BIOGAS GENERATION FROM LATEX EFFLUENT WATER

By

SANGEETHA JOSE

A THESIS SUBMITTED TO THE AVINASHILINGAM INSTITUTE FOR HOME SCIENCE AND HIGHER EDUCATION FOR WOMEN (DEEMED UNIVERSITY), COIMBATORE - 641 043

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

IN FAMILY RESOURCE MANAGEMENT

MAY 1997

BIOGAS GENERATION FROM LATEX EFFLUENT WATER

By

SANGEETHA JOSE

A THESIS SUBMITTED TO AVINASHILINGAM INSTITUTE

FOR HOME SCIENCE AND HIGHER EDUCATION

FOR WOMEN (DEEMED UNIVERSITY)

COIMBATORE - 641 043

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN FAMILY RESOURCE MANAGEMENT

MAY - 1997

Certified as Bonafide research work

Sathyanathamuthu 9-5-97
Signature of the
Head of the
Department

Subhal Jayadeesan
Signature of the
Guide

Dean
Faculty of Home Science

Acknowledgement

ACKNOWLEDGEMENT

The researcher expresses her gratitude to **Padmashree Dr. (Tmt.) RAJAMMAL P. DEVADAS, M.A., M.Sc., Ph.D., (Ohio State), D.Sc., (Madras), Hon. D.H.L. (Oregon State), Hon. D.H.L. (Ohio State), Hon. D.Sc., (C. Azad Agri University, Kanpur), Hon. D.Sc., (University of Ulster, Northern Ireland), Chancellor,** Avinashilangam Institute for Home Science and Higher Education for Women (Deemed University), Coimbatore, for providing the opportunity to conduct the study.

She records her sincere thanks to **Dr. (Tmt.) LAKSHMI SANTHA RAJAGOPAL, M.Sc., (Tennesse), Ph.D., (Madras), Vice Chancellor,** and **Dr. (Tmt.) SAROJA PRABHAKARAN, M.A., Dip.Ed., (Madras), Ph.D., (Mother Theresa),** Registrar, Avinashilingam Institute for Home Science and Higher Education for Women, (Deemed University), Coimbatore, for all the encouragement given to carry out the study.

She wishes to convey her sincere thanks to **Dr. (Mrs.) USHA CHANDRASEKHAR, M.Sc. (Madras), Ph.D., (Purdue),** Dean of Faculty of Home Science and Higher Education for Women, (Deemed University), for all the help extended during the conduct of the study and **Dr. (Mrs.) SATHYAVATHI MUTHU, M.Sc., M.Phil., Dip.Ed., Ph.D., (Madras),** Professor and Head of the Department of Family Resource Management, Avinashilingam Institute for Home Science and Higher

Education for Women (Deemed University), Coimbatore for her valuable suggestions and for providing required infrastructure for conducting the study.

She feels extremely priveleged to have worked under the valuable guidance of **Dr. (Mrs.) GNANAMBAL JAGADEESAN, M.Sc., M.Phil., Dip.Ed., (Madras), Ph.D. (Avinashilingam)**, Reader, Department of Family Resource Management, Avinashilingam Institute for Home Science and Higher Education for Women (Deemed University), Coimbatore under whose unstained help she has been able to execute her research and complete it successfully. She records her deep sense of gratitude for her unalloyed efforts, suggestions and guidance.

Special thanks are extended to PARIYAR LATEX and the rubber growers of Varappatty and Oonukal for their kind co-operation to conduct the study.

The investigator for ever indebted and owes her thanks to every one who ever helped in all the way to conduct the study by supporting and encouraging.

Contents

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

Introduction

INTRODUCTION

"In this world, nothing is a waste,
everything got it's own use
But to take its advantage,
Someone have to realise its value"

- Adi Sankara

The development in agriculture, industry and Science and Technology has resulted in the modern civilization which provide better living standards for human beings. The utilization of natural resources and production of better quality products resulted in most cases concommitant increase in the generatin of unwanted waste or effluent. The socio-cultural roots of the present environmental crisis lie in the paradigm of scientific materialism and economic determinism which fail to recognize the activity (Neeri, 1991).

Rubber is an important and essential raw material in today's industrial world. Hevea or rubber is planted in over 20 countries stretching from countries in South East Asia to Ivory cost in Africa and some parts of Central and South America with an estimated cultivated area of nine million hectares as remarked by Naimah et al., (1992). Tropical rain forests are generally considered to contain a great diversity of plant and animal species. But day by day these forests are reducing in area and in number. Sivanadyan and Moris (1992) suggested rubber plantation as the remedy to save the environmental balance and also as an environment friendly industrial material.

In India, it is grown in an area of over five lakh hectares with annual production of between 3.5 to 8.5 lakh tonnes. It is about 5.3 per cent and 6.8 per cent of area under production and total production of the world respectively.

Hevea brasiliensis is a native of Brazil introduced to Kerala in 1902. According to Chattopadhyay (1996), Kerala accounts for 86 per cent of total area and 94 per cent total production of rubber in India . About 25 to 30 per cent of total rubber area in the Kerala state is concentrated in the district of Kottayam followed by Ernakulam. But 50 per cent of total area of Kottayam is covered by rubber plantation. Most of these cultivable land is in the hands of small farmers. The main concentration of rubber is in South Kerala covering south mid land zones.

There is a physiographic limit of growing rubber specially to the higher elevation. Complete elimination of weed is never recommended in rubber plantations. The leguminous plants which is friendly with rubber is fixing the nitrogen in soil and enriching the nutrients in a view of large amounts of nutrients cycled and the substantial reserves occuring as tree nutrient banks. The mature rubber ecosystem has been viewed as nutritionally self-sustaining ecosystem (Sivanadayan, et al.,1991). Because of its easiness to cultivate and as a stable income today, rubber plantation is welcoming by all the farmers even by replacing the other crops like tapioca, cashew, pineapple, paddy etc.

The main crop from the rubber tree is latex, a milky white gummy juice, which is collected by the process of tapping. One of the main important form in which the crop is processed is ribbed smoked sheet/RSS/rubber sheet.

According to the study conducted by the Rubber Board (1996) there are nearly 1.25 lakh RSS producing units discharging nearly one crore 16 lakh *l* of liquid waste and are distributed through out the rubber growing area. The effluent generating from sheet processing factories are varying from few litres to several thousand litres.

The most noticeable level of pollution in rubber industry is caused by the effluents from the processing units. Untreated chemicals like acidic water, small solid particles of unused latex, settleble solids in the form of bark shavings, sand particles etc are the main constituent of this effluent water. This effluent water is highly polluted with high Biochemical Oxygen Demand (BOD), Chemical Oxygen

Demand (COD), nitrogen and acetate. The odour originates from the aging of proteinaceous material present in the effluent water is a main source of air pollution. The generation of untreated effluent water to the ground is causing high salt concentration in the soil. Mathew (1996) remarked that the high nitrogen content causing algal bloom and eutrophication of water ways and excessive amount of nitrates in ground and surface water which results in the toxicity to the aquatic life.

A large quantity of sawdust generating from the rubber wood processing industry, is becoming a big polluting problem by dumping without any use or recycling. In the same way crumb waste from crumb rubber factory is also resulting as a menance to the environment. The saw dust and crumb waste are of low combustion value, hence it is not getting importance as a fuel.

The recycling of effluent water by microbial action and trickling filtration is possible but the use of this recycled water caused the degradation of products.

The world today is confronted with scarcity of fuel. The discriminate consumption of fossil fuels and denudation of forests contribute to energy crisis which necessitate exploration of the non conventional source of energy that could be generated at low cost by recycling and reuse of wastes. The anaerobic digestion of waste by microbial action is energy generating and environmental friendly.

The possibility of utilizing liquid waste from rubber processing factories as well as solid waste like sawdust and crumb waste from rubber industries for the generation of biogas arised in this situation. But it is not fully explored yet. Rubber wood waste being lignocellulosic can be depolymerised by microorganisms to monomers which serve as precursor to produce methane, alcohol and single cell protein.

Rubber is a common agricultural crop in Kerala. The processing units are an unavoidable component of rubber based industries. The effluent water generated from the processing unit pollutes the environment and creates unhealthy surrounding. The Government has not taken any effort to control this menace. So far no study has been undertaken to recycle the effluent water. Hence this initiated the investigator to take up the study on 'Biogas Generation from Latex Effluent Water' with the following main objectives: To

- find out the socio-economic profile of surveyed families

- study the cultivation of rubber crop and collection and processing of latex for the production of rubber sheets.
- analyse the composition of rubber latex
- develop a suitable model for the generation of biogas from effluent water . - estimate the quantity and composition of biogas from latex effluent water.
- assess the increased yield of biogas and methane content from the selected substrata and
- analyse the manurial value of biodigested slurry samples.

It is hoped that the study could throw light on improving the quality of life of the rubber growers by recycling latex effluent water which ensure safe ecofriendly environment.

Review of Literature

II REVIEW OF LITERATURE

The literature pertaining to the study on "Biogas Generations from Latex Effluent Water" comprised of the following main aspects:

A. Rubber as a plantation

B. Production of rubber sheets

C. Latex effluent water - a menace to the environment

D. Latex effluent water as a source of energy and

E. Utilization of effluent water and biodigested slurry.

A Rubber as a Plantation Crop

Replacement of natural vegetation with various plantation crop is a global phenomenon. Rubber was introduced in Kerala as one of the plantation crops in the beginning of the century. At present it covers about 18 per cent of the total agricultural land in the state. As an estate crop it has mostly replaced natural vegetation and small holding crop it is being raised in the places earlier given for tapicca, cashew nuts and even coconut (Chattopadhyay, 1986).

Kerala landers is significant for tree crops. Homestead garden and tree crop culture adds to the high biomass density. Rubber cultivation is not restricted to the estate alone, it has gradually become a peasant's crop.

A large variety of plant species can survive and establish themselves in a rubber plantation, if it is left unmanaged. This suggests that rubber plants do not produce any allelopathic agents which inhibit the growth of other plant species. Many crop plants like Cashew, banana, pineapple, coffee, etc. can be grown successfully in rubber plantation at different stages. Some medicinal plants can grow very well in matured plantations.

