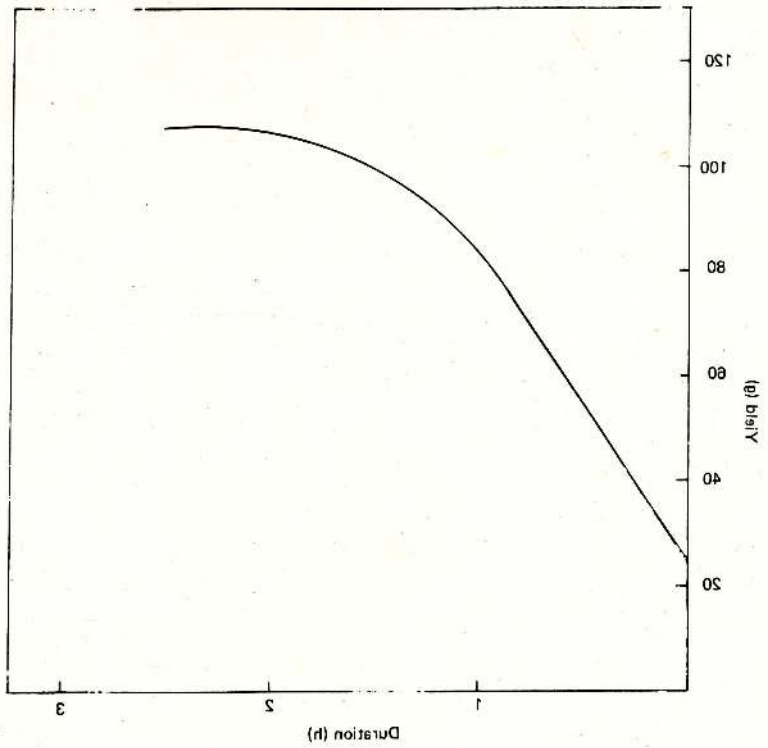

Figure 4. Effect of duration of calcination on the formation of aluminium sulphate.

maximum yield was obtained when ball clay calcined at 1173° K was used. It was also revealed that the quantity of H_2SO_4 used for leaching is also important in getting the maximum yield of aluminium sulphate.

3.1.4 Effect of temperature and duration of leaching on the yield of aluminium sulphate

Dediyawela ball clay calcined at 1173° K was used in this experiment. Leaching of alumina was carried out at two temperature ranges between 338° K and 373° K using 40 ml conc. H_2SO_4 diluted to 400 ml with distilled water for different durations.

The results are shown in Figure 6. Yield of aluminium sulphate obtained increases with temperature of leaching. Complete leaching of alumina was obtained with durations of 2 hours.

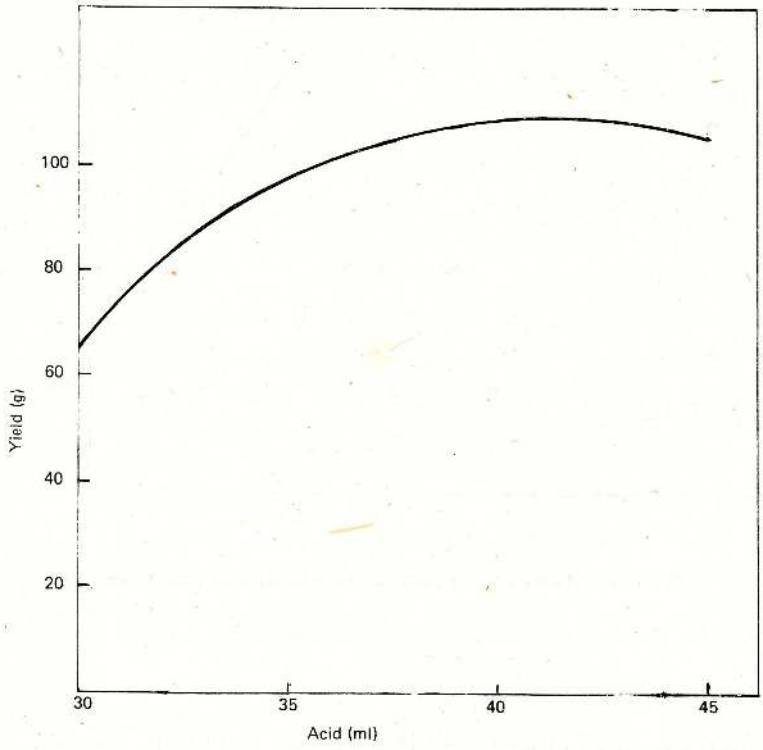

Figure 5. Effect of quantity of Conc H_2SO_4 acid on the yield of aluminium sulphate.

3.2 Laterite type of clay as the starting material

Laterites are extensively developed in the South-West Region of the island. They are mainly kaolinite clay materials with gibbsite, geothite and silica. Most of the laterites are developed *in situ*. In addition there are secondary laterites.

Laterites obtained from Kiribedda and Homagama were used in this investigation. The chemical composition of laterites used are given in Table 2.

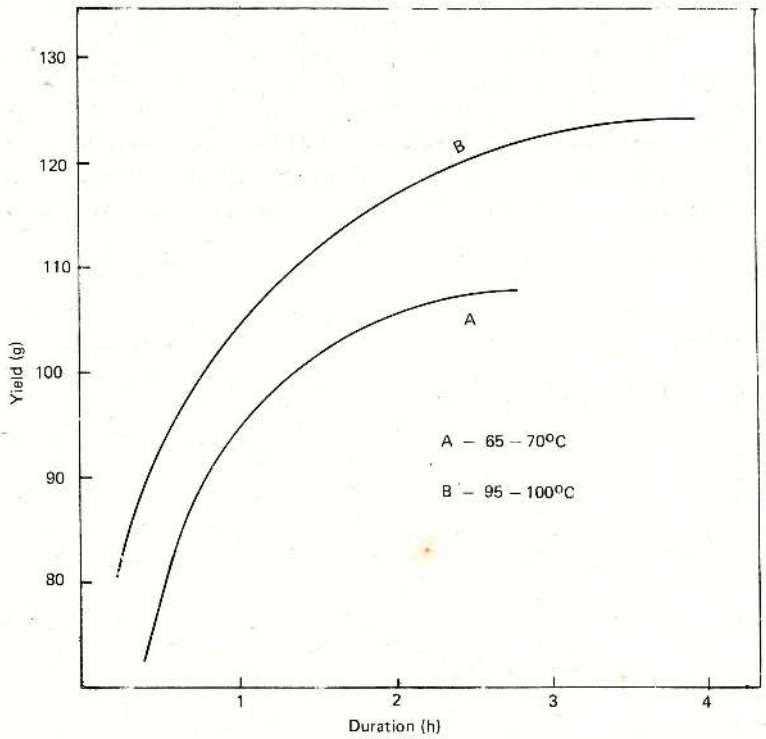

Figure 6. Effect of duration and temperature of treatment on the formation of aluminium sulphate.

Table 2. Chemical composition of laterites

Constituent	*Kiribedda*	*Homagama*
	percent by weight	
SiO_2	59.22	60.82
Al_2O_3	22.23	20.03
Fe_2O_3	14.56	14.15

Quantities of alumina leached using conc. H_2SO_4 were very low compared to the total available alumina in laterite. Therefore calcination of laterite at high temperature is necessary to convert the alumina to an acid soluble form.

3.2.1 Effect of temperature of calcination on the formation of aluminium sulphate

Known weights (1000 g) of laterites calcined at different temperatures were leached using conc. H_2SO_4 and the durations of calcination and leaching were kept constant at 2 hours and 2 hours respectively throughout the experiment. The temperature of leaching was 343° K and the volume of H_2SO_4 added was 40 ml diluted to 400 ml with distilled water. Maximum yield of aluminium sulphate was obtained from the sample of laterite calcined at 1173° K. The results are given in Figure 7.

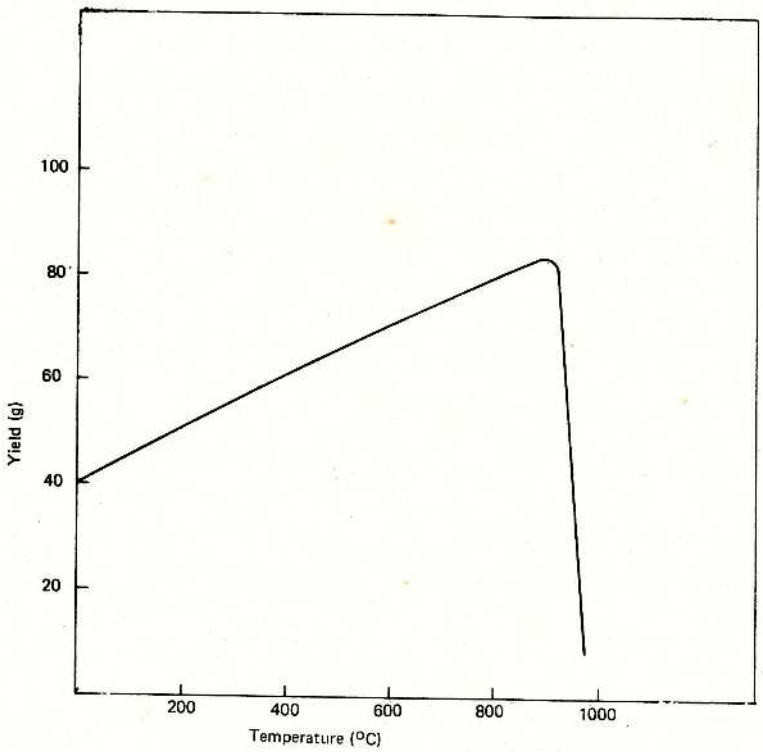

Figure 7. Effect of temperature of calcination on the formation of aluminium sulphate.

3.2.2 Duration of calcination of laterite on the yield of aluminium sulphate

Laterite calcined at 1173° K for durations varying from 1/2 hr to 05 hrs were used in this investigation. The volume of H_2SO_4 added was 40 ml diluted to 400 ml with distilled water.

The results are given in Figure 8. Increase of duration of calcination beyond 2 hours did not increase the yield of aluminium sulphate appreciably.

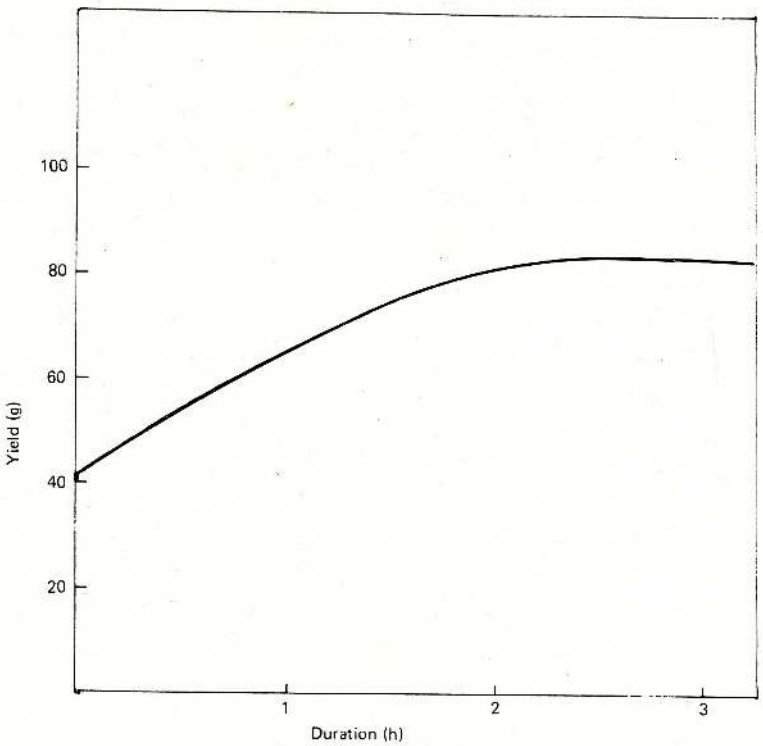

Figure 8. Minimum duration of calcination required for complete conversion of alumina to acid soluble form.

3.2.3 Temperature and duration required for complete leaching of alumina

Laterite calcined at 1173° K was used in this investigation. Temperature of treatment was studied at two ranges between 338° K and 373° K. Duration of treatment was varied between 1 and 10 hours The results are given in Figure 9. At temperature of 373° K in a duration of 7 hours, maximum yield of aluminium sulphate was obtained.

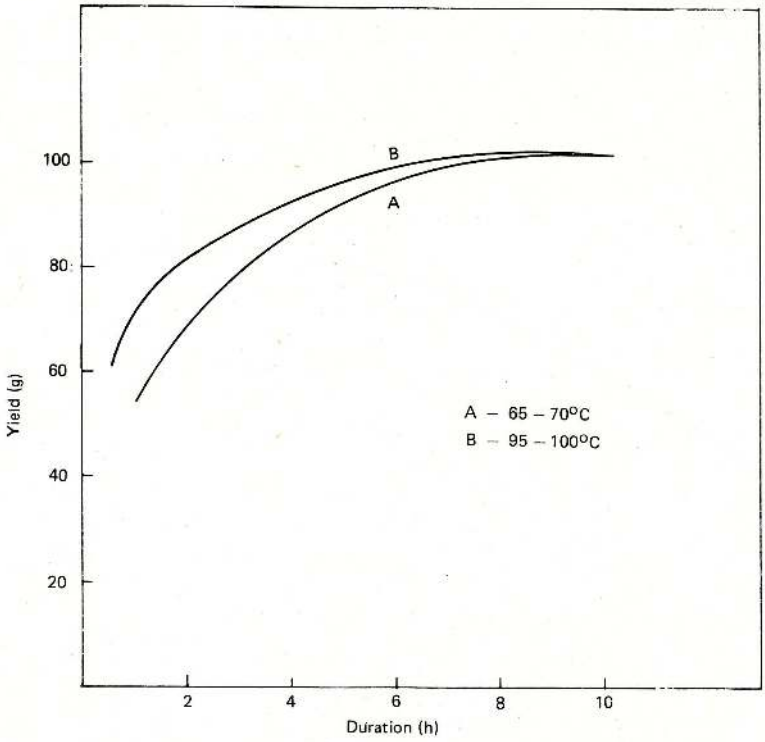

Figure 9. Temperature and Duration required for complete leaching of alumina.

4. Discussion

4.1 Potential of ball clay as the starting material

The experiments carried out clearly show that to get a maximum yield of aluminium sulphate it is necessary to calcine ball clay at 1173° K. Duration of calcination, concentration of H_2SO_4 and temperature and duration of leaching are also important factors which affect the final yield of aluminium sulphate. It is also observed that ball clay calcined at 1173° K for a duration of 2hrs when treated with conc. H_2SO_4 for 2hrs resulted in a conversion of about 73% of alumina present in ball clay to aluminium sulphate.

The X-ray diffraction powder patterns of the commercially available aluminium sulphate and the aluminium sulphate prepared are given in Figure 10. The iron content of the aluminium sulphate prepared ($Al_2(SO_4)_3.18H_2O$) by the process developed is very low (less than 0.4%).

Recycle process of treatment was also tried in order to reduce the free acid in the crystallized aluminium sulphate. The use of excess water in the process of leaching with H_2SO_4 resulted in slow crystallization of aluminium sulphate.

4.2 Potential of laterite as the starting material

The chemical analysis shows the presence of high percentage of Fe_2O_3 which affect the final quality of the product.

To get a maximum yield it is necessary to calcine laterite at 1173° K for a duration of 2 hours.