Study of deforestation in 1905 to 1984 by Chattopadhyay (1986) has brought out that Kerala's natural vegetation cover has reduced from 44 per cent to 14 per cent in 1984. Repetto (1987) put forth that deforestation in lower altitudes (<30m) can be attributed to growth of rubber plantation. Specific investigation points out that cashew was replaced by rubber in many places.

In the early 20th century the stimulus provided by motor transport in the developed countries led to rubber plantation under the control of small farmers in parts of Malaysia, India and Ceylon (Redclift 1987). Use of rubber plantation for aforestation programmes would contribute to mitigating the damaging effects of the even increasing of CO_2 in the atmosphere as remarked by Satheesan et al., (1993) because of high photosynthetic productivity of `Hevea'. The rubber tree is a major source of fuel wood in so many rubber growing countries.

Distribution of photosynthetic active radiation (PAR) pattern in rubber plantation shows that more than 80 per cent of PAR is intercepted by the upper canopy within 5m from the top of the canopy (Satheesan et al., 1985). Penetration of sunlight is poor which constraints photosynthesis and results in poor creation and consequent lower DO value.

Water used by rubber plantation is estimated to be 500mm to 600mm lower than the typical tropical rain forest ecosystem. The rate of evaporisation is lower for rubber plantation compared to the forest ecosystem. This may contribute to the decreasing trend of local rainfall under micro climate.

Balagopalan (1995) and Amma (1996) reported that organic carbon and total nitrogen are less under rubber plantation than forest. Jinghua (1990) pointed out that organic matter content under rubber plantation lies mostly between 10 and 20 g/kg. against 158 g/kg. under evergreen forest.

Rubber planting in denuded forests will certainly reduce human pressure on the nearby afforested areas as the local population will be drawing not only a steady income from the rubber plantation but also supplies of fire wood. The virgin forests would thus be left lonely undisturbed

(FAO, 1981). If the tribal people are also helped to grow rubber on their own, they can be effectively weaned away from shifting cultivation on to settled agriculture (FAO, 1990).

B. Production of Rubber Sheets

The different kinds of crop harvested from rubber plantation are highly susceptible to bacterial action due to contamination on keeping. Therefore it is essential to process them into forms that will allow safe storage and marketing (Thariah et al., 1988; Turjanmua, 1993).

The product collected in the form of latex can be processed into Ribbed smocked sheets, Crepe rubber, Preserved latex and latex concentrates and Block rubber or crumb rubber any of the above forms. But the cup collected as field coagulum can be processed only into cube or block rubbers (Nair and Sebastian, 1996).

Latex coagulated in suitable containers into slabs of coagulum and sheeted through a set of smooth rollers followed by grooved set and dried to obtain ribbed sheet rubber. Depending upon the drying method, sheet rubbers are classified into two-ribbed smoked sheets and air dried sheets (Rubber Board, 1995).

The latex collected is brought to the processing factory before precoagulation sets. In cases where the latex is found to be prone to precoagulation, an anticoagulent is used. A drop of the solution of anticoagulant are added to the collection cups at the time of tapping if found necessary. The rest of the required quantity of the solution is added into the collection buckets when they are half full. Anticoagulents should not be poured into empty collection buckets.

The collected latex is shifted to a tank for and filtering. After filtering the latex is mixed with enough water and diluting them. The diluted latex is poured into the aluminimum dishes and mixed with acetic or formic acid. The latex kept for coagulation is removed from aluminimum pans after coagulation.

The sheets after two or three hours of dripping in shade are put in the smoke house where the temprature is maintained between 40^{O} and $60^{O}C$. Smoke house has two chambers where precise control of temprature and humidity is possible. In the smoke house the sheets are dried gradually where by blisters are avoided. In addition, the creosotic substances present in the smoke prevent mould and yeast growth on smoked sheets.

It is preferable to smoke sheets on the first day at a low temprature (40^{o} to 43^{o}c.) . For the subsequent days (ie.second to fourth day)the sheets are to be dried at high temprature (not exceeding 60^{o}C) and fairly low relative humidity (Bristow Sears, 1989).

The sheets are turned on the reapers every day for a uniform smoking and drying and to avoid reaper marks on dry sheets. The completely dried sheets are removed to the packing shed where they are carefully inspected and graded according to the standards published by Rubber Manufactures Association (RMA). This standard at present provides for six grades of ribbed smoke sheets viz. RSS IX, RSS1, RSS2, RSS3, RSS4 and RSS5. The grading of sheet rubber is carrying out by visual examination. Normally, this is accomplished by holding rubber sheets against light as pointed out by Polhums (1992) when the most obvious effects will become apparent.

C. Latex Effluent Water - a menace to the Environment

According to Mathew et al., (1987) there are four types of rubber factories which generate effluent viz. sheet processing effluent (SPE) by ribbed smoked sheet (RSS), crumb processing effluent (CPE) by technically specified rubber (TSR) fabrics, crepe rubber effluents (CRE) by crepe rubber (CR) factories and the latex concentrate effluent (LCE) by latex concentrate (LC) factories.

The extent of pollution varies in different factories depending on the type and quantity of rubber processed.

The effluent from CR and RSS factories are more pollutant than the other ones. The LC control only 1/10 of the total microbial population compared to the CRE (Soman et al., 1996).

Proteins, sugars, lipids, carotenoids, inorganic and organic solids of latex, various chemicals added for processing and water used for processing constitute the effluent from natural rubber processing units (John, 1974; John, 1975 and Dolmet, 1978).

Biological treatment of effluent by trickling, filtration was reported to be efficient in reducing pollution. The treatment system which is adopted at present is very expensive.

The fast growth of micro-organisms causes depletion of oxygen content in the effluent and receiving water bodies.

The average effluent generation from these factories varies from 18 to 26 litres per kilogram of processed rubber (Mathew et al., 1996).

There are nearly 1.25 lakh R.S.S. producing units discharging nearly 1 crore 16 lakh l as liquid waste and are distributed throughout the rubber growing areas. These units are not following any type of effluent treatment methods. The pollution load of these factories were found to be very high. This effluent would be deteriorating the soil characters and water quality when it lets out (KSLUB, 1996).

Waste from latex concentrate factory is highly polluted with very high BOD, COD, nitrogen phosphate and sulphates etc. As concentrated H_2SO_4 is an important chemical for the processing of skim latex, it would lead to corrosion of the effluent tanks and deteriorate the soil structure. This may increase the salt concentration in the soil which would ultimately lead to the exosmosis. If irrigated directly, the high nitrogen content will result in algal bloom and growth retardation. If let out into water ways result will be excessive amounts of nitrate in ground and surface waters, ammonia toxicity to fish and altered effectiveness of chlorination by ammonia. Small scale units are not causing much problem rather than the bad smell and slight irritation to the plant growth in the polluted area as stated by Chick (1973).

During RSS processing, addition of formic acetic acid causes the reduction in pH of the effluent. This effluent causes very high levels of BOD and COD indicating that the TS are mainly of organic with high oxygen requirements for their oxidation.

SPE contained all the different groups of bacteria in large number. The yeast population in the effluent was very high compared to other effluents. The optimum pH required by yeast for its growth is 4 to 5 and obviously the RSS effluent favoured its protileration (Mathew and Kothandaraman, 1991).

D. Latex Effluent water as a Source of Energy

Latex effluents from rubber processing factories were used for culturing bacteria (John et al., 1977) and for the production of ethenol by different groups of yeast (Hobson, 1976). Diluted and partially treated effluent supports the growth of unicellular algae like chlorella sp. (Kulkarni and Stalin, 1973 and Kothandaraman and Nair, 1978).

As remarked by John (1977) and Dolmal (1979) solid waste was utilized for the cultivation of oyster mushroom.

Rubber wood sawdust, the solid waste from rubber wood industry contain different levels of cellulose and lignin (Hegerty, 1973) which is a good substrata for mushroom cultivation. Kothandaraman (1987) has successfully cultivated oyster mushroom using rubber wood saw dust.

Fang (1985) made attempts to use the effluents from rubber processing factories for biogas production.

Refining the agricultural commodities in agro industries to suit modern market requirements generates plenty of wastes. These wastes can also be used for biogas production (Hobson et al., 1981) reported that apple waste, carrots, asparagus, peas, french beans, spinach and strawberries from a canning industry have been shown to produce biogas on anaerobic digestion (Kalia et al., 1992) observed methenogenesis from apple pomer and vegetable wastes like raddish leaves, cauliflower leaves and stalk of rotten cabbage. Hubson, (1976) remarked that generation of biogas from tomato processing waste.

Wood waste of soft wood which are low in lignin content are good substrate for methanogenesis since the major components like cellulose and hemicellulose are easily attacked by an aerobic cellulolytic organisms leading to the formation of simple carbohydrates, the substrate for methane production (Mathew, 1996).

Canel and Wong (1980) and Jimenez et al., (1990) observed that biogas generation from lignocellulose wastes like cardboard, newspaper, saw dust and sugarcane waste, when fermented anaerobically with pig manure.

Bousfild et al., (1979) reported that anaerobic digestion of cow dung, chicken manure, pig manure, farm wastes, sewage sludge and elephant grass produced gas that contained 65 to 60, 65 to 70, 60 to 70 and 68 to 60 per cent methane respectively. The aerobic digestion of pig manure at 35^{o}C yielded methane upto 72 per cent and CO_2 upto 28 per cent (Anglo, 1978).

It was shown that the rate and efficiency of conversion of mixture of straw and cow manure with initial solids at 25 per cent dry matter was surprisingly close to the decay rate in a 10 per cent solid mixture (Jesger et al., 1978).

The efficiency of the digestion process can be increased substantially by giving proper pretreatments which improve the bio degradability. Dc Renzo (1977) predigestion of substrate for biogas production is reported to enhance the methane content in the biogas.

Bryant (1972) told that the optimum C:N ratio recommended for an anaerobic digester was 30:1. Addition of glucose or cellulose increased C:N ratio from 8-25% and resulted in methane production upto 60-70 per cent. Seeding was recommended or a start up practice by Hubson and Shaw (1976) for quickening the digestion process. Hashimoto (1989) reported that methane production rate increased at a reducing rate upto an inoculum substrate ratio of two, after which it remained constant.

During the conversion of carbohydrate to CO_2 and CH_4 equal volumes of each gas was produced. However all the CO_2 content of the gas output increased with increased temperature (Zauner, 1986).

Methane producing organisms grow at pH values between 5.9 to 7.78 and the optimum being 6.1 to 6.9. The best pH for rapid fermentation was between 6.8 and 8.0 (Chonker, 1981; Mathew and Kothandaraman, 1991) observed that a pH of 7.5 was optimum for fast methanogenesis. However a pH from 6.5 - 7.4 was found to be optimum for gas production and pH above 7.8 had inhibitory effect.

E. Utilisation of Effluent Water and Biodigested Sludgy

The rapid urbanisation and the industrial development necessitate increasing demands for water. Rubber processing factory effluents are reported to be used as a source of fertilizer and irrigation water for field crops (Jimenez, 1990).

Solids that are neither broken down nor converted into methane, settle down in the digester. Depending on the raw materials used and the conditions of digestion the sludge that settles down contains many elements essential to plant life. viz. N.P.K. and other micro nutrients. It can be used as manure directly after diluting with water, as dried manure, as starter inoculum for compost and as a manure by impregnating it with urea and super phosphate.

Daliya and Vasudevan, (1996) reported that the spent slurry and sundried slurry were superior to farm yard manure and compost. Effect of application of biodigested slurry as manure on crop growth depended upon the crop to which it was applied.

Application of slurry to replace half of the nitrogenous fertilizer in vegetable crops gave better yield thus complete replacement of synthetic fertilizer with it. Total replacement of the nitrogenous fertiliser with slurry influenced maximum yield in fodder crops. Biodigested slurry is found to increase the growth of aquatic weed like lemba and phytoplankton.The bio digested slurry after the gas generation was found to be an efficient organic manure (Chawla, 1973).

The water used in the pale latex crepe factory for the washing of rubber during the process of rolling was collected and reused in the rollers. The rubber samples were examined for the different technological properties. The study showed that recycling of once used water and even the raw effluent had no adverse effect on the properties of the processed rubber. The effective and economic effluent treatment systems are to be formulated for different rubber processing factories.

Waste water from natural rubber processing industries could be treated aerobically after proper primary clarification thereby reducing the concentration of organic and inorganic compounds. Due consideration is to be given for recycling of effluent in the processing, utilization of wastes for energy generation, single cell protein production, pisciculture etc is to be given (Mathew, 1996).

Methodology

III - METHODOLOGY

The methodology of the study on "Biogas generation from Latex Effluent Water" comprised of three major phases:

A. Household survey

B. Analysing the composition of rubber latex

C. Recycling of latex effluent water for biogas generation.

A. Household Survey

Survey research is a branch of social scientific investigation that studies large and small population by selecting and studying samples from the population to discover the relevant incidence, distribution and interrelation of sociological and psychological variables (Devadas, 1989).

Household survey was carried out to gather information on cultivation of rubber crops and production and processing of rubber sheets which consisted of the following headings:

1. Selection of locale
2. Selection of sample
3. Selection of method
4. Formulation of tool
5. Conduct of the study and
6. Consolidation and analysis of data.

1. Selection of locale

Varappatty and Oonukal villages in Eranakulam district of Kerala was selected by the investigator, where rubber farming is the main agricultural crop for the farmers. The failure of coconut farming due to the attack of different diseases, change of climatic condition and fluctuation in the price level of common agricultural products like cocoa, paddy, banana etc., made the farmers to switch over to rubber cultivation as the major agricultural crop (Deepika, 1997).

The two villages namely Varappatty and Oonukal were within 15 km. distance and Varappatty being the native of the investigator, the choice was made to select the areas for the conduct of the study.

2. Selection of sample

According to Gupta (1991) sample is that part of the universe selected for the purpose of investigation and should exhibit the characteristics of the universe.

Fifty rubber growers inhabitated at Varappatty and Oonukal villages were selected based on purposive sampling method to carryout the research work. Purposive sampling denotes the method of selecting a number of groups of units in such a way that the selected groups together yield as nearly as possible the same average or proportion as the totality with respect to these characteristics which are already matter of statistical knowledge (Varma, 1993).

3. Selection of method

In direct personal interview method, there is a face to face contact with the person from whom the information to be obtained. The interviewer asks them questions pertaining to the survey and collects the desired information. The information thus obtained is first hand and original in character as stated by Gupta (1991). Hence interview method was chosen for the study.

In addition observation was also made by the investigator to gather extra information pertaining to the study. Observation is a method of collecting data with the use of eyes rather than that of ears or the voice. It was helpful in studying collective behaviour and complex social situations following up of individual units composing the situation, understanding the whole and the parts in their interrelation and getting out of the way details of the situation (Saravanavel, 1996).

4. Selection of tool

According to Kothari, (1997) a schedule is a proforma containing a set of questions which is being filled in by the enumerators who are specially incharge of it.

The investigator adopted this tool because it was very useful in extensive enquiries and can lead to fairly reliable data.

An interview schedule was prepared by the investigator to collect the data from the respondents which consisted of the following details such as headings such as socio-economic background of the families, land holdings, cultivation of rubber crop, collection and processing of rubber sheets from latex, and the economics of rubber sheet production in 10 households at Varappatty village of Eranakulam district.

Pre testing helps in enriching the design of the schedule and assists in testing the validity and reliability of statistical technique to be adopted for data processing and analysis. Thus the pre-testing is the proving ground for the sample design and it is preview of how well interviewers perform, respondents behave and procedures work in practice (Saravanavel, 1996).

The schedule was modified based on the response received from the informants and the final schedule is given in Annexure I.

5. Conduct of the study

The investigator personally visited the families of rubber growers and explained about the purpose of the study. A good rapport was established with the respondents and questions were asked informally in sequential manner in their own language which helped to get the relevant answers for the study.

6. Consolidation and analysis of data

The data thus collected were consolidated, tabulated and analysed, and the findings are interpreted in Chapter IV.

B. Analysing the Composition of Rubber Latex

The rubber latex was collected in a plastic container in the selected farm households by the investigator and it was analysed for its composition in the laboratory by adopting the standard methods of BIS under IS-3708 and IS-9316.

C. Recycling of Latex Effluent Water for Biogas Generation

This aspect is dealt under the following headings:

1. Assessing the quality of latex effluent water
2. Conducting the experiment for biogas generation
3. Recommending suitable design for biogas generation and
4. Analysing the manurial value of digested slurry

1. Assessing the quality of latex effluent water

The effluent water collected from sheet rubber processing unit was analysed for physiochemical characteristics. The physical quality of the effluent water such as appearance, colour and odour was assessed through observation method.

The investigator collected effluent water at the exit point from the selected processing unit in a 2.5 litre polyethylene container. The observation made by the investigator showed that there was no variation in the quality of effluent water collected from the sheet processing unit in different timings of the day.

The appearance of the effluent water sample collected from the processing unit was observed by looking into the nature of water. The colour of the sample was recorded visually and odour by sniffing.

The chemical composition of effluent water such as pH, total solids, suspended solids, dissolved solids, volatile solids, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total nitrogen etc. was assessed using standard methods (Annexure II).

2. Conducting the experiment for biogas generation

A trial experiment was conducted to generate biogas from sheet processing effluent water. A cylindrical galvanised iron drum of 200l capacity was used as digester, and the inlet and outlet pipes were provided in such a way to feed the influent water and collect the digested effluent water respectively. The gas outlet pipe with the regulater was fitted at the top of the digester tank. The whole unit was made air tight.

The effluent water was fed into the digester upto two third height and it was kept under anaerobic decomposition for 15 days. The gas was tested by connecting to a bunsen burner. The observation made by the investigator showed that the gas was found to be inflammable.

The investigator made an attempt to utilize wastes such as crumb waste, saw dust, predigested saw dust and cow dung from rubber industry for biogas generation.

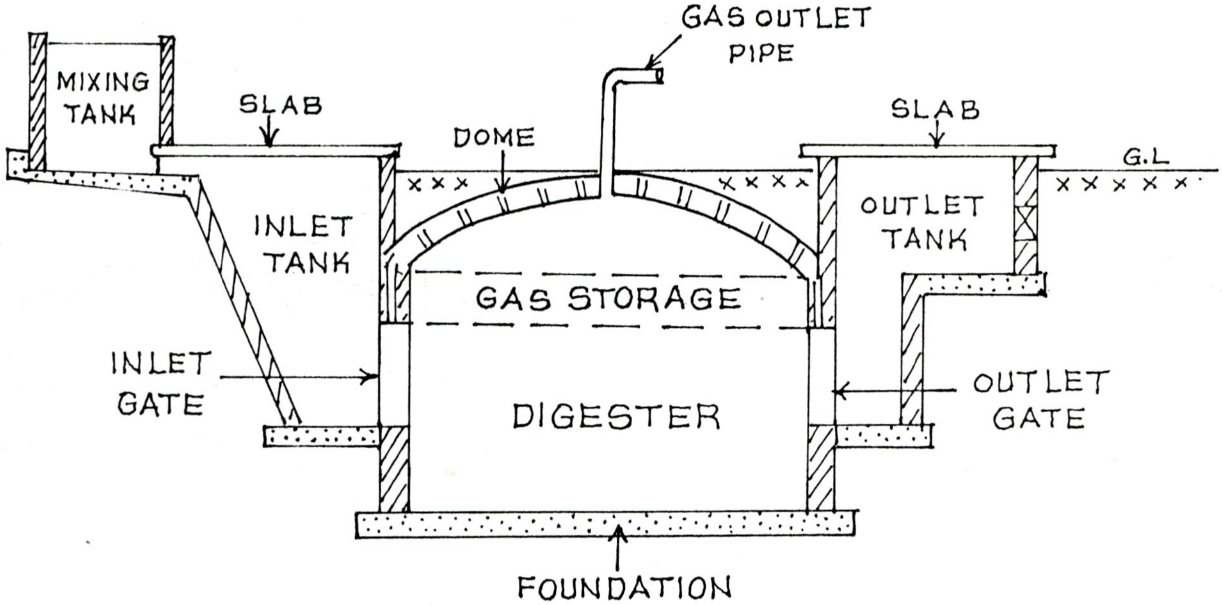
The experiment was conducted using five litre capacity test cans which was made air tight. The selected substrate were fed into it in different concentrations (5, 10 and 15 per cent). The quantity of biogas was measured for a period of three to six weeks.