Leaching also has to be carried out under controlled conditions. About 83% of the alumina present in laterite can be converted into aluminium sulphate. The main impurity observed was iron and by recrystallization the major fraction of iron present in aluminium sulphate was removed as filtrate.

5. Conclusion

Ball clay is one of the main raw materials[3] used in ceramic and rubber industry. The reserves are limited and it is not advisable to use it as the starting material for manufacture of aluminium sulphate, whereas laterites are hardly used as a raw material at present. The disadvantages in using laterites are the low alumina content and high iron content. By carefully selecting laterites of high alumina and low iron content, it may be possible to develop a method for the manufacture of aluminium sulphate. It is necessary to carry out pilot plant scale trials before commencing any large scale manufacturing of aluminium sulphate using laterites as the starting material.

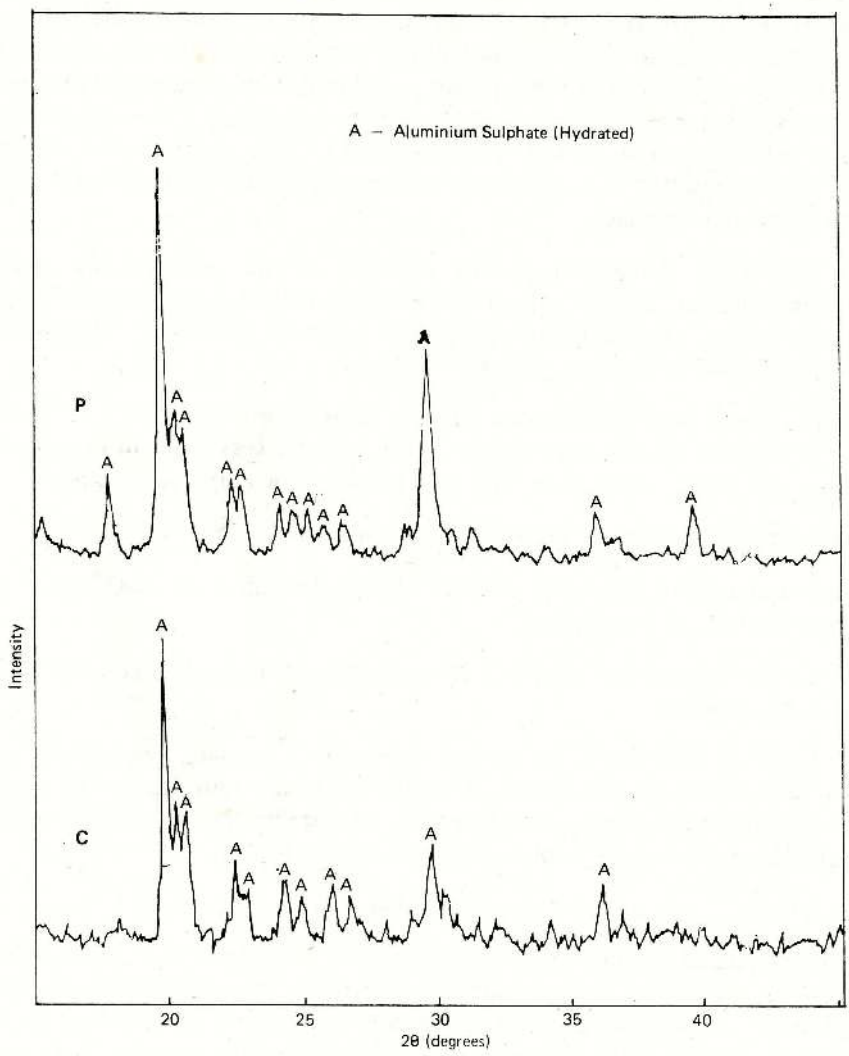

Figure 10. X-ray diffraction patterns of Aluminium Sulphate.

C - Commercial grade Aluminium Sulphate.

P - Prepared Aluminium Sulphate.

Acknowledgement

The authors wishes to thank the staff of the Section of Minerals Technology, CISIR, for their kind help given during carrying out the above work.

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A Quantitative Study of the Direct Use of Kerosene for Lighting in Sri Lanka Households

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Abstract: It is known that over 80% of households in Sri Lanka use kerosene for lighting; but there is no reliable information on the quantity used. The present study which was based on a stratified sample was carried out to obtain quantitative information on kerosene consumption in the household sector. The country was divided into four zones. Households were stratified by zones and by sectors within the zones, and sample households were selected at random in proportion to the number of households in each stratum. In the sample households, kerosene consumption (for lighting) in a 24-hour period was measured and other information collected. The mean *per caput*/day consumption was estimated at 16.8 ± 6.2 ml, 50.9 ± 3.4 ml and 75.2 ± 11.8 ml, and the mean per household/day consumption at 95.3 ± 35.3 ml, 286.5 ± 19.5 ml and 349.0 ± 52.3 ml in the urban, rural and estate sectors respectively. The total consumption for the year was estimated at 264×10^6 litres. The 'bottle lamp' (without a chimney) was the most common type of lamp in use. Half the households in the whole sample and 62.1% in the rural sector were receiving 'kerosene stamps' on which they could obtain kerosene up to a certain value a month free of charge.

1. Introduction

The Sri Lanka census of population and housing carried out in 1981 showed that 82.4% of the houses used kerosene for lighting.[4] This dependence of a large proportion of the population (consisting mainly of the rural poor) on kerosene for providing a basic need prompted the government which has a monopoly over the production and distribution of kerosene to introduce a general price subsidy on this product following the fuel crisis of 1973-74. Hence, although there was a sharp initial price increase in January, 1974, thereafter, while the prices of other petroleum products kept rising steeply, the price of kerosene remained low. This was the position till 1979 when the government reduced the subsidy on kerosene, and the sale price rose from Rs. 3.48 to Rs. 10.68 a gallon.* Simultaneously a "kerosene stamp" scheme was introduced to enable the needy to obtain kerosene for lighting free of charge up to a certain value in a month. After 1979 there have been more price increases, of which the last two were in March and in July, 1983, during the period of this study. The results of these two increases was to raise the price of kerosene from Rs. 17.68 to Rs. 29.97 a gallon. Even with the last increase there continued to be a subsidy though at a much reduced level.

* In June, 1983, 1 US $ = Rs. 23. One gallon = 4.546 litres.

As the price of kerosene in the open market was a subsidised one, there was a general belief that industrialists and others were using kerosene in place of other fuels to benefit by the subsidy. One view was that the proportion so used was small,[6,8] but a World Bank mission was of the opposite view and has stated, "a large proportion of the kerosene consumption (well over half) is in uses for which the subsidy was never intended, as an industrial heating fuel, in standby generators, as a cooking fuel for the better off households, etc."[9] The data on local sales of kerosene published by the Ceylon Petroleum Corporation give the total consumption in the country, but there is no information on the quantity used for lighting; hence the conflicting views on how much of the kerosene is diverted to other uses.

The writer decided to carry out a sample study of kerosene directly used in household lighting with the main objective of estimating the quantity so used. Information was also collected on the types of kerosene lamps used and on whether the sample households were receiving kerosene stamps. This study was combined with one on biomass fuel consumption. The biomass fuel study has been described elsewhere, [10] while the present paper deals with the study on kerosene consumption.

2. Methodology

2.1 Sampling design and procedure

In the biomass fuel study with which the kerosene consumption study was combined three categories of biomass fuel were recognized, and on the basis of predictable variations in the composition of the biomass fuel mix, the country was divided into four zones. This was the first step in a two-stage stratification of the population. The second stage was the division of the population (and the households) in each zone into three sectors, urban, rural and estate, recognized in the national census. This stratification developed for the biomass fuel consumption study was considered acceptable for the kerosene consumption study, and the same sample households were used for both investigations. In fact the data for both studies were collected at the same time when the investigating team visited the sample households.

The four zones into which the country was divided are:

1. **Dry lowlands:** Administrative districts: Hambantota, Amparai, Anuradhapura, Polonnaruwa, Moneragala, Trincomalee, Badulla (1/4), Puttalam (1/4), Mannar, Vavuniya, Jaffna, Batticaloa, Mullativu;

2. **Up-country, Tea:** Administrative districts: Kandy, Matale, Nuwara Eliya, Badulla (3/4);

3. **Coconut:** Administrative districts: Colombo, Kurunegala, Gampaha, Galle, Matara, Puttalam (3/4);

4. **Rubber:** Administrative districts: Kalutara, Ratnapura, Kegalle.

Two of the 24 districts (Badulla and Puttalam) were each divided between two zones, the fraction given against their names denoting the proportion of the households assigned to each zone. Except in these two cases the district boundaries were used to define the boundaries of the zones and each zone therefore does not represent a completely homogeneous unit. A certain amount of overlap was unavoidable; for example, although Zone 4 is predominantly a rubber growing area, there are some tea plantations within it. The zonation is shown in Figure 1.

Stratification of the population and the households into the three sectors, urban, rural and estate was done on the basis of the data provided by the 1981 census.[3,5] The urban sector comprises the areas falling within the limits of municipal councils, urban councils, and town councils. The rural sector consists of village council areas but excludes the areas falling into the estate sector. The estate sector includes crop plantation estates of 8.1 ha (20 acres) or more in area and with 10 or more resident labourers. Since the estate sector populations (as defined in the census report) in the Dry lowland and Coconut Zones are relatively small, and moreover, as the domestic biomass fuel consumption and kerosene consumption patterns in these two strata were not expected to be different from those in the corresponding rural sector strata, the estate sector in each of these zones was combined with that of the corresponding rural sector. The population and the households were, accordingly, divided into ten strata. They are Dry lowlands, urban (1U); Dry lowlands, rural (1R); Upcountry, Tea, urban (2U); Upcountry, Tea rural (2R); Upcountry, Tea, estate (2E); Coconut, urban (3U); Coconut, rural (3R); Rubber, urban (4U); Rubber, rural (4R); and Rubber, estate (4E).

The total sample size was set at around 500 households and the allocation of the sample among the strata was done in proportion to the number of households within each stratum. However, to keep the sampling error down, the minimum sample size for a stratum was set at 10 households. The total sample finally consisted of 518 households.

Within each stratum, the districts and the locations within the districts where the sampling was to be done were chosen randomly. Having decided on a location the team went to the spot and adopted a random procedure to select the households, e.g. the team would proceed along a randomly selected road or pathway and in one case select every third housing unit on the right side and in another pick every fifth dwelling on the left, and so on, thereby simulating a "circular sampling system."

Figure 1. Map showing the four zones.

2.2 Data Collection

The team that collected the data comprised two Staff Assistants (both physical science graduates) and a labourer. The writer accompanied the team in the early stages and occasionally afterwards. Each sample household was visited twice. On the first visit the purpose of the study was explained to the senior householder present. A note was made of whether the house was provided with electricity, and if the household used kerosene lamps either as a supplement to electric lights or as the only source of lighting, the team proceeded to measure the quantity of kerosene available for use in the lamps. The kerosene oil in the lamps was drained into a measuring cylinder into which was also added the kerosene that was usually found in a storage container in the house. The total volume was measured to the nearest 5 ml and the oil was then poured back into the lamps and storage container. The investigating team was instructed that, if they came across any households that used kerosene both for lighting and for cooking, the oil for use in lighting should be measured and stored separately. Instructions were also given that, if any households were using kerosene for generating electricity, the quantity of oil so used was not to be included in this study. In some households there was insufficient kerosene for use during the night of the visit and the householder expected to purchase some before nightfall. In such cases the householder was instructed to keep a careful record of the quantity and the cost of the kerosene purchased. Finally the team instructed the household not to deviate from its usual practice in the use of lamps that night.

The team revisited the household 24 hours later and measured the quantity of kerosene remaining. If any oil was purchased, its volume was determined in millilitres by measuring a quantity equal to that which was purchased, and a further check was made by comparing the quantity with the price paid. From the data collected, the quantity consumed by the lamps during the previous night was obtained. The team also recorded the number and types of lamps used by the household and the number of members present during the previous night. A note was also made of whether the household was receiving kerosene stamps. The field work started in February and was completed in September, 1983.

3. Results

3.1 Kerosene Consumption

The mean *per caput*/day consumption and the mean per household/day consumption of kerosene for lighting in the 10 strata as calculated from the sample data are given in Table 1. Taking the *rural sector only*, the lowest *per caput* and per household values are in the Dry lowlands (1R) and the highest in the Coconut Zone (2R). Tests of significance (t test) indicated that the difference between the mean values of 1R and 2R both for the *per caput* consumption and the per household consump-

tion were highly significant. In the mean *per caput* values, the difference between 2R and 3R and between 2R and 4R were also highly significant. The other differences between the rural sector means were not statistically significant.

Table 1. Data on kerosene consumption for lighting

Stratum	*Per caput consumption*		*Per household consumption*	
	Mean/day in ml	*SE of mean*	*Mean/day in ml*	*SE of mean*
1U	12.8	6.17	92.3	44.35
2U	18.3	11.44	117.5	77.57
3U	17.8	4.43	93.6	22.09
4U	17.6	6.28	90.0	37.32
1R	43.8	3.03	263.6	18.07
2R	66.7	4.84	352.0	27.83
3R	50.4	2.95	274.1	16.70
4R	52.0	3.52	302.7	19.36
2E	77.6	5.76	384.4	25.23
4E	70.5	13.37	278.3	54.01

In all the zones the urban sector mean was very much lower than the corresponding rural and estate sector means. This was expected since many urban households use electricity and not kerosene for lighting. Taking the country as a whole, the *per caput*/day mean consumption values were 16.8±6.2 ml, 50.9±3.4 ml, and 75.2±11.8 ml, and the per household/day means were 95.3±35.3 ml, 286.5±19.5 ml and 349.0±52.3 ml in the urban, rural and estate sectors respectively.

Taking the rural sector which is the dominant sector in terms of both size and total household consumption of kerosene, the sample households were classified according to the number of members present in the household at the time of the study. The mean household consumption was calculated for each class and these values (for the range two to nine members/household) were plotted against household size to indicate the relationship between the mean household consumption and the number of persons comprising the household. The data from the four rural sector strata were plotted separately. The values for households with one member and with over nine members were omitted in plotting the data as the number of households representing these classes was very small.