Since 10 per cent of the concentration was found to be satisfactory, the total production of biogas and the percentage of methane were recorded using water displacement method and Gas Chromatography respectively.

3. Recommending suitable design for biogas generation

Fixed dome type model was recommended by the investigator to utilize latex effluent water for the generation of biogas. (Figure 1) Two cubic metre capacity bio gas plant was constructed in one of the surveyed villages of Varappatty in Ernakulam district.

It was an underground cylindrical well like structure made of masentry work where the fermentation takes place. The top of the plant was dome shaped and was an integral part of the digester. The dome was made of brick and cement mortar with gas leak proof structure. The gas outlet pipe was projected out on the top of the dome and fixed to the masantry dome. The inlet pipe was fixed at one side of the digester and connected to the exit of the latex



FIXED DOME MODEL RECOMMENDED
FOR BIOGAS GENERATION

Figure.1

processing unit. The outlet pipe was fitted at the other side of the digester to discharge the treated effluent water.

4. Analysing the manurial value of digested slurry

The manurial value of digested slurry of selected samples was analysed for nitrogen, phosphorous and potash contents. Annexure IV exhibits the procedure adopted for the estimation of manurial value of selected samples. Since the fresh effluent water did not have any solid content, the spent wash water was used directly for irrigating the agriculture crops.

Results and Discussion

IV · RESULTS AND DISCUSSION

The finding of the study on "Biogas Generation from Latex Effluent Water" comprised of the folowing main headings.

A. Findings of the household survey

B. Composition of rubber latex

C. Generation of biogas from latex effluent water

D. Physio-chemical characteristics of effluent water.

E. Manurial value of biodigested slurry.

A. Findings of the Household Survey

The information gathered from 50 farm families on cultivation of rubber crops, collection of latex and production of rubber sheets are discussed under the following headings:

1. Socio-economic profile of the selected families
2. Cultivation method of rubber crops.
3. Collection and processing of latex for the production of rubber sheets and
4. Economic benefits of rubber plantation
5. Estimation and utilization of effluent water

1. Socio-economic profile of selected families

This aspect consisted of the details such as family size and pattern, educational status of the heads of the families, occupational level of the heads of the families and monthly income of the families.

Family size and pattern

Table I exhibits the family size and pattern of the surveyed families.

TABLE I

FAMILY SIZE AND PATTERN

Particulars	Percentage (No:50)
Family size	
Small (1-3 members)	58
Medium(4-6 members)	30
Large (Above 6 members)	12
Family pattern	
Nuclear	88
Joint	12

It is clear from the table that 58 per cent of the families belonged to small family size of having one to three members followed by 30 per cent in the medium family size of four to six members and the rest of them (12 per cent) were of large family category of above six members.

With regard to family pattern, a majority of 88 per cent of them were of nuclear family and the rest of them in the joint family system. This might be due to the disintegration of joint family system. According to Jannet (1992) a joint family is joint in functioning and/or property and/or residence. But the joint family system is gradually replaced by nuclear family. The size of the family is shrinking and kinship relationship is confined to two or three generations only. Urbanisation, increased educational status especially of women, search of comfortable life and high standard of living are the main causes for this disintegration of joint family system.

House structure

Over half of the surveyed families (58 per cent) had R.C.C. houses, but it is surprised to know that about one-fourth of the families dwelt in thatched houses and 18 per cent of them occupied tiled houses.

Religion

Generally Christians are found to be predominant in Varappatty and Oonukal villages of Ernakulam district. The survey showed that about 84 per cent of the surveyed families were of christians whereas the minority of them were Hindus and Muslims (8 per cent each).

Educational level

According to 1991 census, Kerala has the high literacy rate in India (90.59 per cent) in the total population. In Kerala 94.95 per cent of males are literates and Kerala women stand in the topest level of literacy with the covering of 86.93 per cent of literate women (Manorama Year Book, 1995).

The educational status of the heads of the families and homemakers are shown in Table II.

TABLE II

EDUCATIONAL LEVEL OF THE HEADS OF THE FAMILIES AND HOMEMAKERS

Educational level	Percent	
	Heads of the families	Homemakers
S.S.L.C.	10	16
Pre degree	20	28
Degree	32	32
Post graduate	22	24
Professional	16	-

It is heartening to note that both heads of the families and homemakers were literate with the minimum qualification of S.S.L.C. It is interesting to know that 16 per cent of the heads of the families were professionals. Over half of the heads of the families were graduates (56 per cent) of which one fifth of them obtained post graduation. About 20 per cent of them studied upto pre degree level.

There was not much difference observed in the educational level between heads of the families and homemakers. Almost one third of the homemakers were obtained either pre degree or degree levels. It is surprised to note that about one fourth of the homemakers studied upto post graduate level whereas it was one fifth in the case of heads of the families.

Occupational status

The occupational status of the heads of the families is depicted in Table III.

TABLE III

OCCUPATIONAL STATUS OF THE HEADS OF THE FAMILIES

Occupational status	Percent (N:50)
Agriculture	34
Business	
Small scale	24
Large scale	16
Doctor	6
Engineer	6
Bank Officer	4
Unskilled worker	4
Skilled worker	6

It is clear from the survey that about 40 per cent of the heads of the famlies were doing business at the small scale level, (24 per cent) and large scale level (16 per cent).

It is interesting to observe that over one fifth of the heads of the families were professionals - doctors (6 per cent) and engineers (6 per cent). A least minority of them were bank officers (4 per cent), unskilled workers (6 per cent) and skilled workers (4 per cent).

Total income of the families

Table IV shows the monthly income of the surveyed families.

TABLE IV

MONTHLY INCOME OF THE FAMILIES

Income (in Rs.)	Percent (N:50)
5000 - 10000	32
10000 - 15000	26
15000 - 20000	24
Above 20000	18

It is observed from the survey that all the families belonged to high income categories of earning Rs.5000/- and above/month. It is clear from the study that agriculture was the main occupation and the main source of income was received from rubber plantation. It is heartening to note that about one third of them earning Rs.5000 - 10000/month followed by 10000 - 15000 by 26 per cent and 15000-20000 by 24 per cent. About 80 per cent of the surveyed families earned above Rs.20000/month. They received an additional income from capital investment and about one tenth of them obtained from rent also.

HUDCO classified the income level as low income - below Rs. 1250/- per month, middle income - Rs.1250/ - Rs. 2650 per month, upper middle income Rs. 2650 - Rs.4450 per month and high income above Rs. 4450 per month.

Cultivation method of rubber crop

The details about land holdings, area of rubber cultivation, rubber species and procurement of saplings, method of cultivation and plant protection are explained beneath:

Land holdings

The land holdings of the surveyed families are given in Table V.

TABLE V

LAND HOLDINGS OF SURVEYED FAMILIES

Category of farmers	Area in Acres	Percent (N : 50)
Marginal	2.5 - 5	30
Medium	5 - 7.5	36
Large	Above 7.5	34

As stated by the National Agricultural Corporation (1971) the farmers were categorised according to their land holdings as small farmers having below 2.5 acres, marginal farmers (2.5 - 5 acres), medium farmers (5 - 7.5 acres) and large farmers, owning above 7.5 acres.

The surveyed families belonged to marginal, medium and large farmers category of having more than 2.5 acres. It is understood from the study that majority of 36 per cent of the families were of medium farmers having 5 - 7.5 acres followed by large farmers of having above 7.5 acres (34 per cent) and marginal farmers of 2.5 to 5 acres (30 per cent). The families were almost equally distributed in all the three categories.

Area of rubber cultivation:

Table VI exhibits the area of rubber cultivation by the surveyed families.

TABLE VI

AREA OF RUBBER CULTIVATION

Rubber cultivation (in acres)	Percent (N : 50)
Below 5	44
5 - 10	24
10 - 15	22
Above 15	10

Rubber is a major crop cultivated by all the surveyed families. The observation made by the investigator revealed that a majority of 44 per cent of the farmers cultivated the rubber within five acres and one fourth of item cultivated in 5 to 10 acres of land area. One third of the families raised the crop in more than 10 acres of land area, which proved that rubber was considered as the main source of income for the surveyed families. (Fig. 2).

Preparation of land

Rubber plantation in India are mostly situated on sloping and undulating lands. Since the area surveyed was hilly lands, adequate soil conservation measures were necessary when planted with rubber. Contour terracing was adopted by the farmers to protect against soil erosion. Pits with the size of 2 1/2' x 2 1/2' x 2 1/2' were excavated with the spacing of 22/11 or 20/11 and filled with compost and top soil. Silt pitting was practised by the people to check soil erosion. Soil conservation needs were partially satisfied by the construction of countur bunds with stone boulders. The stone bunds checked the surface run off and at the same time allowed the water to filter through the bunds. There were around 40 slit pits per acre in the surveyed areas with the size of 4' x 2 1/2' x 1 1/2'.

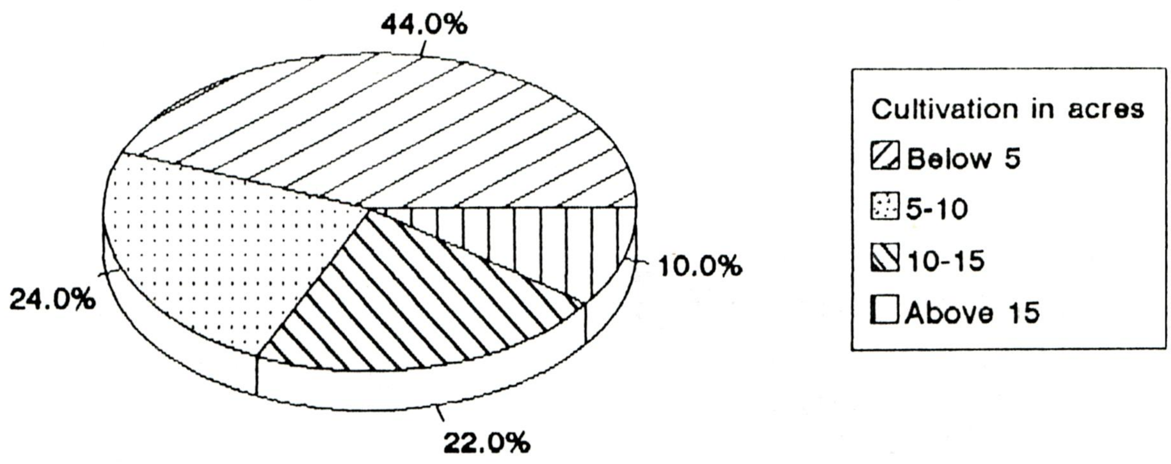


Figure 2
AREA OF RUBBER CULTIVATION

Propagation method

Budding method was adopted for propagation of rubber. Bud grafting consists of insertion of a strip of bark, containing a bud known as bud patch under the bark of young seedling stock and bandaged. The tissue of the bud patch and the seedling become firmly units within three or four week after grafting. Subsequently when the seedling stem is shown off above the grafter position the grafted bud sprouts and grows out to form the new shoot with the characters of the mother plant (Rubber Board, 1995).

Source of sapling

Table VII indicated the source of sapling for procurement.

TABLE VII

SOURCE OF RUBBER SAPLING

Source	Percent (N : 50)
Rubber board nursery	56
Private nursery	32
Self nursery	12

The budded rubber sapling was procured either from the private nursery/ rubber board nursery or developed in their own nursery. A majority of 56 per cent of the farmers procured rubber saplings from rubber board nursery. This might be due to good quality product and comparatively cheap in price. One third of the farmers procured the sapling from nearby private nursery. It is heartening to observe that 12 per cent of the large farmers had self nursery and the saplings were produced in their own nursery and made use of it for their personal plantation.

Selection of rubber species

The selection of rubber species depended upon the area, climate, latex production capacity and resistance to pests and diseases. Table VIII shows the rubber species selected for plantation.

TABLE VIII

DETAILS ABOUT RUBBER SPECIES

Species	Percent (N : 50)
RRII 105	78
RRM 600	18
PB5/81	10
GG-2	6
GG-1	4

Over three fourth of the farmers preferred latest variety of RRII 105 at IRRI (Indian Rubber Research Institute) because of high breed and immune to fungal attack. The latex could be collected after six years of its maturity. The other variety such as RRM 600, PB5/81, GG2 and GG1 were the conventional species found in the minority of surveyed families.

Planting

The number of saplings planted/acre varied from 150 to 180 depended upon the soil structure and the type of land. Since Kerala is getting good monsoon over the year, the surface and ground irrigation were not required for rubber plantation.

Mulching was done by the farmers before the onset of the regular summer. Usually the month of November was the ideal time for mulching to protect the plant from adverse effect of drought. Mulching with dry leaves, grass cutting and cover crop loopings around the plant was undertaken as a cultural operation for young clearings to prevent soil degradation and improvement of the water and plant nutrient holding capacity of the soil.

The manure was applied during the three stages of growth namely nursery, immature and mature stages. As recommended by Rubber Research Institute of India, the manurial requirement were adhered, containing NPk Mg 10:10:4:1.5. Cover crops were established and maintained in rubber plantation for the purpose of conserving soil, improving or maintaining of soil structure and fertility. Leguminous creepers were established as ground covers in rubber plantations (Plate I). They were helpful in keeping down the soil temperature during the summer months, suppressing weed growth and the proper utilization of fertilizer applied to the rubber plant.

Rain guarding was adopted by all the rubber growers to collect latex during monsoon period.

Plant protection:

Table IX exhibits the pests and diseases affecting rubber plantation, symptoms indicated and general measures adopted by the rubber growers.

PLATE 1. CULTIVATION OF RUBBER CROP

Shading provided for one year old rubber plant

Countur terracing adopted for rubber cultivation

Matured rubber plantation with ground cover crops

TABLE IX

PLANT PROTECTION MEASURES ADOPTED BY THE FARMERS

Disease caused	Symptoms	Control measures
Abnormal leaf fall	Falling of leaves in large number with black lesion out	Prophylatic spraying before monsoon
Patchcanker	Swelling and cutting panel burst with amber coloured liquid oozing out	Washing with 0.75% Dithane M.45
Powdery mildew	Tender leaf fall with ashy coating	Bavistin 0.05% spraying
Brown blast	General yellowish colouration and unhealthy plant	Not yet discovered
Pink disease	White or pink colouration in the bark	Prophylactic treatment
Birds eye spoting	Necrotic spots in young plants	Bordeaux mixture
White ants	Cutting of root and destroyed stem	D.D.T
Rat	Cutting of root	Rat poison

The observation made by the investigator showed that young plants of below three years old were normally affected by white ants and rats which damaged the tap root system. The pesticide D.D.T was sprayed to control white ants and trap to control rats. The farmers reported that the various types of diseases such as abnormal leaf fall, pink disease, patch canker, brown bast,powdery mildew and birds eye spoting affected the crops and the symptoms were noticed by them. The recommended pesticides were sprayed by the rubber growers at the suitable time to control pests and diseases.

Collection of latex

The latex produced /tree, quantity and frequency of collection, method of collection, and tappers engaged in collection of latex are detailed beneath:

Latex production

The quantity of latex produced/tree/year is exhibited in Table X and Fig. 3..

TABLE X

AMOUNT OF LATEX PRODUCED/TREE/YEAR

Amount (Kg.)	Percent (No.50)
4.5 - 5	44
5 - 5.5	54
5.5 - 6	2

The amount of latex produced per tree varied with the type of species, the climatic conditions, the area and the care and protection measures adopted by the farmers. The

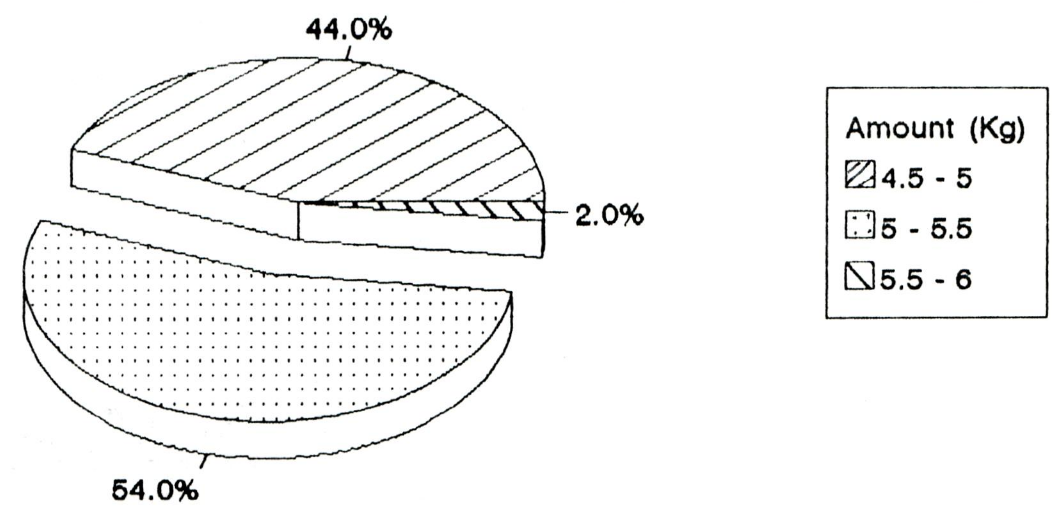


Figure 3

AMOUNT OF LATEX PRODUCED PER TREE PER YEAR

high yielding latex production was found in PRII 105 species in comparison with other species. On an average the latex production per tree per year was found to be 4.52. to 6 kg. A majority of 54 per cent of the beneficiaries stated that 5 to 5.5 kg. of latex was produced per tree per year followed by 4.52 to 5 kg. in 44 per cent of the families. An insignificant percentage of them (27 per cent) obtained an amount of 5.5 to 6 kg. of latex per tree per year.

Person in charge for the collection of latex

Tappers were involved by all the surveyed families to collect latex. The number of tappers engaged by the farmers varied from one to five based on the area of rubber plantation.

Frequency of tapping

Table XI shows the frequency of collecting latex by the tappers.

TABLE XI

FREQUENCY OF TAPPING

Frequency	Percent (N : 50)
Daily	14
Alternate days	66
Twice a week	20

Two third of the beneficiaries collected latex on an alternate day followed by 20 per cent twice a week. A majority of 14 per cent of them collected latex daily eventhough it was not advisable to practice.

Method of tapping

The main product form the rubber is latex, a milky white dispersion of rubber in water which was harvested by the process of tapping. Tapping was done by the workers called tappers, with a tapping knife. The latex that flows out from the rubber tree on tapping was channelled into a container attached to the tapping panel. Polythene cups or coconut shells were commonly used as containers in most of the estates. Latex collected in the cup was transfered to a clean bucket and then to a big can for easy transportation to the processing unit.

Quantity of latex collected :

Table XII shows the quantity of latex collected per day by the beneficiaries

TABLE XII

QUANTITY OF LATEX COLLECTED BY THE FAMILIES PER DAY

Quantity	Percent (No. 50)
Below 50	48
50-100	22
100-150	16
150-200	10
Above 200	4

It is revealed from the study that nearly half of the surveyed families collected less than 50L of latex per day. This might be due to the small land holding capacity of farmers who cultivated rubber plantation crop in less than five acres of land. One fifth of the surveyed families collected 50 to 100l of latex daily, 100-150l & by 16 per cent and 150 to 200l & by 10 per cent. Only a minority of 4 percent of them collected above 200l of latex per day from their rubber estate (Fig. 4).