To determine the function that would suitably express the relationship between household consumption and household size, two functions were tested; these are the equation $y = a + b\,x$ which connotes a linear relationship and the equation $y = \beta\, x^{\infty}$ which connotes a curvilinear relationship. Although it is generally expected that the relationship between household consumption and household size would follow the pattern of the "law of diminishing returns" and hence that Cobb

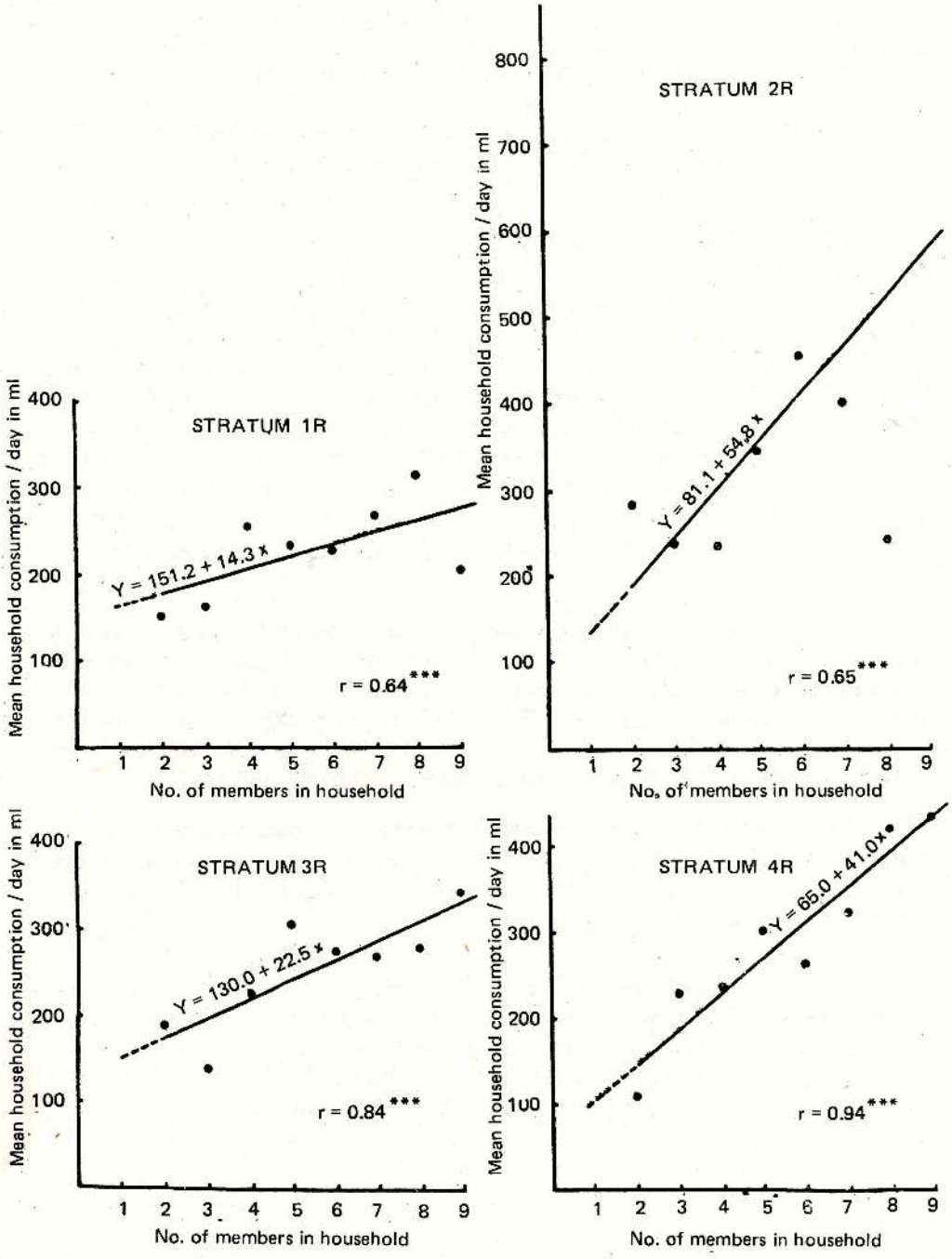

Figure 2. Relationship between mean household consumption and household size in the four rural sector strata.

Douglas' function ($y = \beta x^{\alpha}$) would express the relationship better, it was found in this analysis that in all four cases the goodness of fit of the two functions (as indicated by the coefficients of determination) within the range covered by the graphs did not differ significantly. It was hence decided to fit the simpler linear regression line (Figure 2). The regressions indicate that the per household consumption increases with increase in household size. It was therefore decided, for the rural sector, to avoid using the stratum mean directly for estimating total consumption, and instead, to use the mean consumption per household for each household size as derived from the regression equation.

To compute the total consumption of kerosene it was necessary to estimate the number of households in each stratum in 1983 from the 1981 census data, and this was done by using the average annual growth rates in housing in the period 1971 - 1981 which have been published by the Department of Census and Statistics.[4] The estimated number of households in each of the rural sector strata was then distributed among nine categories, namely, households with 1-member, 2-members, 3-members, and so on up to 9 and more members based on similar data on the distribution of housing units given in the census publication.[4] The figures so obtained were used together with the corresponding mean per household consumption values estimated from the regression equation (the mean consumption of one-member households being obtained by extrapolation) to compute the total consumption in the rural sector.

A housing unit is generally occupied by a single household, but in a very small percentage of cases two or more households occupy a single house. Hence there is some approximation in using the data on housing units for estimating the increase in the number of households from 1981 to 1983 and for distributing the households according to size. This was unavoidable since more direct information on households was not available; but the resulting error is probably negligible.

Table 2 gives the estimated number of households in each rural sector stratum classified according to household size, the estimated mean per household/day consumption (as derived from the regression equation) and the estimated total consumption for the year 1983.

For the urban and estate sectors which are much less important than the rural sector in this study, the mean household consumption and the estimated number of households were used for computing the annual consumption. The results are shown in Table 3. Based on the estimates presented in Tables 2 and 3, the 1983 consumption of kerosene for direct use in lighting in the entire country is reckoned at 264×10^6 litres.

Table 2. Estimated kerosene consumption in the four rural sector strata in 1983

Household size	Stratum 1R			Stratum 2R			Stratum 3R			Stratum 4R		
	Estimated no. of households	Mean consumption/household/day in ml	Estimated total consumption for the year in litres	Estimated no. of households	Mean consumption/household/day in ml	Estimated total consumption for the year in litres	Estimated no. of households	Mean consumption household/day in ml	Estimated total consumption for the year in litres	Estimated no. of households	Mean consumption/household day in ml	Estimated total consumption for the year in litres
1	45892	165.5	2772221.0	21131	135.9	1048171.6	61869	152.5	3443783.2	26525	106.0	1026252.3
2	58078	179.9	3813604.8	26744	190.7	1861529.5	78298	175.0	5001284.8	33569	147.0	1801144.7
3	91632	194.2	6495151.1	42193	245.5	3780809.2	123532	197.5	8905113.1	52961	187.9	3632250.7
4	111208	208.5	8463206.8	51207	300.3	5612773.7	149924	220.0	12038897.2	64276	228.9	5370163.4
5	111638	222.9	9082700.2	51406	355.2	6664685.1	150503	242.5	13321396.8	64524	269.9	6356485.1
6	99267	237.2	8594338.3	45709	410.0	6840351.9	133825	265.0	12944223.1	57374	310.9	6510715.5
7	65898	251.5	6049271.7	30344	464.8	5147920.3	88839	287.5	9322542.6	38088	351.9	4892156.0
8	47604	265.9	4620134.8	21920	519.6	4157215.7	64177	310.0	7261627.6	27514	392.8	3944737.2
9 and over	67481	280.2	6901484.3	31073	574.4	6514640.9	90972	332.5	11040589.4	39003	433.8	6175618.0
Total	698698		56792113.0	321727		41628097.9	941939		83279457.8	403834		39709522.9

Table 3. Estimated kerosene consumption in the urban and estate sector strata in 1983

Stratum	*Mean household consumption in ml*	*Estimated no. of households*	*Estimated total consumption for the year in litres*
1U	92.3	124066	4179721.5
2U	117.5	40094	1719531.4
3U	93.6	330311	11284745.0
4U	90.0	48597	1596411.5
2E	384.4	138473	19428592.7
4E	278.3	44721	4542736.8
Total		726262	42751738.9

This study revealed that in many households which use biomass fuel for cooking, a small quantity of kerosene is used as an ignition fuel to start the kitchen fire in the morning. This could not be measured separately and was included in the quantity recorded as kerosene used for lighting.

3.2 Lighting

In the rural and estate sectors, of the 421 sample households, 404 (96.0%) used only kerosene lamps for lighting, while in the total sample covering all three sectors, of the 518 households, 429 (82.8%) depended entirely on kerosene for lighting.

The naked flame "bottle lamp" was found to be the most common kerosene lamp in use in the households. It consists of a bottle of convenient size or a discarded electric bulb suitably modified, and a wick in a wick-holder. The wick-holder is generally placed loosely on top of the bottle with the wick dipping into the oil in the bottle. There is no chimney. Often, the householder adopts some device to keep the lamp steady and prevent it from being knocked over. This generally consists of either partially filling the bottle with pebbles or sand or placing the bottle in an empty can (Figures 3-6).

The other types of lamps in use were the table type chimney lamp, the suspended chimney-lamp, the hurricane lamp, and the mantle type pressure lamp. The data on the use of bottle lamps and of other types of lamps by the sample households are given in Table 4.

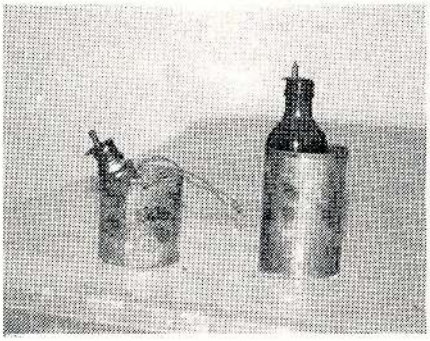

Figure 3. Bottle lamps placed in empty cans to keep them steady.

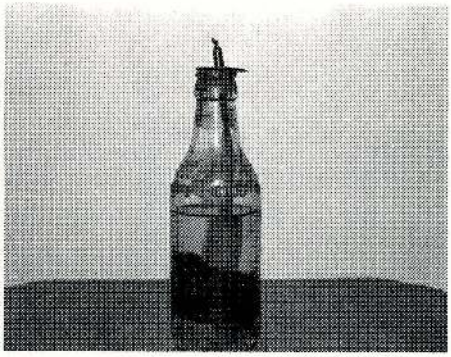

Figure 4. Bottle lamp partially filled with coarse sand.

Figure 5. Three bottle lamps and a table model chimney lamp.

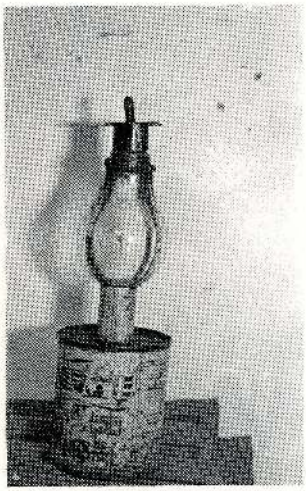

Figure 6. Lamp made out of a discarded electric bulb and fixed on to a stand

Table 4. Use of the "bottle lamp" and other kerosene lamps in the sample households

Stratum	*No. of house-holds in sample*	*Households with bottle lamps only*	*% households with bottle lamps only*	*Households with bottle lamps and other lamps*	*% households with bottle lamps and other lamps*	*Households with other lamps only*	*% households with other lamps only*	*Households with elec-tric lights and bottle lamps*	*% households with elec-tric lights and bottle lamps*	*households with elec-tric lights and other lamps*	*% households with elec-tric lights and other lamps*
1U	20	1	5.0	3	15.0	—	—	1	5.0	—	—
2U	10	1	10.0	1	10.0	—	—	1	10.0	—	—
3U	54	7	13.0	8	14.8	—	—	7	13.0	1	1.9
4U	13	1	7.7	3	23.1	—	—	1	7.7	1	7.7
1R	114	64	56.1	45	39.5	1	0.9	—	—	—	—
2R	52	18	34.6	33	63.5	—	—	—	—	—	—
3R	151	53	35.1	86	57.0	1	0.7	4	2.6	—	—
4R	68	26	38.2	41	60.3	—	—	1	1.5	—	—
2E	24	7	29.2	15	62.5	2	8.3	—	—	—	—
4E	12	6	50.0	6	50.0	—	—	—	—	—	—
Total	518	184	35.5	241	46.5	4	0.8	15	2.9	2	0.4

Seventy two households (not accounted for in Table 4) used only electricity for lighting; one of them used a kerosene-driven generator, two used a 12-volt storage battery connected to low-wattage fluorescent tubes (a system popularised by the National Engineering Research and Development Centre), and the other 69 obtained their electricity from the national power supply. Of the 17 households which used both electricity and kerosene lamps for lighting (included in Table 4), three used a storage battery and the others used the power supply.

3.3 Kerosene Stamps

In the total sample of 518 households, 258 (50%) reported that they were receiving kerosene stamps, while in the rural sector, of the 385 households in the sample 239 (62%) were receiving stamps. The data for all the strata are given in Table 5.

Table 5. Sample households receiving kerosene stamps

Stratum	*No. of households in the sample*	*No.of households receiving kerosene stamps*	*% households receiving kerosene stamps*
1 U	20	3	15.0
2 U	10	—	—
3 U	54	12	22.2
4 U	13	3	23.1
1 R	114	82	71.9
2 R	52	27	51.9
3 R	151	89	58.9
4 R	68	41	60.3
2 E	24	1	4.2
4 E	12	—	—

4. Discussion

Kerosene which is produced at the government-owned Ceylon Petroleum Corporation refinery near Colombo is distributed to depots throughout the country and from there it is supplied to co-operative stores and other retail outlets from where the households obtain their requirements. The co-operative stores supply the kerosene to the consumer either on payment of cash or in exchange for kerosene stamps, and the quantity obtained by the consumer on any visit to the store is very variable; depending on his economic circumstances, a householder may sometimes purchase as little as 100 ml at a time.

According to data published by the Ceylon Petroleum Corporation for the period 1970 to 1980,[1] there were fluctuations in the total quantity of kerosene sold each year; the highest was recorded in 1972 when 278 157 tonnes were consumed and the lowest in 1980 (188 288 tonnes). More recent data available at the Corporation showed that in 1982 the quantity of kerosene sold was 174 090 tonnes and in 1983 (up to October) it was 133 380 tonnes.[2] On a proportionate basis the output for the whole of 1983 would work out to 160 056 tonnes. The present study gives an estimated consumption for 1983 of 264×10^6 litres or 207 400 tonnes* which, surprisingly, is higher than what is expected to be the output figure for 1983.

Fernando *et al* who have made a study of the kerosene consumption pattern in Sri Lanka based on sales data have worked out a series of values which are said to indicate the quantity of kerosene required to meet the essential household needs of the population for each year in the period 1970 - 1980.[6] The quantity for 1980 is estimated at 206 600 tonnes which is higher than the quantity sold in that year. Using the same index and the estimated 1983 population, the quantity of kerosene required to meet the basic needs in 1983 works out to 214 900 tonnes. At present, with the high market price of kerosene, very few households use it for cooking, and the essential household needs may be considered as being almost totally represented by the quantity that is required for lighting.

In the present study half the number of sample households were found to be receiving kerosene stamps - a result which agrees with the national data available in the Department of the Food Commissioner which operates the kerosene stamp scheme.[7] Although kerosene stamps are meant to provide kerosene up to a certain value per month free to a household, in reality there is an opportunity cost attached to the kerosene obtained on stamps as the householder could alternatively take certain types of foodstuffs free instead of the kerosene.† It is therefore possible that in times of financial stress, many households forego the kerosene in favour of foodstuffs and so cause a reduction in kerosene consumption. Such a trend would manifest itself if kerosene consumption in selected households is monitored over a prolonged period of several days or weeks. This may account, in some measure, for the estimate in this study being higher than what is expected to be the supply figure of the Ceylon Petroleum Corporation while yet falling a little short of the hypothetical estimate of the quantity required to supply the essential household needs of the population. It is also possible that the quantity of kerosene actually being marketed in the country exceeds the sales figures given by the Corporation, and if this is so, it would have contributed to the observed discrepancy. Whatever may be the reason for the difference, the magnitude of the estimate of consumption in this study shows that most of the kerosene supplied by the Corporation goes for direct use as household lighting fuel.

* Converted into tonnes using the Corporation's factors: 4.546 litres = 1 gallon; 280 gallons = 1 tonne.

† At the time of writing, the value of a kerosene stamp was Rs. 21.73. Each month the household exchanges a stamp for either kerosene or foodstuffs at the local co-operative store; the store surrenders its collection of kerosene stamps to the Food Commissioner's Department and obtains cash reimbursement up to the amount covered by the stamps.

5. Conclusions

1. This study has shown that most of the kerosene consumed in the country is used for lighting in households and that kerosene consumption for lighting is heaviest (84% of the estimate) in rural areas.

2. The bottle lamp (without chimney) is the most common type of lamp used.

3. In the rural sector more than half (62%) of the households and in the urban sector a much smaller proportion (19%) receive kerosene stamps.

Acknowledgements

The writer wishes to express his thanks to the Natural Resources, Energy and Science Authority of Sri Lanka for having provided the funds and other resources for carrying out this study, to J. A. Chandrasiri and M. A. N. Gunaratne, Staff Assistants, for having carried out the field work and helped in the analysis of the data, and to Valentine Abeywardena, former Biometrician of the Coconut Research Institute, for his help and guidance in the statistical work.

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ලිපිවල සාරාංශ – සිංහල පරිවර්තන

කෘෂිකාර්මික ප්‍රයෝජන සඳහා දිනපතා වර්ෂාපතන දත්ත විශ්ලේෂණය කිරීම.

සවිත්‍රී අබේසේකර, ඊ. කේ. සෙනෙවිරත්න, ඇන් ලික' සහ ආර්. ඩී. ස්ට'න්

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වර්ෂාපතන දත්තයන් පිළිබඳව පරිපූර්ණ විශ්ලේෂණයකින් ශස්‍ය විද්‍යාත්මකව ප්‍රයෝජනවත් ප්‍රතිඵල ලබාගැනීමට නම් එම විශ්ලේෂණය සඳහා දිනපතා මිණුම් භාවිතා කළ යුතු බව මෙම ලිපියෙන් පෙන්නුම් කෙරේ. මෙහි විශ්ලේෂණ ක්‍රම දෙකක් විස්තර කර ඇති අතර ඒවා පැහැදිලි කිරීමට අනුරාධපුර දිස්ත්‍රික්කයේ මරදන්කඩවල ප්‍රදේශයේ වසර 56 ක දිනපතා වර්ෂාපතන වාර්තා ප්‍රයෝජනයට ගෙන ඇත.

ශ්‍රී ලංකාවේ ජලාශයන්හි දක්නට ලැබෙන ඇතැම් හොලොතුරියාවන් තුල අඩංගු ග්ලයිකොසයිඩ් භාගික පිළිබඳ සන්සන්දනාත්මක අධ්‍යයනයක්.

එම්. මහේන්ද්‍රන්, ටී. ඩබ්ලිව්. ඒබ්‍රහම්, එස්. ආර්. ක්‍රිෂ්ණරාජා සහ පද්මිණී ඉලංගනායගම්

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හොලොතුරියාවන් දහයකගෙන් ග්ලයිකොසයිඩ් භාගික වෙන්කර ගෙන ඒවා සන්සන්දනාත්මක පරීක්ෂණයකට භාජනය කරන ලදී. එම විශේෂයන් දහයෙහිම, හොලොතුරින් 'ඒ' අන්තර්ගත විය. Holothuria edulis සහ Havelockia versicolor හැරුණුකොට, සෙසු විශේෂයන් සියල්ලෙහිම හොලොතුරින් 'බී' ද අන්තර්ගත වන බැව් පෙනී ගියේය. පරීක්ෂණයට භාජනය කළ සියළුම විශේෂයන්ගේ ග්ලයිකොසයිඩ් භාගික, අම්ල ජලවිච්ඡේදනයට භාජනය කිරීමෙන්, ප්‍රධාන වශයෙන්ම ජෙනින් සංයෝග දෙකක් (22 — 25 — epoxy — 7, 5(II) holostadien — 3 — 17 — diol සහ එහි ඩිඔක්සි අයිසි ප්‍රතිසමය) ද, සිනි වර්ග හතරක්, එනම් ග්ලූකෝස්, සයිලෝස්, 3 — 0 මෙත්ලි ග්ලූකෝස් සහ ක්විනොවොස් ද, ලැබිණ.

කෙටිකාලීන පරීක්ෂණයන්හිදී ඇතැම් ප්‍රකට කාසිනෝජනකයන් විකෘතිකාරක නොවන සේ පෙනී යාම පිළිබඳ ගැටළුව.

කේ. එච්. අබේවික්‍රම

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ඇතැම් ප්‍රකට කාසිනෝජනකයන් විකෘතිකාරක නොවන සේ පෙනී යන්නේ මක් නිසාද යන්න පැහැදිලි කර ගැනීමට ප්‍රයත්නයක් දරනු ලැබේ. සැබෑ කාසිනෝජනකය වන්නේ, දූනට සැක කරනු ලබන්නා වූ කාසිනෝජනකය නොව, අන්තර් මධ්‍ය ද්‍රව්‍යයක් බව මෙහි දී උපකල්පනය කෙරේ. දූනට හඳුනාගෙන ඇති DNA හානි සහ ප්‍රතිසංස්කරණ විධි ඇසුරින්, කාසිනෝජනක

යන්ගේ ක්‍රියාකාරිත්වය පිළිබඳ ආකෘතියක් සකස් කරගනු ලැබේ. මෙම අන්තර්මධ්‍ය ද්‍රව්‍යය ඇසුරුකොට ගෙන සමීකරණ සකස් කළ විට, එමගින් සුලභව දක්නට ලැබෙන ප්‍රතිචාර රටාවන් පමණක් නොව, ඇතැම් අත්හද බැලීම් වලදී ප්‍රතිචාරය සම්බන්ධයෙන් නිරීක්ෂණය කරන ලද යම් යම් විශේෂතාවන් පවා පැහැදිලි වන බැව් පෙනී යයි. ආකෘතියේ පරාමිතීන්ගේ අනුපාත යන් තක්සේරු කිරීම සඳහා අත්හද බැලීමක් කිරීමෙන්, සැබැවින් ම සිදු වන්නේ මෙම ක්‍රියාවලිය ද යන්න වටහා ගැනීමටත්, ඇතැම්විට කාසිනෝජනනයට හේතු වන හානි වර්ග හඳුනා ගැනීමටත් හැකි වනු ඇත.

කුඩා පරිමාණයේ මෝල් වලින් ලැබෙන පොල්තෙල් වල ඇflප්ලටොක්සින් දූෂණය: දූෂණ මට්ටම් හා එකී මට්ටම් සහ තෙල්වල අන්තර්ගත මුක්ත මේද අම්ල ප්‍රමාණය අතර ඇති සම්බන්ධය.

යූ. සමරජීව, ටී. වී. ගමගේ සහ එස්. එන්. අර්සකුලරත්න

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කඩින් කඩ සැකසුමට භාජනය කරන ලද (අව්වේ වියලූ හෝ දුම් ගැසූ) III වන ශ්‍රේණියේ බාල කොප්පරා මද වලින්, කුඩා පරිමාණයේ මෝල්වලදී, යන්ත්‍රානුසාරයෙන් නිස්සාරණය කරන ලද පොල්තෙල්, එහි අන්තර්ගත මුක්ත මේද අම්ල සහ ඇflප්ලටොක්සින් බී 1 ප්‍රමාණයන් නිර්ණය කිරීම සඳහා විශ්ලේෂණය කරන ලදී. මෙම තෙල් සාම්පල වල, විශාල පරිමාණයේ කාර්මික යන්ත්‍රාගාරවලදී ප්‍රමාණවත් ලෙස සැකසුම් කරන ලද කොප්පරා වලින් නිස්සාරණය කරගත් තෙල් වල වූවාට වඩා සැළකිය යුතු තරම් අධික වූ ඇflප්ලටොක්සින් මට්ටම් (තෙල් නියැදි 115 ක මධ්‍යන්‍ය අගය සිය කෝටියට කොටස් 186) පැවතිණ. මෙසේ ප්‍රමාණවත් නොවන අයුරින් සැකසූ කොප්පරා වලින් ලබාගත් තෙල් සහ සුන්නක්කු ආහාරයට ගැනීමෙන් මිනිසුන් ගේ සහ සතුන්ගේ සෞඛ්‍යයට විය හැකි උපද්‍රවය කෙරෙහි පොල් කර්මාන්ත අංශයෙහි අවධානය යොමු කරවනු ලැබේ.

කුඩා පරිමාණයේ මෝල් වලින් ලබාගත් පොල් තෙල් සාම්පල 100 ක අන්තර්ගත මුක්ත මේද අම්ල ප්‍රමාණය (එෆ්.එෆ්.ඒ.) සහ ඇflප්ලටොක්සින් බී 1 මට්ටම් අතර ඇති සම්බන්ධතාවය පරීක්ෂා කරන ලදුව, එම සාධක දෙක අතර අන්‍යෝන්‍ය සම්බන්ධතාවයක් නොමැති බැව් පෙනී ගියේ ය. පොල්තෙල්වල ''තත්ත්වය'' පිළිබඳ රසායනික දර්ශකයක් ලෙස සම්ප්‍රදායිකව භාවිතා කරනු ලබන, එහි අන්තර්ගත මුක්ත මේද අම්ල ප්‍රමාණයෙන්, එහි ඇflප්ලටොක්සින් දූෂණය පිළිබිඹු නොවෙයි. ඒ නිසා වානිජමය වශයෙන් නිපදවන පොල්තෙල් වල ඇflප්ලටොක්සින් දූෂණය නිර්ණය කිරීම සඳහා වෙනම විශ්ලේෂණයක් කිරීමට සිදු වෙයි. එබඳු තෙල්වල මේද අම්ල සහ ඇflප්ලටොක්සින් මට්ටම් අතර අන්‍යෝන්‍ය සම්බන්ධයක් නොමැතිවීමට හේතු විය හැකි කරුණු ද මෙහි දී සාකච්ඡාවට භාජනය කරනු ලැබේ.

එප්පාවල ඇපටයිට් පිළිබඳ මූලික පරීක්ෂණාගාර අධ්‍යයන II

ඒ. අමරසේකර සහ එම්. ජී. එම්. යූ. ඉස්මයිල්.

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එප්පාවල ඇපටයිට්වල ඇති ෆොස්ෆේට් වලට සෝඩා අළු යෙදීමෙන්, ඒවා සිට්රික් අම්ල යේ ද්‍රාවනය වන ස්වරූපයකට පරිවර්තනය කළ හැකි බව මීන් පෙර පවත්වන ලද පරීක්ෂණයන් ගෙන් හෙලි විය. මෙහි වාර්තාවන අත්හද බැලීම් මාලාවේ දී භාවිතා කරන ලද්දේ එප්පාවල ඇඹරුම් පිරියතින් ලබාගත් ඇපටයිට් ය. මෙම කුඩුකල ඇපටයිට් සෙ. 1400 දී හස්මීකරණය කිරීමෙන් P_2O_5 සිට්රික් අම්ලයේ ද්‍රාව්‍ය වන ස්වභාවයට පූර්ණ වශයෙන් පරිවර්තනය විය. මෙම කුඩුකල ඇපටයිට් නියැදිය, රසායනික සහ ශක්තිඅපකිරණක වර්ණාවලිමාන විශ්ලේෂණයන්ට භාජනය කිරීමෙන්, එහි ප්‍රධාන අපද්‍රව්‍ය වශයෙන්, ඇලුමිනා, යකඩ ඔක්සයිඩ් සහ සිලිකා අන්තර්ගත වන බව පෙනී ගියේ ය. මෙම අපද්‍රව්‍ය ඇපටයිට්වල ඇති P_2O_5 සිට්‍රික් අම්ලයේ ද්‍රාව්‍ය ස්වභාවයට පරිවර්තනය වීමට හිතකර විය. ශුද්ධ ඇපටයිට් වලට, ඇලුමිනා, යකඩ ඔක්සයිඩ් සහ සිලිකා අන්තර්ගත රතු මැටි යෙදීමෙන් P_2O_5 මෙසේ සිට්‍රික් අම්ලයේ ද්‍රාව්‍ය වන ස්වභාවයට පරිවර්තනය කිරීම කෙරෙහි හිතකර බලපෑමක් ඇති විය.

ශ්‍රී ලංකාවේ පොල් නිෂ්පාදනයන්හි ඇෆ්ලටොක්සින් දූෂණය පිළිබඳ සමීක්ෂණයක්: ආපතනය, ප්‍රභවයන් සහ නිර්දේශ.

යූ. සමරජීව සහ එස්.එන්. අර්සකුලරත්න.

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ශ්‍රී ලංකාවේ "පොල් ත්‍රිකෝණයේ" විශාල පරිමාණයේ මෝල් හතලිස් පහක, කොප්පරා, තෙල් සහ පුන්නක්කු ප්‍රධාන කොටගත් නිෂ්පාදන ඇෆ්ලටොක්සින් වලින් දූෂණය වී ඇත්දැයි පිරික්සීම පිණිස එම මෝල් වර්ෂයක කාලයක් තුල අධ්‍යයනයට භාජනය කරන ලදී. අධ්‍යයනයේ අරමුණ වූයේ දූෂණයේ ආපතනය හෙවත් දූෂණය වීමේ අවස්ථා ප්‍රමාණය, දූෂණ මට්ටම්, සහ දූෂණයේ ප්‍රභවය නිර්ණය කිරීමයි.

මේ සඳහා ගන්නා ලද සාම්පල 344 කින් 50% ට ආසන්න ප්‍රමාණයක, ඇෆ්ලටොක්සින් බී 1 මධ්‍යම සහ අධික අතර ප්‍රමාණයන් (ග්‍රෑමයට මයිකෝ ග්‍රෑම් 0.05—1, දශලක්ෂයකට කොටස්) අන්තර්ගත විය. කිසිදු සාම්පලයක දශ ලක්ෂයකට කොටස් 1 ඉක්ම වූ ඇෆ්ලටොක්සින් මට්ටම් නොපැවතිණ. දිලීර ගණාවාසයන් අධිකව පැවති තෝරාගත් කොප්පරා මද 99 ක් අතුරින් 50% ක, දශලක්ෂයකට කොටස් 0.05 සිට 4 දක්වා වූ දූෂණ මට්ටම් පැවතුණ අතර, දශ ලක්ෂයකට කොටස් 10 සිට 20 දක්වා වූ, අධික ඇෆ්ලටොක්සින් මට්ටම් පැවතියේ කොප්පරා මද දෙකක පමණි. කොප්පරා මද වලින් 29% ක ඇෆ්ලටොක්සින් මාත්‍රාවක සිට දශ ලක්ෂයට කොටස් 0.05 දක්වා වූ ප්‍රමාණයක් අන්තර්ගත විය. මේ අතර, මද වලින් 18% ක ඇෆ්ලටොක්සින් නොපැවතිණ. කොප්පරා වලින් තැනූ නිෂ්පාදනයන්හි පැවතියේ, වෙනත් තෙල් ගන්නා ඇට වර්ග පිළිබඳව වාර්තා වූවාට වඩා අඩු දූෂණ මට්ටම් ය. මෙසේ වීමට හේතු සාකච්ඡාවට භාජනය කර ඇත.

සමීක්ෂණය පැවති කාලසීමාව තුල අබණ්ඩව නිෂ්පාදනයෙහි යෙදුණ මෝල් 25 ක, නිෂ්පාදිතයන්ගේ ඇෆ්ලටොක්සින් මට්ටම් ''නිතිපතා අධික'' ''වරින් වර අධික'' ''නිතිපතා මධ්‍යම-අඩු'' සහ ''අඩු හෝ නොර'' යනුවෙන් වර්ග කරන ලදී. මෙම රටාවන් හා වර්ෂා පතනය, කොප්පරා වේලීමේ ක්‍රම, ගබඩා තත්ත්වයන්, කොප්පරා දිගුකල් ගබඩා කර තැබීම, තෙල් නිස්සාරණය සඳහා උසස් තත්ත්වයේ කොප්පරා බාල කොප්පරා සමඟ සම්මිශ්‍රණය කිරීම සහ තත්ව පාලනය නොමැතිවීම යන සාධකයන්ගේ අන්‍යෝන්‍ය සම්බන්ධය පරීක්ෂා කරන ලදී.