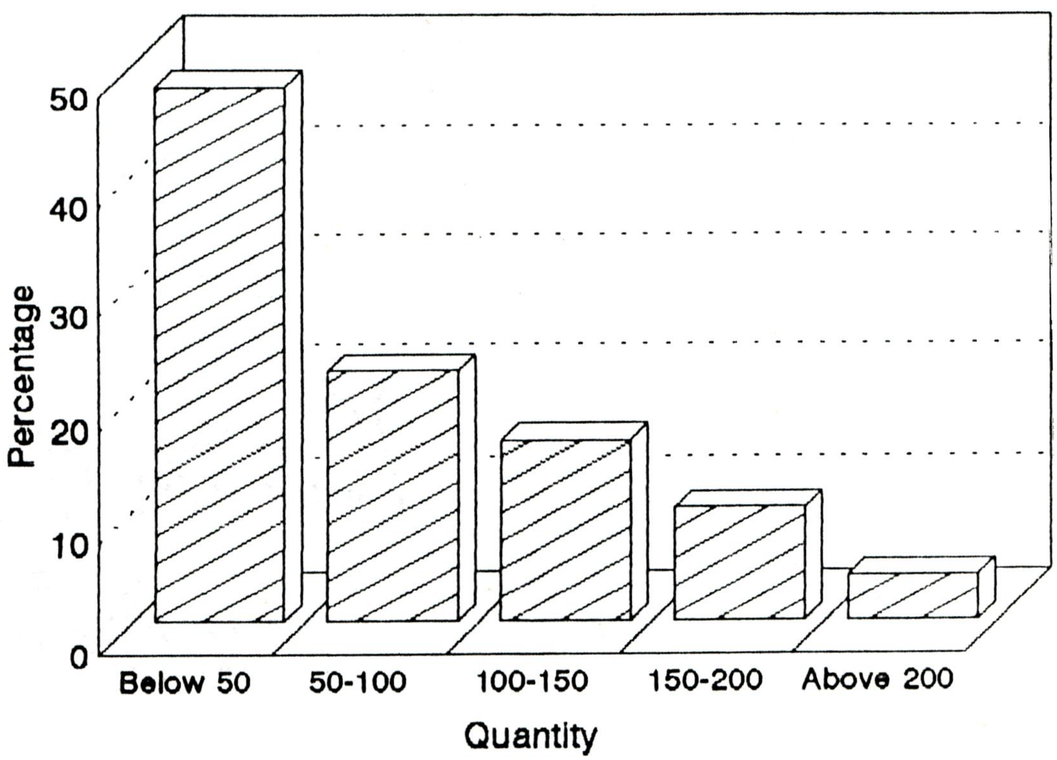


Figure 4
QUANTITY OF LATEX COLLECTED PER DAY

Tree lace, shell scrap and earth scrap

Latex which gets dried upon the tapping panel (tree lace) and the collection cup (shell scrap) also form part of the product and were collected by the tapers in a basket just prior to tapping. The latex split or over shelled on the ground (earth scrap) when dried up was also collected as scrap once in a month. Paul and Pothen (1996) remarked that 15 to 25 per cent of the total production is constituted by the tree lace, shell scrap and earth scrap which together called as field coagulum. The products were dried and stored in the smoke house and were taken along with the rubber sheets to the market.

Operation of latex processing unit

The details such as ownership of processing unit, functioning of the unit, details about the workers, production and marketability of rubber sheet are given beneath.(PLATE II)

Ownership of processing unit

Table XIII indicates the ownership of processing unit in the surveyed areas.

PLATE 2. COLLECTION OF RUBBER LATEX

Tapping

Pouring to a big bucket

Latex being collected in a container

Transfering into a jar for transportation

TABLE XIII

OWNERSHIP OF THE PROCESSING UNIT

Ownership of processing unit	Percent (N : 50)
Private unit	64
Common unit	30
Rented unit	6

It is noticed from the survey that two third of the families had private processing unit for the production of rubber sheets. About one third of them using common processing unit by the members in the same family. Only six percent of them depended on the rental units for the processing of rubber sheets.

Water quality

The water was found to be good in all the processing units in the surveyed areas.

Functioning of processing unit

The latex was collected by the tappers either daily or alternate days. The collected latex was strained through mesh to a big tank and mixed with equivalent quantity of water. An approximate quantity of three litre of this mixture was poured into the aluminium dish and mixed 250ml of dilute formic acid to each dish. This content was allowed to coagulate for a whole night. The coagulated content was pressed through a rolling machine and the resultant rubber sheet was dried under sunlight for a day. Then it was transferred to the smoke house for complete drying (Plate III).

Work pattern

It is understood from the study that the number of workers engaged in the processing unit depended up on the area of rubber cultivation. It is found from the survey that there were one to five workers involved in latex collection and processing in the surveyed farms. Generally, they used to work for eight hours from 6 a.m to 12 p.m.

When the tree was tapped and the vessel was cut, the pressure at the location of the cut was released and the viscous latex exudes. This exudation of latex would result in the displacement of latex along the length of latex owing to strong forces of cohesion existing in the liquid phase. Hence it was necessary to commence tapping early in the morning as late taping will reduce the exudation of tapping.

The workers of registered farmers were entitled to get medical allowances and pensions for the workers and scholarship for their children. It is heartening to observe

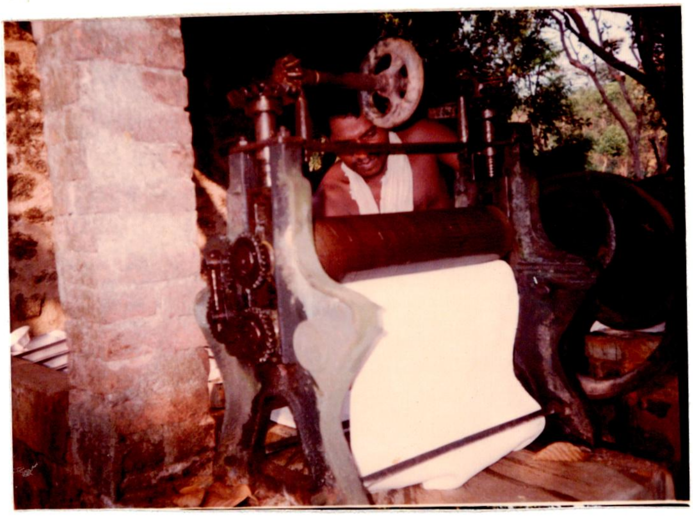
PLATE 3. PROCESSING OF LATEX FOR RUBBER SHEET PRODUCTION

Latex processing unit

Filtering of latex

Keeping for coagulation

Coagulated latex



Rolling of coagulated latex

Furnace of smoke house

Rubber sheet in a smoke house
for drying

that one third of the worker's children received scholarship from the Government through Rubber Board. About 28 per cent of the workers obtained medical allowances and 16 per cent of them got pension from the Government.

Only two per cent of the workers reported that they had skin irritation which might be due to the chemical used in the processing of latex.

Production of rubber sheet

About 1.5 to 2 l of latex was needed for the production of one sheet.

Table XIV depicts the production of rubber sheets by the rubber growers.

TABLE XIV

NUMBER OF RUBBER SHEETS PRODUCED BY THE GROWERS PER DAY

Number of sheet	Percent (N : 50)
20 - 40	44
40 - 60	26
60 - 80	12
80 - 100	8
Above 100	10

The observation made by the investigator revealed that a majority of 44 per cent of rubber growers produced 20 to 40 sheets per day followed by 40 to 60 sheets by 26 per cent and 80 to 100 by 12 per cent of them. Only 10 per cent of the large farmers of having above 7.5 acres produced above 100 sheets per day. It is also noticed that large land area was occupied by rubber cultivation (Fig. 5).

Weighing and grading

It is found from the survey that the weight of the sheet was ranged between 600 and 700g per sheet. Grading of rubber sheet was carrying out by visual examination. The completely dried sheets were removed to the packing shed where they were carefully inspected and graded according to the standards published by the Rubber Manufacturer's

Association (RMA) for ribbed smoke sheets as RSSIX, RSSI, RSS2, RSS3, RSS4 and RSS5 (Rubber Board, 1995).

It is found from the study that two third of rubber growers produced RSS4 grade sheets followed by RSS3 grade by 42 per cent. It is surprised to note that only two per cent of growers produced good quality second grade RSS, rubber sheets.

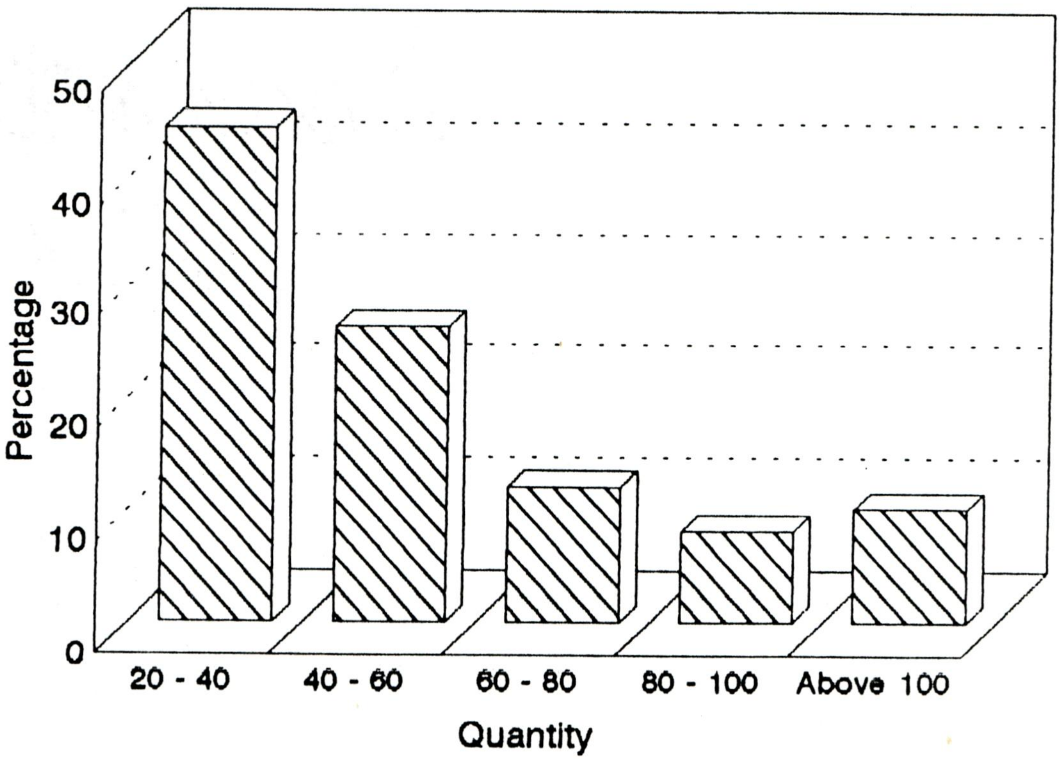


Figure 5

RUBBER SHEETS PRODUCED BY THE GROWERS PER DAY

Marketing of the product:

Table XV exhibits the marketability of rubber products of the farmers.