ශ්‍රී ලංකාවේ ඇල්ගී ස්ථර සහ පිට වලින් සමන්විත පුරා පරිසරයන් පිළිබඳව ඇති නූ රසායනික සාක්ෂි.

සි. බී. දිසානායක, ඒ. සේනාරත්න, එස්. වී. ආර්. වීරසූරිය සහ ජී. පී. වන්නිගම.

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ශ්‍රී ලංකාවේ එකිනෙකට වෙනස් ඇල්ගී ස්ථර සහ පිට තැන්පතු පුරා පරිසරයන් වෙන් කර දැක්වීම සඳහා, ෆෙන්ද්‍රීය කාබන් අන්තර්ගතය සහිත V/Mn අනුපාතයන් සහ භෞමික පරිසර යක වූ උසස් ශාක පෙන්නුම් කරන C—29 ස්ටෙරෝල් සංයෝගයක් භාවිතා කර ඇත. ප්‍රධාන වශයෙන් ම, සමුද්‍ර, උදම් තැනි, කලපු සහ භෞමික නිෂ්ඨාපන පරිසරයන් රූපරේඛනය කිරීමේදී මෙම රසායනික පරාමිතීන් ප්‍රයෝජනවත් විය.

මහනුවර නගරයේ අලෙවිය සඳහා ඇති ආහාරයන්ගේ සෞඛ්‍යාරක්ෂක තත්ත්වය පිළිබඳ සමීක්ෂණයක්.

වන්දා පී. කොඩිකාර, පී. සිල්වා සහ ඩී. එස්. අතුරලිය

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මහනුවර නගර සභා ප්‍රදේශය තුල අලෙවිය සඳහා නිරාවරණයව තිබූ, අනුභවය සඳහා පිළියෙල කල ආහාර සහ පාන වර්ග 183 ක නියැදි වල සෞඛ්‍යාරක්ෂක තත්ත්වය බැක්ටීරි විද්‍යාත්මක වශයෙන් පරීක්ෂා කරන ලදී. ශ්‍රී ලංකා ප්‍රමිති කාර්යාංශය විසින් පනවා ඇති බැක්ටීරි විද්‍යාත්මක ප්‍රමිතීන්ට අනුකූල වූයේ, පරීක්ෂණයට භාජනය කල අයිස්ක්‍රීම් නියැදි අතුරින් සියයට 19 ක් පමණි. සෙසු අතුරුපස වර්ග (පලතුරු සලාද, දිවුල් කිරි) වල පැවතියේ අයිස් ක්‍රීම් වල වූවාට වඩා අඩු මධ්‍යනය බැක්ටීරියා ගහනයන් (ඊ කොලයි1, අසුචිමය ස්ට්‍රෙප්ටොකොකයි සහ සමස්ථ ජීවය සංඛ්‍යාව) ප්‍රමාණයකි. පලතුරු බීම වර්ග පිළියෙල කරන ස්ථාන අනුව, ඒවායේ අසුචිමය දූෂණ මට්ටම්වල වෙනසක් දක්නට නොලැබිණ. මෙයේ වූයේ එම ආහාර යන්හි අඩු pH අගය හේතුකොට ගෙන ය.

හිමායනය යටතේ සහ අඩු pH අගයන්හි දී ආහාරයක අසුචිමය දූෂණය නිර්ණයේ දී, අසුචිමය ස්ට්‍රෙප්ටොකොකයි බැක්ටීරියාව, ඊ කොලයි 1 වර්ගයේ බැක්ටීරියාවට වඩා හොඳ දර්ශකයක් වන බව පෙනී යයි.

ශ්‍රී ලංකාවේ බොල්ගොඩ II වැවෙහි විල් වීදාහව පිළිබඳ අංශ කීපයක්.

1 සත්ව ප්ලවාංගයන්ගේ සංයුතිය සහ සෘතු අනුව ඇතිවන විවලනතාවයන්.

එස්. විග්නරාජා සහ පී. අමරසිරිවර්ධන.

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ශ්‍රී ලංකාවේ බොල්ගොඩ II. වැවෙහි වෙසෙන Nauplii, Copepoda, Rotifera, Cladocera, සහ Ostracoda යන විවිධ ප්ලවාංග කාණ්ඩයන්ගේ බහුලතාවය, ව්‍යාප්තිය සහ සංයුතිය පිළිබඳව අධ්‍යයනය කරන ලදී. මෙම ප්ලවාංග කාණ්ඩයන්හි සෘතු අනුව ඇතිවන බහුලතාවය කෙරෙහි සහ විවලනතා රටාව කෙරෙහි බලපාන ඇතැම් භෞතික සාධක මෙහි විස්තර කර ඇත. මෝසම් කාලවලදී සත්ව ප්ලවාංග ගහණය බහුලවීමට ප්‍රධාන වශයෙන් ම හේතු වන්නේ සුළඟ සහ වර්ෂාපතනය බැව් මෙම පරීක්ෂණයෙන් හෙලි විය. තවද, වැවෙහි ප්ලවාංගයන්ගෙන් 70% ක් පමණ Nauplii සහ Copepoda වලින් සමන්විත වූ අතර, වැවෙහි ගැඹුර ප්‍රමාණය අනුව ඔවුන්ගේ ගහණීයතාව වෙනස් විය.

යාපනය අර්ධද්වීපයේ තෝරාගත් ඇතැම් ප්‍රදේශයන්හි ළිං ජලයෙහි සහ පසෙහි අන්තර්ගත නයිට්‍රේට් ප්‍රමාණය.

ආර්. මාගේස්වරන් සහ එස්. මහාලිංගම්

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මෙම ලිපියෙන් විස්තර වන්නේ, යාපන අර්ධද්වීපයේ තෝරාගත් ස්ථාන ගණනකින් ලබාගත් පාණීය ජලයෙහි සහ පසෙහි පවතින නයිට්‍රේට් ප්‍රමාණය පිළිබඳව කළ අධ්‍යයනයක ප්‍රතිඵලයි. මේ අතරින් ස්ථාන කීපයකම, ජලයෙහි සහ පසෙහි අන්තර්ගත නයිට්‍රේට්-නයිට්‍රජන් ප්‍රමාණය ලෝක සෞඛ්‍ය සංවිධානය මගින් පාණීය ජලය සඳහා පනවා ඇති ජාත්‍යන්තර ප්‍රමිතියෙහි නියමිත ආරක්ෂාදයි මට්ටම් ඉක්මවන බැව් පෙනී යයි.

ශ්‍රී ලංකාවේ ලැටරයිට් වර්ගයන්ගේ ජනනය සහ සංස්ථිතිය.

ජේ. ඩබ්ලිව්. හේරත් සහ එච්. සී. එන්. සී. පතිරණ.

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මෙම ලිපියෙන් ශ්‍රී ලංකාවේ ලැටරයිට් වර්ගවල ජනනය සහ සංස්ථිතිය පිළිබඳ විස්තරයක් ඉදිරිපත් කෙරේ. දිවයිනෙහි පවතින උණුසුම් දේශගුණය සහ, අතරින් පතර වියලි කාලසීමා වන් ද සහිතව බහුලව ලැබෙන වර්ෂාපතනය, මෙහි ලැටරයිට් සහ ලැටරයිට් පස් වර්ග සෑදීමට හිතකර වෙයි. වෙරළාසන්න ප්‍රදේශ වලින් ද, අභ්‍යන්තර ප්‍රදේශ වලින් ද, ලබාගත් ලැටරිටික ද්‍රව්‍ය මෙම අධ්‍යයනයේ දී පරීක්ෂාවට භාජනය කරන ලදී. මෙම ලැටරයිට් වලින් වැඩි ප්‍රමා

ණයක් සෑදී ඇත්තේ විවිධ වර්ගවල නයිස් පාෂාණයන් ගෙන්, වාකොනයිට් වර්ගවලින් සහ ග්‍රැනයිට් වර්ග වලින් බව මෙහි දී පෙනී ගියේය. එහෙත් පාදක සංකීර්ණය සමන්විතවී ඇති පාෂාණයන්ගේ විෂමජාතීය භාවය නිසා, කිසියම් තනි නියැදියක ප්‍රාකෘතික පාෂාණය හඳුනා ගැනීමට නො හැකි වෙයි. ලැටරිටික ද්‍රව්‍යයන්හි ප්‍රධාන වශයෙන් අන්තර්ගතවන ඇලුමිනීය ලෝහ වර්ග නම්, ට්‍රයිහයිඩ්‍රේට්, ජිබ්සයිට් (AL_2O_3, $3H_2O$) හෝ හයිඩ්‍රජිලයිට්ය. බහුලතම ස්ඵටිකමය ෆෙරික් ඔක්සයිඩ හයිඩ්‍රේට් වර්ගය, ගෝතයිට් (Fe_2O_3, H_2O) ය. සංයුතියෙන් බෝක්සයිට් වර්ග වලට ආසන්න වන ඇලුමිනීය බනිජ වර්ග ඒවායේ විරළ වෙයි. දිවයිනෙහි නිරිතදිග භාගයෙහි ඇතැම් ප්‍රදේශවල යකඩ නිධි සෑදීමට තරම් වූ යකඩ හයිඩ්‍රොක්සයිඩ් (විශේෂයෙන් මඳ වශයෙන් ස්ඵටිකරණය වූ ජියෝතයිට්) ප්‍රමාණයන් අන්තර්ගත කොටගත්, බෙහෙවින් යමුසු ලැටරයිට් කුළුකඳු බහුල වශයෙන් දක්නට ලැබේ. එහෙත් මෙම යමුසු ලැටරයිට් ද ඇතුළු, ශ්‍රී ලංකාවේ ඇති ලැටරයිට් වර්ග, වාණිජමය වැදගත් කමකින් තොර බැව් පෙනී යයි. එනමුත් ඒවා ගොඩනැගිලි ද්‍රව්‍ය (ගඩොල්) වශයෙන් ද, හිරියල් වණ්ණි (විශේෂයෙන්ම මෙරට සමර යනුවෙන් හැඳින්වෙන කහ සායම්) සඳහා ද භාවිතා කරනු ලැබේ. ලැටරයිට් වර්ග වල ඇති බෙහෙවින් සවිවර ස්වභාවය, භූගත ජලය ප්‍රතිආරෝපණය සඳහා බෙහෙවින් හිතකර සාධකයක් වෙයි. ලැටරයිට් වලට යටින් පිහිටි ශෛල ආන්තික මැටි, අභිර්වේධ්‍ය ස්ථරයක් වශයෙන් ක්‍රියා කරමින් ලැටරයිට් තුල භූගත ජලය එක්රැස්වීමට ආධාරක වෙයි.

Cellulomonas වල සයිලනෝලිටික ක්‍රියාකාරිත්වය පිළිබඳ ලාක්ෂණිකරණය.

ඊ. එස්. පීරිස්, පැමෙලා ඒ. ඩී. රිකාඩ් සහ ජේන් එම්. ඩැලී.

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Cellulomonas CS1 -17 වල සයිලනෝලිටික එන්සයිම උපරිම වශයෙන් නිෂ්පාදනය වීමට ස්වායු තත්වයන්, සෙ. 30^0 ක උෂ්ණත්වයක් සහ 6.2 සහ 7.2 අතර pH අගයක් අවශ්‍ය විය. මෙම තත්ව යන් යටතේ, පැය 48 ක් ඇතුලත සයිලනෝලිටික ක්‍රියාකාරිත්වය උපරිම මට්ටම් වලට පත් විය. වර්ධක මාධ්‍යයට තවදුරටත් බණිජ ලවණ සහ යීස්ට් නිස්සාරණ එක්කිරීමෙන් මෙම කාලය පැය 24 දක්වා අඩුවිය.

සයිලනේස් එක් රැස් කර ගැනීමෙන් යටත් පිරිසෙයින් පැය 48 ක් ගත වන තෙක්, 5.4 සහ 8.4 යන pH අගයන්හි දී එය සෙ. 30^0 ක උෂ්ණත්වයක් දක්වා ස්ථාවරව පැවතිණ. එම උෂ්ණත්ව පරාසය තුලදීම β- සයිලොසිඩේස් ස්ථාවරව පැවතියේ මෙම pH පරාසයේ ඉහළ මට්ටමේ දී පමණකි.

වර්ධනය වෙමින් පවතින සෛල මෙන් ම එම සෛල වල රෝපන පෙරණයේ ද සයිලාන් ජලවිච්ඡේදනය කිරීමේ හැකියාව එක හා සමාන විය. එසේ වුවද වර්ධනය වෙමින් පවතින සෛල, ජලවිච්ඡේදිත නිෂ්පාදන පරිවෘත්තියට භාජනය කල අතර එන්සයිම ප්‍රභවය ලෙස රෝපන පෙරණය භාවිතා කල විට එම ද්‍රව්‍යයන් ද්‍රාව්‍ය ඔක්සිහාරක සීනි ලෙස එක් රැස් විය.

කැළණිය—මීගමුව වෙරළබඩ කලාපය සහ එහි විභව භූ විද්‍යාත්මක සම්පත්.

ජේ. ඩබ්ලිව්. හේරත් සහ ඒ. සේනානායක.

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සාගර විද්‍යාවන්ගේ වැදගත් කම වටහා ගනිමින් අභිනව ශ්‍රී ලංකා ජලජ සම්පත් මණ්ඩලය තුල, සාගර විද්‍යාව සහ ඔබවෙරළන ප්‍රදේශ සමීක්ෂණය පිළිබඳ ඒකකයක් පිහිටුවනු ලැබ ඇත. ජලජ සම්පත් මණ්ඩලය මගින් මූලාරම්භක කර ඇති කාර්ය වැඩසටහන් වලට, දිවයිනෙහි වෙරළබඩ ප්‍රදේශය පිළිබඳ සවිස්තර ගවේෂණයද ඇතුලත් වෙයි. මෙය, 1984 මුල් භාගයේ දී ඉටු කිරීමට යෝජිත ජල විද්‍යාත්මක හා සාගර විද්‍යාත්මක සමීක්ෂණ හා ඒකාබද්ධව කෙරෙනු ඇත. මෙම ලිපියෙහි, කැළණිය — මීගමුව අතර වෙරළබඩ කලාපයට සීමාවූ අධ්‍යයනය, එම සමීක්ෂණයේ පළමුවන අදියරයි. මෙම ලිපියෙන් ප්‍රදේශයේ වෙරළබඩ පොදු ලක්ෂණ පිළිබඳවද, එහි විභව භූ විද්‍යාත්මක සම්පත් පිළිබඳවද විස්තරයක් කරනු ලැබේ. වෙරළ ඔස්සේ පිහිටි ස්ථාන කිහිපයක ඉල්මනයිට් සැළකිය යුතු ප්‍රමාණයන් පවතී. ඇතැම් ස්ථානයන්හි වෙරළේ වැලි වලින් ගන්නා ලද නමුත් නියැදිවල. ඉහිජ ඉල්මනයිට් සියයට 6ක් පමණ අධික ප්‍රමාණයක් පවතියි. මුතුරාජවෙල වගුරු බිමෙහි පිට තැන්පතුවක් පිළිබඳවද විස්තර කෙරේ.

වෙරළාසන්න ප්‍රදේශ සහ වෙරළාසන්න පරිසරය, සමාජ ආර්ථික සංවර්ධනය සඳහා වැදගත් සම්පත් වන බැවින්, වෙරළබඩ කලාපය අර්ථාන්විත අයුරින් පාලනය කිරීමේ වැදගත් භාවය ද සාකච්ඡා කර ඇත.

බැටළුවන් මුහුන් කිරීමේ අත්හද බැලීම්—දෙනුන් පිළිබඳ සාධකයන්ගේ බලපෑම්.

එල්. ඒ. ගුණවර්ධන සහ එම්. අගලවත්ත.

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මෙම විශ්ලේෂණය සඳහා අවශ්‍ය දත්ත සපයා ගන්නා ලද්දේ වීරවිල පිහිටි රජයේ සත්ව ගොවිපලෙනි. මෙම අධ්‍යයනයේ අරමුණ වූයේ විල්ට්ෂයර් හෝන් × දේශීය (WL) බැටළුවන්, බිකනරි (B) වර්ගයේ බැටළු දෙනුන් සමඟත්, විල්ට්ෂයර් දේශීය × බිකනරි (WLB) වර්ගයේ බැටළු දෙනුන් සමඟත්, මුහුන් කිරීමෙන් ලත් දෙමුහුන් පැටවුන් උත්පත්තියේ දී, මාස 3 ක දී සහ මාස 6 දී පෙන්නුම් කළ බර අනුව, බැටළුවන්ගේ කරණීයතාව නිර්ණය කිරීමයි. දෙවනුව, බැටළු දෙනුන්ගේ වර්ගය, වයස, බැටළු පැටවුන් උපන් වර්ෂය සහ ගැහැණු පිරිමි බව යන සාධකයන් උත්පත්තියේ දී, මාස 3 දී සහ මාස 6 දී පැටවුන්ගේ බර කෙරෙහි බලපෑ අන්දම විශ්ලේෂණය කරණ ලදී.

මේ සඳහා විශ්ලේෂණ ආකෘති දෙකක් භාවිතා කරන ලදී. WL බැටළුවන් හා WLB බැටළු දෙනුන් ගේ සම්බන්ධය වඩා යහපත් වූ අතර, ඔවුන්ගේ මුහුන් පැටවුන් සෑම වයසකදීම, WL×B මුහුන් පැටවුන්ට වඩා සැළකිය යුතු තරම් බරින් වැඩි විය. බැටළු දෙනගේ වර්ගය, බැටළු පැටවා උපන් වර්ෂය සහ ගැහැණු පිරිමි බව, පැටවා උපතේ දී, මාස 3 දී සහ මාස 6 දී ශරීර බර කෙරෙහි වැදගත් අයුරින් බලපෑ බැව් එක් ආකෘතියකින් පෙන්නුම් කෙරිණ. අනෙක් ආකෘතියෙහි බැටළු දෙනගේ වර්ගය වැදගත් වූයේ මාස 3 දී හා 6 දී පැටවාගේ බර සම්බන්ධ යෙන් පමණකි. මේ අතර, එහි බැටළු පැටවාගේ ගැහැණු පිරිමි බව, සෑම වයසකදීම වැදගත් වූයේ ය.

දේශීය අමු ද්‍රව්‍ය වලින් ඇලුමිනියම් සල්ෆේට් සංශ්ලේෂණයට මගක්.

ජේ. එම්. එස්. ජයතිලක සහ එම්. ජී. එම්. යූ. ඉස්මායිල්

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ශ්‍රී ලංකාවේ වාර්ෂික ඇලුමිනියම් සල්ෆේට් අවශ්‍යතාව, මෙට්රික් ටොන් 15,000 ක් පමණ වන අතර, මෙම මුළු ප්‍රමාණයම ආනයනය කරනු ලබයි. ශ්‍රී ලංකාවේ බෝක්සයිට් නොමැති හෙයින්, ඇලුමිනියම් සල්ෆේට් සංශ්ලේෂණය සඳහා ඇලුමිනා ලබාගැනීමේ ප්‍රභවයන් වශ යෙන්, Al_2O_3 සියයට 36 ක් පමණ අඩංගු වන දෙදියවල බෝල මැටිද, Al_2O_3 සියයට 20 ක් පමණ අඩංගු ලැටරිටික මැටි ද භාවිතා කරන ලදී. හෂ්මීකෘත බෝල මැටි වලට H_2SO_4 අම්ලය යොදා පිළියම් කිරීමෙන් ඇලුමිනියම් සල්ෆේට් සෑදේ. ප්‍රතිවක්‍රීකරණ පිළියම් ක්‍රියාවලියේ දී නිෂ්පාදිතයේ අන්තර්ගත මුක්ත අම්ල ප්‍රමාණය අඩු විය. නැවත ස්ඵටීකීකරණය කිරීමෙන් එහි අතිරික්ත යකඩ ප්‍රමාණය ඉවත් කෙරිණ.

ශ්‍රී ලංකාවේ නිවෙස්වල ආලෝකකරණය සඳහා සෘජු ආකාරයෙන් භූමිතෙල් භාවිතය පිළිබඳ ප්‍රමාණාත්මක අධ්‍යයනයක්.

එල්. සී. ඒ. ද එස්. විජේසිංහ

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ශ්‍රී ලංකාවේ නිවෙස් අතරින් 80% කට වැඩි සංඛ්‍යාවක්, ආලෝකය ලබා ගැනීම සඳහා භූමිතෙල් භාවිතා කරන නමුදු, භාවිතාවන භූමිතෙල් ප්‍රමාණය පිළිබඳ නිශ්චිත තොරතුරු අප සතුව නොමැත. ස්ථරගත නියැදියක් මත පදනම් වූ මෙම අධ්‍යයනය සිදු කරන ලද්දේ ගෘහස්ථ අංශයෙහි භූමිතෙල් පරිභෝජනය පිළිබඳව ප්‍රමාණාත්මක තොරතුරු ලබාගැනීමේ අටියෙනි.

මේ සඳහා රට, කලාප හතරක් වශයෙන් බෙද, එහි නිවෙස්, කලාප අනුවත්, කලාප තුල වූ අංශ අනුවත් ස්ථරගත කරන ලදී. නියැදියේවූ නිවාස සංඛ්‍යාව සසමිහාවි ලෙස තෝරා ගන්නා ලද්දේ එකිනෙක ස්ථරයේ වූ මුළු නිවාස සංඛ්‍යාවට සමානුපාතිකවන පරිද්දෙනි. නියැදි ලෙස තෝරා ගත්තා ලද නිවෙස් වල, පැය 24 ක කාල පරිච්ඡේදයක් තුල වූ භූමිතෙල් පරිභෝජනය (නිවෙස් ආලෝක කිරීම සඳහා) මැන, වෙනත් තොරතුරු ද එක්රැස් කරන ලදී.

නාගරික, ග්‍රාමීය සහ වතු යන අංශයන්හී එක් පුද්ගලයකු වෙනුවෙන් දෛනික මධ්‍යන්‍ය පරිභෝජනය පිළිවෙලින් මී.ලී. 16.8 ± 6.2 මී.ලී. 50.9 ± 3.4 සහ මී.ලී. 75.2 ± 11.8 වශ යෙන් ද, නිවෙසකට දෛනික මධ්‍යන්‍ය පරිභෝජනය පිළිවෙලින් මී.ලී. 95.3 ± 35.3, මී.ලී. 286.5 ± 19.5, සහ මී.ලී. 349.0 ± 52.3 වශයෙන් ද තක්සේරු කරන ලදී. වර්ෂය සඳහා මුළු පරිභෝජනය ලීටර් 264×10^6 විය.

වඩාත්ම සුලභ වශයෙන් නිවෙස් වල භාවිතා වනු දක්නට ලැබුණේ විමිනිය රහිත කුප්පි ලාම්පුවයි.

සම්පූර්ණ නියැදියට ගැණුනු නිවෙස්වලින් අඩකටත්, ග්‍රාමීය අංශයේ නිවෙස් වලින් 62.1% ටත් මසකට එක්තරා වටිනාකමක භූමිතෙල් ප්‍රමාණයක් නොමිලයේ ලබා ගැනීමේ හැකියාව ලබා දෙන "භූමිතෙල් මුද්දර" හිමි වී තිබිණ.

J. Natn. Sci. Coun. Sri Lanka 1983 **11** (2): 373–382

இந்த இதழின் கட்டுரைகளின் சுருக்கங்கள்

அன்ருட மழைவீழ்ச்சித் தரவுகள் கமத் தொழிலுக்கு உதவுமாறுபற்றிய பகுப்பாய்வு

சாவித்திரி அபேசேகரா, ஈ. கே. செனெவிரத்தினே,
ஆன் லீக்கர், ஆர். டீ. ஸ்ரன்.

J. Natn. Sci Coun. Sri Lanka 1983 **11** (2): 165–183

பயன்கூர் நிலப்பயிரியல் பெறுபேறுகளைக் கொண்டியலும் முழுதும் அளாவிய மழைவீழ்ச்சித் தரவுகளைப் பெறவேண்டுமாயின் நாளாந்த அடிப்படையில் அமைந்த அளவிடல் முறையொன்று இருக்க வேண்டுமென்பது சான்று காட்டி விளக்கப்பட்டுள்ளது. அனுராதபுர மாவட்டத்து மரதங்கடவளை என்னுமிடத்தில் 56 ஆண்டுகள்வரை சேகரிக்கப்பெற்ற அன்ருட மழைவீழ்ச்சித் தரவுகளின் உதவியைக்கொண்டு இரண்டு பகுப்பாய்வு முறைகள் முன்வைக்கப்பட்டுள்ளன.

இலங்கை நீர்நிலைகளில் காணப்படுகின்ற சில ஓலோதூரியன்களில் உள்ள கிளைக்கோசைட்டுப் பகுதிகள்பற்றிய ஒப்பியல் ஆய்வு.

எம். மகேந்திரன், ரீ. டபிள்யூ. ஆப்பிரகாம்,
எஸ். ஆர். கிருஷ்ணராசா, பத்மினி இலங்கநாயகம்.

J. Natn. Sci. Coun. Sri Lanka 1983 **11** (2): 185–190

பத்து ஓலோதூரியன்களினின்று (கடலட்டைகளினின்று) வேருக்கப் பெற்ற கிளைக்கோசைட்டுப் பகுதிகள் ஒப்பியல் சோதனைக்கு உட்படுத்தப்பட்டன. எல்லாப் பத்து இனங்களிலும் ஓலோதூரின் A அடங்கியிருந்தது. ஓலோதூரியா ஏதுலிஸ், *(Holothuria edulis)* அவ்லோகியா வேர்சிகுலோர் *(Havelochia versicolor)* ஆகிய ஈர் இனங்கள் நீங்கலாக, ஏனைய இனங்களில் ஓலோதூரின் B இருப்பது காணப்பட்டது. சோதனைக்குட்பட்ட எல்லா இனங்களினதும் கிளைக்கோசைட்டுப் பகுதிகள் அமிலநீர்ப்பகுப்புக்கு உள்ளாக்கப்பட்டபோது, இரண்டு பிரதான சாதிகளும் *(22, 25* — epoxy — *7, 9 (ii)* ஓலோத்தாதியன். *3-17-* idol உம் அதன் ஒட்சியகற்றியொப்பியும்) குளுகோசு இக்சிலோசு, *3-0-* மெதில் குளுகோசு, குயினேசு ஆகிய நான்கு சீனிப் பொருள்களும் பெறப்பட முடிந்தன.

சில காசினேசன்கள் குறுந் தவணைச் சோதனைகளின்போது மியுற்ருசன்களாகக் காட்சி அளிக்க ஏன் தவறுகின்றன?

கே. எச். அபேவிக்கிரமா.

J. Natn. Sci. Coun. Sri Lanka 1983 **11** (2): 191–202

இது சில காசினேசன்கள் மியுற்ருசன்களாகக் காட்சியளிக்க ஏன் தவறுகின்றன வென்பதற்கு விடை தேடும் ஒரு முயற்சியாகும். இதுவரை ஐயுறப்பெற்ற காசினேசன், உண்மையான காசினேசன் எனக் கொள்ளமுடியாதெனவும் அது இவ்விரண்டிற்கும் இடைப்பட்ட ஒரு பொருளாக இருக்கவேண்டுமெனவும் கருத்துக் தெரிவிக்கப்படுகிறது. இற்றைய நாள்வரை அறிந்த DNA சிதைவுச் செப்ப முறல் உருவங்களைப் பயன்படுத்திக்கொண்டு காசினேசன் நுண்செயல் ஒழுங்குக் குரிய மாதிரியுருவொன்று அமைக்கப்பட்டுள்ளது. இவ்விடைநிலைப் பொருளின் ஊடாகக் காசினேசன் தூண்டப்பேற்றுக்கான சமன்பாடுகளைப் பெற்றபோது, பொதுவாக அவதானிக்கப்படுகின்ற தூண்டப்பேற்றுப் பாங்குகள் இருக்கின்றன வென்பது மட்டுமன்றி வேறு சில பரிசோதனைகளின்போது அவதானிக்கப்பெற் றுள்ள ஏனைய சிறப்புக்கூறுகளும் உளவென்பதும் அச்சமன்பாடுகளின் வழிப் புலனையது. இம்மாதிரியுருவின் பரமான விகிதாசாரத்தை மதிப்பிடற்குரிய பரி சோதனையின் மூலம் உண்மையில் ஏற்படுகின்ற செயல் ஒழுங்கு இதுதானெவென அறிய முடியும். அத்துடன் காசினேமாவை உண்டுபண்ணும் சேதத்தின் தன்மை யும் கண்டுபிடிக்கப்படலாம்.

சிறு பரிமாண ஆலைகளில் உற்பத்தியாகும் தேங்காய் எண்ணெய், அவ்லாதொட்சின் கலக்கமுற்று மாசுபடல்; நச்சுமட்டங்களும் சுயாதீனக் கொழுப்பு அமில உள்ளடக்கத்துடன் அவை கொண்டாடும் உறவும்.

யூ. சமரஜீவா, ரீ. வீ. கமகே,
எஸ். என். அரசகுலரத்தினை.

J. Natn. Sci. Coun. Sri Lanka 1983 **11** (2): 203–210

வெயில் உலர்ப் பதனிடப்பெற்ற அல்லது புகையுலர்ப் பதனிடப்பெற்ற III ஆந் தர அல்லது தரங் குறைவான கொப்பரைவைப் பயன்படுத்திச் சிறு பரிமாண ஆலை களில் உற்பத்தியாகும் தேங்காய் எண்ணெயில் சுயாதீனக் கொழுப்பு அமிலம், அவ்லாதொட்சின் BI ஆகியவற்றின் உளதாந்தன்மை அறிதற் பொருட்டுப் பரீட்சையொன்று மேற்கொள்ளப்பட்டது. பெரும் பரிமாணக் கைத்தொழில் ஆலைகளில் செம்மையாகப் பதனிடப்பெற்ற கொப்பரைவிலிருந்து பெறப்பட்ட எண்ணெய் மாதிரிகளில் உள்ள அவ்லாதொட்சின் BI (இப்பரீட்சைக்கு எடுக்கப் பட்ட *115* தேங்காய் எண்ணெய் மாதிரிகளின் இடைப் பெறுமானம் *186* ppb ஆகும்) அளவுகளைவிட அதிக அளவுகள் சிறு பரிமாண ஆலைகளிலிருந்து பெறப் பட்ட எண்ணெய் மாதிரிகளில் இருந்தன. செம்மையாகப் பதனிடப் பெறுத

கொப்பரைவைக் கொண்டு உற்பத்தியான தேங்காய் எண்ணெயையும் புண்ணாகை யும் உட்கொள்ளும் மக்களுக்கும் கால்நடைகளுக்கும் ஏற்படக்கூடிய இச்சுகாதார இடையூறு பற்றித் தேங்காய்க் கைத்தொழிலில் ஈடுபட்டவர்கட்கு எச்சரிக்கை விடப்படுகிறது.