TABLE XV

MARKETABILITY OF PRODUCTS BY THE GROWERS

Particulars	Percent (N : 50)
Method of marketing	
Through middleman	94
Direct selling	6
Frequency of selling	
Monthly	72
Once in six months	28

A majority of 94 per cent of farmers sold their products to middle men and then to merchant. Only a minority of six per cent of them sold directly to the merchant. With reference to frequency of selling, two third of farmers sold their products once a month whereas the rest of them sold once in six months. Lorry or jeep was used for the transportation of their products to the market.

4. Economic benefits of rubber plantation

The production of rubber sheets from the latex processing units, tree lace, shell scrap and earth scrap from the plantation fetched a reasonable market value and the rubber growers received an attractive income from rubber plantation. It is heartening to note that the rubber cultivators could get Rs.1000 to Rs. 15000 per month as their main source of income from the rubber production.

Estimation and utilization of effluent water

The quantum of effluent water let out from the processing unit varied based on the production of rubber sheets. It was estimated by the investigator that on an average 200-1000 l of effluent water was let out daily from the latex processing unit of the surveyed areas.

All the rubber growers remarked that they were not utilized the latex effluent water from the processing unit for any purposes. It is disheartening to remark that they did not make an attempt to recycle effluent water. It is observed from the study that the effluent water was stagnated around the processing unit and created unsighty appearance and changed the soil characteristics, foul odour and smell. (Plate IV).

PLATE. 4. EFFLUENT WATER LET OUT FROM THE PROCESSING UNIT

Effluent water coming out from the processing unit

Unsighty appearance of stagnating effluent water

B. Composition of Rubber Latex

The composition of rubber latex was estimated and the data are exhibited in Table XVI.

TABLE XVI

COMPOSITION OF RUBBER LATEX

Particulars	Percentage
Rubber	30 - 40
Protein	2 - 25
Ash	0.7 - 0.9
Resin	1 - 1.6
Sugar	1 - 1.5
Water	55 - 60

It is clear from the table that latex was constituted with 30 to 40 per cent of rubber, 2 to 2.5 per cent of protein, 1 - 1.6 per cent of resin and 1 - 1.5 per cent of sugar. The ash was found to be less than one per cent (0.7 to 0.9 per cent). Latex contained 55 to 60 per cent of water molecules.

C. Generation of Biogas from Latex Effluent Water

The quantity of biogas generated from effluent water, composition of biogas and yield of biogas generation and methane content using different substrata are explained beneath.

1. Volume of gas generated from latex effluent water:

The total biogas production from latex effluent water was found to be 80 per cent during second week and above 90 per cent in the third week of retention period. The gas production was estimated by water displacement method in the experimental and the total yield of gas production was found to be 35 to 40 l/10 l of effluent.

2. Composition of biogas from latex effluent water

Table XVII depicts the approximate composition of biogas produced from rubber sheet processing unit.

TABLE XVII

COMPOSITION OF BIOGAS FROM LATEX EFFLUENT WATER

Components	Percentage
Methane	50 - 60
CO_2	30 - 40
H_2	5 - 10
H_2S	Trace
N_2	Trace

It is known from the analysis that the methane content was found to be 50 to 60 per cent and 30 - 40 per cent of carbon-dioxide. The other gaseous products were 5 - 10 per cent of hydrogen, and traces of hydrogen sulphide and nitrogen.

3. Biogas production and percentage of methane content with different substrate:

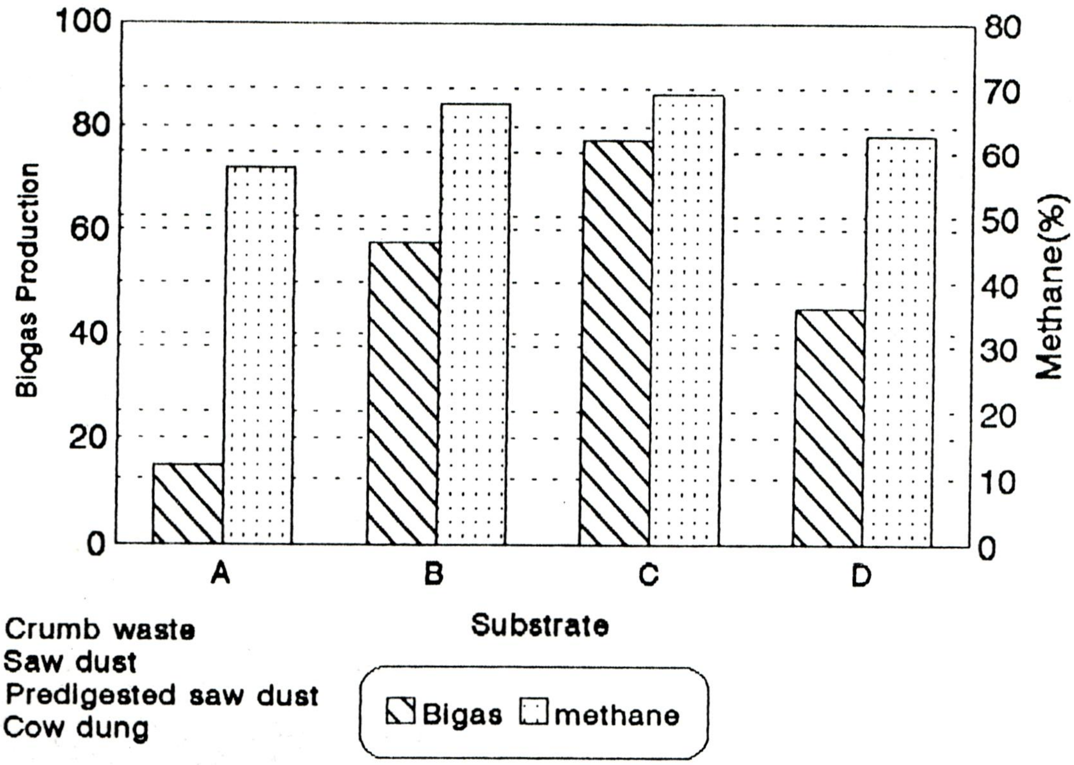
The different substrata such as crumb waste, saw dust, predigested saw dust and cow dung at the rate of 10 per cent were added with sheet processing effluent water separately in an experimental can and the increased yield of biogas production and methane content was estimated and the findings are given in Table XVIII and (Fig.6).

TABLE XVIII

INCREASED YIELD OF BIOGAS PRODUCTION AND METHANE CONTENT USING DIFFERENT SUBSTRATA

Substrata	Biogas production (ml x 10^3)	Methane (%)
Crumb waste	10 - 20	55 - 60
Saw dust	55 - 60	65 - 70
Predigested sawdust	75 - 80	68 - 70
Cowdung	40 - 50	60 - 65

Among the different substrata used for the experiment, predigested saw dust showed the highest yield of biogas production (75 - 80 l) followed by saw dust (55-60 l) and cow dung (40 - 50 l). The least production of biogas was found in crumb waste. When sheet processing effluent water was used without substrata, the gas production was found to be 35 - 40 l.



A. Crumb waste
B. Saw dust
C. Predigested saw dust
D. Cow dung

Figure 6

BIOGAS PRODUCTION AND METHANE CONTENT FROM DIFFERENT SUBSTRATA

4. Installation of latex effluent biogas plant

The experiment proved that latex effluent water could be used to form biogas generation hence this made the investigator to install a small sized two cubic metre capacity latex effluent biogas plant in one of the surveyed area of Varapatty in Ernakulam District (Plate - V).

It was bit below the ground level. The gas holder was the integral part of the digester and being a fixed dome the pressure was variable from 0-150 cm of water column. The cost of the construction of the biogas plant was Rs. 6000/-. The effluent was directed from the processing unit to the digester where anaerobic digestion takes place by the action of micro organisms. The digested treated effluent water was let out through the exit pipe line and directly used for irrigation. The gas generated from the latex effluent water was used for day's cooking and lighting during power failure (Plate - VI).

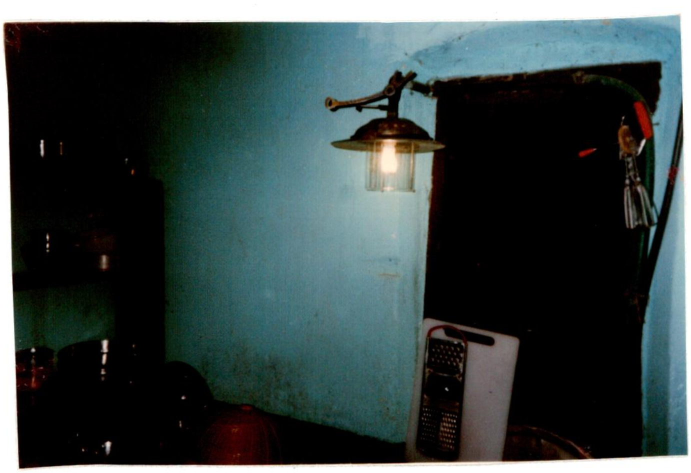
5. Opinion of the plant owner

After the installation of biogas plant the plant was kept under observation for a period of two months. The view of the plant owner about the utilization of latex effluent water for biogas generation was gathered by the investigator informally. The plant owner was satisfied with the performance of biogas plant. They stated that the gas was sufficient for cooking and also for lighting. They also

PLATE. 5. LATEX EFFLUENT BIOGAS PLANT INSTALLED

Underground plant with outside inlet and gas pipe

PLATE. 6. BIOGAS USED FOR COOKING AND LIGHTING



Used for lighting

Used for cooking

suggested that the gas could be used in smoke house of processing unit for drying of sheets and for operating generator and diesel engine.

It was easy to maintain the plant without any helper as the effluent was connected directly into the anaerobic digester. There was no recovery expenditure for the maintenance of the plant.