சிறு பரிமாண ஆலைகளில் உற்பத்தியான 100 தேங்காய் எண்ணெய் மாதிரி களில் உள்ள சுயாதீனக் கொழுப்பு அமில உள்ளடக்கமும் அவ்லாதொட்சின் B7 உம் ஒன்றேடொன்று தொடர்பு கொண்டனவாவென்பதும் நுனித்து ஆரா யப்பட்டது. இணைபு எதுவும் கண்டுபிடிக்கப்படவில்லை. தேங்காய் எண்ணெயின் 'தர'த்தை எடுத்துக் காட்டும் ஓர் இரசாயனச் சுட்டியாக சு. கொ. அ. உள்ளடக் கம் (FFA) பல காலமாகப் பயன்படுத்தப்பெற்று வந்ததெனினும் அது எவ்வளவு அவ்லாதொட்சின் கலக்கமுற்றுள்ளதென்பதை உய்த்துணர உதவ மாட்டாது. ஆதலால் அவ்லாதொட்சின் மாசுபாட்டை அறிதற்கு வர்த்தகர்களால் புறம் பான சோதனைகள் மேற்கொள்ளப்படல் வேண்டும். அத்தகு எண்ணெய்களில் உள்ள சு.கொ. அமிலத்துக்கும் அவ்லாதொட்சின் மட்டங்களுக்கும் இடையில் ஓர் இணைபு இன்மைக்கான காரணங்கள் ஆராயப்படுகின்றன.

எப்பாவலை அப்பறைற்று பற்றிய ஆய்வுகூட ஆரம்பப் பரிசோதனைகள் II

ஜே. அமரசேகரா, எம். ஜி. எம். யூ. இஸ்மாயில்.

J. Natn. Sci. Coun. Sri Lanka 1983 **11** (2): 211–224

முன்னர் மேற்கொள்ளப்பெற்ற நுண்ணுய்வுகளின்படி எப்பாவலை அப்பறைற்றி லுள்ள பொசுபேட்டினைச் சோடாச் சாம்பலுடன் தொழிற்படவிடலின் மூலம் கரையுந்தகவுடைய சிற்றிக்கமிலமாக மாற்றமடையச் செய்யலாமெனக் கண்ட றியப்பட்டுள்ளது. இப்பொழுது மேற்கொண்டுள்ள பரிசோதனைத் தொடருக்கு எப்பாவலை அரைத்தற் பொறித்தொகுதியிலிருந்து பெறப்பட்ட அப்பறைற்று பயன்படுத்தப்பட்டுள்ளது. தூள் வடிவத்திலுள்ள இந்த அப்பறைற்று 1400° C வெப்ப நிலையில் நீற்றல் செய்யப்பெற்றதையடுத்து P_2O_5 இன் முற்றுன மாற்றம் என்ற வகையில் கரையுந்தகவுடைய சிற்றிக்கமில உருவம்பெறல் ஆயிற்று. அப்பறைற்றுத் தூள் மாதிரிகளின் இரசாயனப் பகுப்பு வழியாகவும் சக்திக் கலவு நிறமாலைமானிப் பகுப்பு வழியாகவும் கிடைத்த பெறுபேறுகளின்வண்ணம் அலு மினியம், இரும்பு ஒட்சைட்டு, சிலிக்கா ஆகியவை பிரதான மாசுகளாக அப் பறைற்றில் கலக்கமுற்றுள்ளனவென்பது புலனுகியது. இம்மாசுப் பொருள்கள் அப்பறைற்றிலுள்ள P_2O_5 கரையுந்தகவுடைய சிற்றிக்கமில உருவமாக மாற்றம் பெற ஆதரவாக இருந்தன. அலுமினியம், இரும்பு ஒட்சைட்டு, சிலிக்கா என்பன அடங்கப்பெற்ற செங்களிமண்ணுடன் தூய அப்பறைற்று தொழிற்படவிடலுக்குப் பின்னர் P_2O_5 கரையுந்தகவுடைய சிற்றிக்கமில உருவமாக மாற்றம் பெற முடியுமென்பதும் அறியப்பட்டது.

இலங்கைத் தெங்கு உற்பத்திகளின் அவ்லாதொட்சின் மாசுபடல் அளவாய்வு: நேர்வு, காரணம், சிபாரிசுகள்.

யூ. சமரஜீவ, எஸ். என். அரசகுலரத்தினே.

J. Natn. Sci. Coun. Sri Lanka 1983 **11** (2): 225–235

இலங்கையில் ''தென்னை முக்கோணத்தில்'' நிறுவப்பெற்றுள்ள நாற்பத்தைந்து பெரும் பரிமாண ஆலைகளில் உற்பத்தியாகின்ற கொப்பரை, எண்ணெய், புண்ணாக்கு ஆகியவை அவ்லாதொட்சின் மாசுபடலுக்கு உட்பட்டனவாவென அறிதற்கு ஏழு வருடத்திற்கும் மேற்பட்ட காலத்தில் ஆராய்ச்சிகள் மேற்கொள்ளப்பட்டன. இவ்வாராய்ச்சிகளின்போது அவ்லாதொட்சின் மாசுபடலின் நேர்வு, மட்டங்கள், மாசுபடற் காரணங்கள் என்பவை துணியப்பட முயற்சி எடுக்கப்பட்டுள்ளது.

எடுத்தாளப்பெற்ற 344 மாதிரிகளுள் அண்ணளவாக 50% மானவற்றில் அவ்லாதொட்சின் B1 நடுத்தர அதிக மட்டங்கள் (0.05 முதல் 1ug/g, ppm வரை) அடங்கப்பெற்றிருந்தன. எந்தவொரு மாதிரியிலும் 1ppm க்கு மேற்பட்ட மட்டங்கள் அமைந்திருக்கவில்லை. மிகுந்தும் பங்கசுக் குடிகொண்டிருந்த 99 தேர்ந்த கொப்பருப் பருப்புகளின் 50% மானவற்றில் 0.05 முதல் 4ppm வரையான மட்டங்கள் பரவி இருக்கக் காணப்பட்டன. இரண்டே இரண்டு பருப்புகளில் மட்டும் 10 முதல் 20 ppm வரையான அதிக மட்டங்கள் காணப்பட்டன. 29% பருப்புகளில் சிறிதளவு முதல் 0.05 ppm வரை காணப்பட்டன. 18% பருப்புகளில் அவ்லாதொட்சின் அறவே இருக்கவில்லை. உலர்ப் பதனிடப்பெற்ற கொப்பரை உற்பத்திகளில் காணப்பெற்ற மட்டங்கள் ஏனைய எண்ணெய் விதைகளில் இருந்தவற்றைவிடத் தாழ்வானவை. அதற்கான காரணம் ஆராயப்படுகிறது.

அளவாய்வுக் காலப் பகுதியில் இடையறு உற்பத்தியில் ஈடுபட்டிருந்த 25 ஆலைகளில் தயாரிக்கப் பெற்ற பொருள்களில் இருந்த அவ்லாதொட்சின் மட்டங்கள்— ''என்றுமே அதிகமானவை'', ''சிலபோது அதிகமானவை'', ''என்றுமே நடுத்தரத் தாழ்வானவை'', ''தாழ்வானவை அல்லது அற்றவை'' என வகுத்துக் காட்டப்பட்டுள்ளன. மழைவீழ்ச்சி, கொப்பரை உலர்ப் பதனிடல் முறைகள், களஞ்சியத்திடுகைச் சூழமைதி, கொப்பரை நீண்ட காலம் களஞ்சியத்திடுகை, எண்ணெய்ப் பிரித்தெடுப்பதற்குத் தரங் குறைந்த விதைப் பருப்புகளைத் தரமிக்க கொப்பரைவுடன் கலத்தல், தரக் கட்டுப்பாடு இன்மை போன்றவற்றுடன் இப்பாங்கு மாதிரிகள் தொடர்புகொண்டுள்ளன.

இலங்கையில் அல்காப்பாய்வு-முற்றுநிலக்கரித் தொல்லுயிரூழிச் சூழமைதிக்கான புவி இரசாயனச் சான்றுகள்.

சி. பி. திஸாநாயக்கா, ஏ. சேனரத்தினு,
எஸ். வி. ஆர். வீரசூரியா, ஜீ. பி. வன்னிகமா.

J. Natn. Sci. Coun. Sri Lanka 1983 **11** (2): 237–246

இலங்கையில் அல்காப்பாய்வுகளையும் முற்றுநிலக்கரிப் படிவுகளையும் கொண்ட பல்வேறு தொல்லுயிர் ஊழிச் சூழமைதிகளை எல்லைப்படுத்திக் காட்டுதற்குச் சேதனவுறுப்புக் காபன் உள்ளடக்கத்துடனுன V/Mn விகிதங்களும் நிலப்பரப்புக் குரிய சூழமைதியைச் சேர்ந்த உயர்த்தாவரங்களைச் சுட்டுகின்ற C-29 ஸ்தெ ரோல் சேர்வைகளும் பயன்படுத்தப்பட்டுள்ளன. கடல்சார்ந்த படிவுகளையும் வற்றுப் பெருக்குத் தட்டைகளையும் கடலோரிசார் மற்றும் நிலப்பரப்புக்குரிய படிவுகளையும் விரித்துரைப்பதற்கு இவ்விரசாயனப் பரமானங்கள் பெரிதும் உதவு கின்றனவென்பது கண்டுபிடிக்கப்பட்டுள்ளது.

கண்டி மாநகரத்தில் விற்பனையாகும் உணவுப் பண்டங்களின் நலவழிப் பண்பாய்வு.

சந்திரா பி. கொடிகாரா, பி. சில்வா, டீ. எஸ். அத்துரலியா.

J. Natn. Sci. Coun. Sri Lanka 1983 **11** (2): 247–253

கண்டி மாநகரப் பிரதேசத்தில் விற்பனைக்கு வைக்கப்பெற்றுள்ள உணவுப் பான நுகர்வுப் பண்டங்களைச் சேர்ந்த 183 மாதிரிகள் அவற்றின் நலவழிப் பண்பாய்தற் பொருட்டு நுண்கிருமியியல் முறையில் சோதனைக்கு உள்ளாக்கப்பெற்றுள்ளன. பரிசோதிக்கப்பட்ட ஐஸ்கிறீம் மாதிரிகளில் 19 வீதம் மட்டும் இலங்கைக் கட்டளைப் பணியகத்தால் விதிக்கப்பட்டுள்ள பற்றீரிய அளவுகளுக்குள் அமைந்திருந்தது. புருட்சலாட், விளாம்பழக் கிறீம் முதலிய பிற உணவு வகைகளில் அமைந்த சராசரி பற்றீரிய அடர்த்திகள் (E கொலி, மல இசுற்றெற்ரேக் கொக்கசு, மொத்த ஒப் பேற்புக் கணிப்பு) ஐஸ்கிறீமைவிடத் தாழ்வுற்ற நிலையில் இருக்கக் காணப்பட்டன. பழ பானங்களில் காணப்பெற்ற மல மாசுபடல் மட்டங்கள் அவை தயாரிக்கப் பெற்ற இடத்தைப் பொறுத்து வித்தியாசப்பட்டிருக்கவில்லை. காரணம் தாழ் வான pH பெறுமானமாகும். மலம் சார்ந்த இசுற்றெற்ரேக் கொக்கசுக்களின் மூலம் மல மாசுபாடு ஏற்பட்டு இருப்பதை எளிதில் கண்டுபிடிக்க முடிந்தது. தாழ் pH உறைநிலையின் கீழ் E கொலி I இனம் மூலம் அம்மாசுபாடு ஏற்பட்டு இருப்பதை எளிதில் கண்டுபிடிக்க முடியவில்லையெனலாம்.

இலங்கை-பொல்கொட ஏரி II இன் நன்னீரியல் பண்புக்கூறுகள். 1-மாமிதவிய அமைப்பும் பருவ ஏற்றவிறக்கங்களும்.

எஸ். விக்கினராசா, பி. அமரசிறிவர்த்தனே.

J. Natn. Sci. Coun. Sri Lanka 1983 **11** (2): 255–268

இலங்கையிலுள்ள பொல்கொட ஏரி II இல் வாழுகின்ற நவுப்பிலீ (Nauplii), கோபேபோடா (Copepoda), உரோட்டிபெரு (Rotifera) கிளாடோசேரா (Cladocera ஒத்திராகோடா (Ostracoda) முதலிய பல்வேறு மாமிதவியத் தொகுதிகளின் அதிகரிப்பு, பரம்பல், அமைப்பு என்பன ஆராயப்பட்டுள்ளன. பருவம் சார்ந்த அதிகரிப்புக்கும் ஏற்றவிறக்கப்பாங்கிற்கும் ஏதுவான சில பௌதிகவியற் காரணிகள் விரித்துரைக்கப்பட்டுள்ளன. பருவக் காற்றுக் காலங்களில் ஏற்படும் மாமிதவியத்தின் அதிகரிப்புக்குக் காற்றும் மழையும் முக்கிய காரணிகளாக உள்ளனவென இவ்வாய்வின்போது புலனுகியது. ஏரியிலுள்ள மாமிதவியத்தின் சுமார் 70% நவுப்பிலீ, கோபேபோடா இனங்களால் அமைந்திருந்தது. இவற்றின் அடர்த்திகள் ஆழத்துக்கேற்ப வேறுபாடு கொண்டிருந்தன.

யாழ்ப்பாணக் குடாநாட்டுப் பிரதேசங்கள் சிலவற்றிலுள்ள மண்-கிணற்று நீர்சார் நைத்திரேற்று-நைதரசன் உள்ளடக்கம்.

இராஜேஸ்வரி மகேசுவரன், எஸ். மகாலிங்கம்

J. Natn. Sci. Coun. Sri Lanka 1983 **11** (2): 269–275

யாழ்ப்பாணக் குடா நாட்டில் தேர்ந்தெடுக்கப்பெற்ற இடங்கள் சிலவற்றிலுள்ள குடி நீரிலும் மண்ணிலும் காணப்படும் நைதரேற்று உள்ளடக்கம் பற்றிய ஆய்வின் பெறுபேறுகள் இக்கட்டுரையில் விரித்துரைக்கப்பட்டுள்ளன. பலவிடங்களில் அமையும் நைதரேற்று - நைதரசன் அளவானது உலக சுகாதார நிறுவனத்தால் குறித்துரைக்கப்பட்டுள்ள சருவதேசக் குடிநீர் கட்டளைகளுக்குரிய பாதுகாப்பு மட்டத்தையும் விஞ்சிய நிலையில் இருக்கிறது.

இலங்கைச் செம்பூரான் கல்லின் தோற்றமும் ஆக்க அமைவும்.

எம். எம். ஜே. டபிள்யு. ஹேரத், எச். கி. என். கி., பத்திரனே

J. Natn. Sci. Coun. Sri Lanka 1983 **11** (2): 277–292

இலங்கைச் செம்பூரான் கல்லின் தோற்றமும் ஆக்க அமைவும் விவரிக்கப்பட்டுள்ளன. மிகு வெப்பக் காலநிலையும் மாறி மாறி வரும் கோடைக் காலத்துடன் பொழிகின்ற பெருமழையும் இத்தீவில் செம்பூரான் கல்லும் செம்பூரான் கல்லால் ஆன மண்ணும் தோன்றுவதற்குத் துணை புரிகின்றன. நாட்டின் கடலோரப் பகுதிகளிலும் உட்புறப் பகுதிகளிலும் உள்ள செம்பூரான் கற்பொருள்கள் சோத

னைக்கு உட்படுத்தப் பெற்றன. செம்பூரான் கற்கள் பல, பல்வேறு நைசுப் பாறைகளிலிருந்தும் சாணைகைற்றுக்களிலிருந்தும் கிரனேற்றுக்களிலிருந்தும் உருவாகியுள்ளன. ஆனால், அடித்தளச்சிக்கல் அமைப்பிலுள்ள பாறைகளின் இதர வினத்தன்மை காரணமாக செம்பூரான் கல் உருவாதற்கு ஏதுவான தனிப்பட்ட படிவு மூலப்பாறை இன்னதெனச் சுட்டிக் காட்டல் இயலாது. திரிவைத் திரேற்று; சிப்சைற்று ($AI_2O_3,3H_2O$) அல்லது ஐத்திரா கிலேற்று என்பன செம்பூரான் கல்லில் மிகுந்து காணப்படுகின்ற அலுமினியக் கனிசம் ஆகும். கீதைற்று (Fe_2O_3,H_2O)க் கனிசமே மிகப் பொதுவான பளிங்குப் பெரிக்கு ஒட்சைட்டு ஐதரேற்றாகும். போட்சைட்டின் ஆக்க அமைவுக்குச் சமமான அலுமினியக் கனிசம் அரிதில் பெறுகிறது. இரும்புலோகக் கலவை உருவாதற்கு ஏதுவான, சிறிது பளிங்காதல் உற்ற கீதைற்றுக் கனிசம் பெருவாரியாகக் கொண்டியலும் இரும்பு ஒட்சைட்டு வளமிக்க, மிகப் பெரிய இரும்புத்தாது கொண்ட செம்பூரான் கற்பாறைகள் தீவின் தென்-மேற்குப் பகுதிகளில் நிறைய உள்ளன. இரும்புத்தாதுகொண்ட பாறைகளும் உட்பட இலங்கையிலுள்ள செம்பூரான் கற்பாறைகள் வாணிக முயற்சிகளுக்கு உதவக்கூடிய நிலையில் இருப்பதில்லை யெனத் தெரிகிறது. இவை கட்டடப் பொருள்களாகவும் (உள்ளூரில் பாவிக்கப் படும் ''சமர'' எனப் பெயரிய மஞ்சற் பூச்சு வகைகளாகவும்) உபயோகப்படுகின்றன. மேலும், செம்பூரான் கற்பாறைகள் நுண்துளையுடையனவாக இருப்பதனால் அடிநில நீர் வற்றுதிருப்பதற்கும் பெரிதும் துணை புரிகின்றன. செம்பூரான் கற்களுக்கு அடியில் உள்ள குயவர்க்களிமண் கட்டிகள் நீர் உட்புகவிடாது தடுப்பதனால் செம்பூரான் கற்பகுதிகளின் நிலம் நீர் வளமுடைத்ததாகும்.

செல்லுலோமோனசு சைலான் பகுப்புத் தொழிற்பாட்டின் பண்பேற்றக் குறிப்பீடு.

பி. எஸ். பீறிஸ்; பமிலா ஏ. டீ. றிகாட், ஏ. ஜேன், எம். டேலி.

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செல்லுலோ மோனசு CSI-17 மூலம் சைலான் பகுப்பு என்சைம்களின் அதி உயர் உற்பத்திக்கு 30°C வெப்ப நிலையினையும் 6.2 க்கும் 7.2 க்கும் இடைப்பட்ட pH உம் கொண்ட தனி உயிர்வளிச் சூழல் அவசியமாகிறது. இச்சூழலின் கீழ் சைலான்பகுப்புத் தொழிற்பாட்டின் அதி உயர் மட்டங்கள் 48 மணி நேரத்துக்குள் அடையப் பெற்றன. வளர்ப்பு ஊட்கத்திற்கு மேலும் கனிச உப்பும் மதுவச்சாரமும் சேர்க்கப்பட்டதன் பின்னர் இந்த நேரம் 24 மணிவரை குறைந்தது.

5.4 க்கும் 8.4 க்கும் இடைப்பட்ட pH பெறுமானங்களில் 30°C வெப்பநிலை காறும் அறுவடைக்குப் பின், 48 மணிவரை சைலானேசு உறுதியான நிலையில் இருந்தது. அதே வெப்பவீச்செல்லையின் மீது B1 சைலோசிடேசின் உறுதிப்பாடு இந்த pH எல்லையின் உயர்ப் பெறுமானச் சூழ்வில் மட்டுமே நிலைகொண்டிருந்தது.

சைலான் சேர்மப் பிரிப்பு ஆற்றல் பொறுத்தவரை வடி நீர்மத்தொழிற்பாடு வளரும் கலங்களின் தொழிற்பாட்டுக்குச் சமமாக இருந்தது. நீரிடைச் சேர்மப் பொருளின் பெரும்பகுதி வளர்கலங்களால் அனுசேபத்துக்குள்ளாகியது. வளர் வடி நீர்மம் என்சைம் மூலமாகப் பயன்படுத்தப்பட்டபோது நீர்ப்பகுப்புப் பொருள் கரையுந் தக தாழ்த்தும் சீனிகளாக திரளல் உற்றது.

களனி-நீர்கொழும்பு கடலோரப் பகுதி-அதன் புவியியல் வளவாய்ப்பு.

எம். எம். ஜே. டப்ள்யூ. ஹேரத், ஏ. சேனநாயக்கா.

J. Natn. Sci. Coun. Sri Lanka 1983 **11** (2): 307–323

புதிதாக நிறுவப்பெற்றுள்ள தேசிய நீரியல் வளமூல முகமையின் (NARA) ஓர் அங்கமாக, கடலியல் விஞ்ஞானங்களின் முக்கியத்துவத்தை உணர்ந்தவர்களால், ''கடற்கணிமைப் பிரதேச சமுத்திர வாய்வு அளவைக் கூறு'' எனப் பெயரியப் பிரிவொன்று ஸ்தாபிக்கப்பட்டுள்ளது. நாரா நிறுவனத்தின் ஆதரவுடன் தொடங் கப் பெற்றுள்ள இலங்கையின் கடலோரப் பகுதி ஆராய்ச்சித் திட்டங்களுள் 1984 இல் செயற்படும் உத்தேச நிலநீர்ப் பரப்பாய்வு, சமுத்திர வாய்வு அளவை களும் அடங்குவனவாகும். இந்த ஆராய்ச்சி அந்த அளவையின் முதல் கட்ட மாக அமையும் களனி-நீர்கொழும்புக் கடலோரப் பகுதிக்கு உரியது. இக்கட லோரப் பகுதியின் பொதுப் பண்புக்கூறுகளும் புவியியல் வளவாய்ப்புகளும் இங்கு கூறப்பட்டுள்ளன. கடற்கரை நெடுக்கிலும் பற்பலவிடங்களில் குறிப்பிடத்தக்க இல்மனைற்றுப் படிவுகள் உள்ளன. சிலவிடங்களில் இருந்து பெறப்பெற்ற கடற் கரை மணல் மாதிரிகளில் 65 வீதத்திற்கும் மேற்பட்ட கனிச இல்மனைற்று அடங்கி யுள்ளது, தூர்ந்துபோன கடலேரியான முத்துராசவெல சதுப்பு நிலத்தில் உள்ள கீழ் ரக முற்று நிலக்கரிப் படிவும் ஆராயப்பட்டுள்ளது. சமூக பொருளாதார அபி விருத்திக்குக் கடலோரச் சூழல்வளம் பெரிதும் உதவுமாதலால் அக்கடலோரப் பகுதியின் சீரான முகாமிப்பும் இங்கு ஆராயப்படுகிறது.

செம்மறியாட்டுக் கலப்பினப் பரிசோதனைகள்-கடாரிக் காரணிகளின் விளைவு.

எல். ஏ. குணவர்த்தன, எம். அகலவத்தை.

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இந்தப் பகுப்பாய்விற்கு உதவிய தரவுகள் வீரவில அரசாங்கக் கால்நடைப் பண்ணையிலிருந்து பெறப்பட்டவை. விள்ற்சயர் ஓர்ன் × உள்ளூர் (WL) ஆட்டுக் கடாக்களுடன் கலப்பினமாக்கப்பெற்ற பிகனேரி (B), விள்ற்சயர் ஓர்ன்-உள்ளூர் × பிகனெரி (WLB) ஆட்டுக்கடாரிகளின் செயல் நிறைவேற்றுகை கலப்பின வழித் தோன்றல்களின் பிறந்த நேர எடை, 3-மாதம், 6-மாதம் வளர்ந்த பின் ஏற்படும்

உடல் எடை ஆகியவற்றின்படி துணிந்தறிதல் இவ்வாராய்ச்சியின் முதலாவது நோக்கமாகும். இரண்டாவதாக, ஆட்டுக்கடாரியின் இனம், வயது, ஆட்டுக் குட்டியின் பிறப்பு வருடம், பிறக்கும்போது ஆட்டுக்குட்டியின் பால் வேறுபாடு, 3, 6 மாத வளர்ச்சியின் பின் அவற்றின் எடை ஆகியவற்றின் மீதுள்ள விளைவு ஆராயப்பட்டுள்ளது. இந் நோக்கத்திற்கு இரண்டு ஆய்வு மாதிரிகள் பயன்படுத்தப் பெற்றுள்ளன. ஆட்டுக்கடாக்கள் (WLB) ஆட்டுக் கடாரிகளுடன் நன்கு புணர்வுற்றன. இவற்றின் கலப்பின வழித்தோன்றல்கள் எல்லா வயதெல்லைகளைப் பொறுத்தவரையிலும் WLXB கலப்பின ஆடுகளைவிடப் பாரம் அதிகம் கொண்டிருந்தன. ஓர் ஆய்வு மாதிரியின் வண்ணம் ஆட்டுக் குட்டியின் பிறப்பு வருடம், அதன் பால் வேறுபாடு ஆகிய காரணிகள் பிறக்கும் தறுவாயிலும் 3, 6 மாத அகவைகளிலும் உள்ள உடலெடையின் மீது குறிப்பிடத்தக்க தாக்கத்தை விளைவித்துள்ளனவென்பது புலனுகியது. மற்ற ஆய்வு மாதிரியின் வண்ணம், ஆட்டுக்கடாரியின் இனம் 3, 6 மாதங்களில் உள்ள உடலின் எடையை மாத்திரம் பாதித்தது. ஆனால் ஆட்டுக்குட்டியின் பால் வேறுபாட்டுக் காரணி எல்லா அகவைகளிலும் எடை வித்தியாசத்தை உண்டுபண்ணியதெனலாம்.

உள்ளூர் மூலப் பொருட்களைக்கொண்டு அலுமினியம் சல்பேற்றுத் தொகுப்பிற்கு ஓர் இயலும் பாதை

ஜே. எம். எஸ். ஜயதிலக்கா, எம். ஜீ. எம். யூ. இஸ்மாயில்.

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இலங்கைக்கு ஓராண்டுக் காலத்துக்கு 15,000 மெற்றிக் தொன் அலுமினியம் சல்பேற்று தேவைப்படுகிறது. இது முற்றுகவே இறக்குமதி செய்யப்படுகிறது. இலங்கையில் போற்சைற்றுக் கனிசம் கிடைக்காததால் அலுமினியம் சல்பேற்றுத் தொகுப்புக்கு வேண்டிய அலுமினிய மூலங்களாக தெதியவளை உருண்டைக் களி மண்ணும் (இதில் 36% Al_2O_3 உள்ளது) இலெற்றறைற்றுக் களிமண்ணும் (இதில் 2.0% Al_2O_3 உள்ளது) பயன்படுத்தப்பெற்றுள்ளன. நீற்றல் உற்ற உருண்டைக் களிமண் H_2SO_4 அமிலத்துடன் தொழிற்படவிடல் காரணமாக அலுமினியம் சல்பேற்று, விளைகிறது, மீள்சக்கர தொழிற்படவிடல் முறை உற்பத்திப் பொருளிலுள்ள சுயாதின அமிலத்தைத் தாழ்த்தியது. மீள்பளிங்காக்கலின் மூலம் மட்டிறந்த இரும்புப் பொருள் நீக்கப்பெற்றது.

இலங்கையில் வீட்டு விளக்குகளுக்கு நேரடி எரிபொருளாகப் பயன்படும் மண்ணெண்ணெயின் கணியம் பற்றிய ஆய்வு

எஸ். சி. ஏ. த எஸ். விஜேசிங்கா.

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இலங்கையில் 80% குடிமனைகளில் விளக்கேற்றும் எரிபொருளாக கெரசின் பயன்படுத்தப் பெற்று வருகின்றதெனக் கூறினும் பயன்படுத்தப் பெறும் கணியம் பற்றி நம்பத்தகு தகவல்கள் இல்லை. படையுறு மாதிரியொன்றின் அடிப்படையிலமைந்த இவ்வாய்வு குடிமனைப் பகுதியில் கெரசின் நுகர்வுபற்றிய கணியத் தகவல் நாடுதற்கே மேற்கொள்ளப் பெற்றுள்ளது.

இவ்வாய்வுக்கென நாடு நான்கு வலயங்களாகப் பிரிக்கப்பட்டது. குடிமனைகள் வலய வாரியாகவும் வலயங்களுக்குள்ளே பகுதி வாரியாகவும் படையுறச் செய்யப்பெற்று ஒவ்வொரு படையைச் சேர்ந்த குடிமனை எண்ணிக்கை விகிதாசாரத்தின்படி எழுமாற்றுக் குடிமனை மாதிரிகள் தேர்ந்தெடுக்கப்பெற்றன. மாதிரிக் குடிமனைகளில் 24 மணி நேரகாலப் பகுதியொன்றில் (விளக்கேற்றுதற்குரிய) கெரசின் நுகர்வு அளக்கப்பெற்றுப் பிற தகவல்களும் சேகரிக்கப்பெற்றன.

நகர்ப்புறம், கிராமப்புறம், தோட்டத்துறை ஆகிய பகுதிகளின் மதிப்பீடுகள், முறையே, 16.8 ± 6.2 ml, 50.9 ± 3.4 ml, 75.2 ± 11.8 ml என்ற இடைதலா/நாள் நுகர்வினையும், 95.3 ± 35.3 ml, 286.5 ± 19.5 ml 349.0 ± 52.3 ml என்ற இடை குடிமனை/நாள் நுகர்வினையும் கொண்டிருந்தன. ஆண்டுக்கான மொத்த நுகர்வு 264 ± 10^6 லீட்டர் என மதிப்பீடு செய்யப்பெற்றுள்ளது.

குப்பி விளக்கு (சிமினி இல்லாதது) பெரும்பாலும் பயன்படுத்தப்பட்டு வருகிறது. மொத்த மாதிரி தொகையின் சரிபாதியினரும் கிராமப்புறத்து பகுதியின் 62.1 வீதத்தினரும் ஒரு குறிப்பிட்ட மாதப் பெறுமதிக்காக இலவச கெரசின் பெற உதவும் ''கெரசின் முத்திரை'' வழங்கப்பெற்றவர்களாகக் காணப்பட்டனர்.

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