D. Physio-chemical Characteristics of Effluent Water:

Table XIX shows the physiochemical characteristics of effluent water from sheet processing unit.

TABLE XIX

PHYSIO-CHEMICAL CHARACTERISTIC OF EFFLUENT WATER

Particulars	Before	After
Colour	Milky white	Clear solution
Odour	Acidic	No odour
pH	4.6	6.0
Settleble solids	50	Nil
Suspended solids	140	Nil
Total solids	3745	70
Chemical oxygen Demand (COD)	3300	30
Biochemical Oxygen Demand (BOD)	2630	10
Ammoniacal nitrogen	10	Nil
Albuminated nitrogen	100	Nil

The physical characteristics of raw effluent water was milky white with acidic odour. When the effluent water was treated under anaerobic decomposition, the colour was found to be clear without any odour or smell.

It is heartening to note that there was a complete reduction of settleble solids, suspended solids, ammoniacal nitrogen and albuminated nitrogen. There was a marvelous reduction of total solids from 3745 mg/l to 70 mg/l chemical oxygen demand from 3300 mg/l to 30 mg/l and the Biochemical Oxygen Demand from 2630 mg/l to 10 mg/l. The percentage of reduction was from 98.1 to 99.6 and the pH of raw effluent water was 4.6 i.e too acidic whereas the pH of the treated effluent water was neither too acidic nor too alkaline.

E. Manurial value of Biodigested Slurry

Table XX exhibits the manurial value of biodigested slurry samples.

TABLE XX

MANURIAL VALUE OF SELECTED SPENT SLURRY

Treatment	Percentage		
	Nitrogen	Phosphorus	Potassium
Crumb waste + sheet processing effluent	1.92	0.92	0.78
Saw dust + sheet processing effluent	1.82	0.80	0.68
Predigested sawdust + sheet processing effluent	2.26	0.92	0.78
Cowdung + sheet processing effluent	1.95	0.90	0.76

The biodigested slurry obtained after the generation of gas production contained the major plant nutrients viz. nitrogen, phosphorus and potassium.

Among the four treatments, the quality of predigested saw dust slurry sample was found to be the best in comparison with other slurry samples (2.26 per cent N, 0.92 per cent P, 0.78 per cent K.

Eventhough the gas production was not satisfactory with crumb waste, the manurial value was found to be better ranking next to cow dung slurry. (1.92 per cent nitrogen, 0.92 per cent phosphorus, 0.78 per cent potassium). The cow dung slurry from the latex effluent biogas plant ranked second in the plant nutrients such as (nitrogen 1.95 per cent) phosphorus (0.90 per cent), potassium (0.76 per cent). The plant nutrient such as nitrogen (1.82 per cent), phosphorus (0.80 per cent) and potasium (0.68 per cent) were found to be less in saw dust slurry sample, but it seemed to be good compared to conventional organic compost.

Summary and Conclusion

V SUMMARY AND CONCLUSION

A study on "Biogas Generation from Latex Effluent Water" was carried out at Ernakulam District of Kerala state to find out the processing of latex for rubber sheet production and to try the possibility of recycling effluent water for biogas generation.

The findings of the study are summerised under the following aspects:

A. Socio-economic Profile of Surveyed Families:

About 58 per cent of the surveyed families belonged to small family category of having one to three members. A majority of 88 per cent of them belonged to nuclear family. About 58 per cent of the families had R.C.C. houses. Christians were found to be predominant (84 per cent) in the surveyed areas of Ernakulam district.

It is heartening to note that both heads of the families and homemakers were literate with the minimum qualification of S.S.L.C. It is observed from the study that nearly half of the heads of the families and homemakers were graduates.

With regard to the occupational status, about one third of them were agriculturist and 40 per cent of them engaged in business. All the surveyed families belonged to high income category of earning Rs. 5000/- and above per month.

B. Cultivation Aspects of Rubber Crop

The surveyed families were almost equally distributed under marginal (2.5 - 5 acres), medium (5 - 7.5 acres) and large category of farmers (above 7.5 acres). Over half of the surveyed families cultivated rubber in above five acres of land area. Since the surveyed area was a hilly region, contour terracing was adopted by the farmers to protect against the soil erosion.

A majority of 56 per cent of the farmers procurred budded rubber saplings from Rubber Board Nursery. It is interesting to note that 12 per cent of the large farmers had their own nursery where the saplings were developed and used for plantation. About 150-180 saplings per acre was planted in the surveyed areas.

A majority of 78 per cent of the farmers preferred RRII 105 species developed at Indian Rubber Research Institute because of high breed and resistance to fungal attack. Mulching, ground cover crops, rain guarding, manuring and spraying pesticides were adopted by the farmers as protective measures.

C. Collection and Processing of Latex

Tappers were engaged by the farmers to collect latex. On an average the production of latex per tree per year was found to be 4.5 to 6 kg. The observation made clear that about one to five tappers were involved in the collection and processing of latex per day for eight hours. About 52 per cent of the surveyed families collected above 50 l of latex per day from their rubber estate.

The surveyed families produced rubber sheet since 1965 onwards. Nearly two third of the families had their own processing unit with the size of 150 to 600 sq. ft area whereas 30 per cent of them occupied a common unit for rubber sheet production.

The latex collected by the tappers was strained through mesh and mixed with equal quantity of water. The mixture was then poured into an aluminium dish and formic acid was added into it and kept for coagulation. The coagulated rubber sheet was pressed under rolling machine and the sheet was sun dried for a day. Then it was taken to the smoke house for complete drying.

The workers of registered farmers availed benefits such as medical allowance, pension and scholarhsip for their children's education. It is surprised to note that 56 per cent of the surveyed families produced above 40 sheets per day.

D. Marketability of the Product

The weight of the sheet was ranged between 600g to 700g per sheet. Only two third of the rubber growers produced RSS4 grade rubber sheet followed by RSS3 grade by 42 per cent. It is surprised to observe that only two per cent of the growers produced second grade RSS1 rubber sheets. It is heartening to observe that one fifth of the surveyed families obtained above Rs. 10000 per month as a regular income from the rubber sheet processing unit.

A majority of 94 per cent of farmers sold their products through middle men whereas a minority of six per cent of them sold directly to the merchant.

E. Generation of Latex Effluent Water

On an average 200 to 1000 l of effluent water was let out daily from the latex processing unit of the surveyed families. The effluent water was stagnated around the processing unit and polluted the environment. The farmers did not adopt any recycling technique to safeguard the environment.

F. Composition of Rubber Latex

It is interesting to note that about 30 to 40 per cent of rubber was constituted in the latex and the water molecule was found to be 55 to 60 per cent. The other contents noted were protein, resin, sugar and ash.

G. Production of Biogas from Latex Effluent Water

It was proved from the trial experiment that the generation of biogas was noticed after two weeks of the retention period. The generation was maximum during the third week and the total yield of gas production was found to be 35 to 40 l/10 l of effluent.

Among the different substrata taken for the experiment, 10 per cent of the predigested saw dust showed the highest biogas production of 75 to 80 l followed by saw dust (55 to 60 per cent), cow dung (40 to 50l) and crumb waste (10 to 20 l). In all the samples the methane content was ranged from 55 to 65 per cent, indicating the high percentage of 68 to 70 per cent in the predigested saw dust sample.

H. Composition of Biogas from Latex Effluent Water

It is found from the analysis that 50 to 60 per cent of methane,30 to 40 per cent of carbon-di-oxide, 5 to 10 per cent of hydrogen and traces of gaseous products such as hydrogen sulphide and nitrogen were found in the latex effluent water.

I. Installation of Latex Effluent Biogas Plant

Two cubic metre capacity fixed dome type biogas plant was construced in the surveyed area of Varappatty Village of Ernakulam district. The observation made by the investigator showed tha the plant was functioning well and providing required quantum of biogas for cooking and lighting. Biogas requirement for cooking was found to be 0.3 m^3 and for lighting 0.2m^3 per day.

J. Physio-chemical Characteristics of Effluent Water

The physical characteristics of raw effluent water was found to be milky white with acidic odour, but the effluent water after gas production showed a satisfactory remark of clear colour and free from odour and smell.

It is heartening to observe that there was a complete reduction of settleble solids, suspended solids, ammoniacal nitrogen and albuminated nitrogen in the digested effluent water. There was about 98.1 to 99.6 percentage of reduction of total solids, chemical oxygen demand and biochemical oxygen demand observed in the digested effluent water.

K. Plant Nutrients of Biodigested Slurry Samples

It was found from the analysis that the high quality manure was observed in the predigested saw dust slurry sample (nitrogen 2.26 per cent, phosphorus 0.92 per cent and potassium 0.78 per cent) followed by crumb waste, cowdung and saw dust slurry samples.

CONCLUSION

The volumenous amount of effluent water from the existing factories, emergence of more and more processing centers, and extension of rubber cultivation in non traditional areas necessitated the rubber growers to set up a latex effluent anaerobic digester for the generation of biogas, which required comparatively low energy leading to minimal production of biological sludge which is a good organic manure. It could be said that the study would throw insight into the field of biogas technology and recycling latex effluent water for the protection of environment and to assure a better living.

Bibliography

BIBILIOGRAPHY

Anglo,P.H., Tanaka,R.H. and Haga,K. (1978). Production and desulfurisation of biogas from swine waste.

Baclik,A.T., Karim,M.Z., Poon,Y.C., Lim,C.H. and John,C.K. (1987). Land Application of Rubber Factory Effluent, Planters Bulletin, Vol. 192 :)0.63.

Balagopalan,M. 1995. Change in the distribution of organic carbon and different forms of nitrogen in soils under natural forests and teak plantations. Proceedings VII Kerala Science Congress, pp. 110-112.

Bansal,M.K., Mittal,C.P., Sandhi,H.S. and Neelakanthe,S. (1977). Biogas production during anaerobic digestion of live stock excreta, Indian Journal of Airy Science, 30:338-340.

Bousfield,S., Hobson,P.N. and Summers, R. (1979). A note on anaerobic digestion of cattle and poultry waste. Agricultural wastes 1:161-163.

Bristow,G.M. and Sears,A.G. (1985). A new comparison of sheet and crumb waste Part II. some aspects of processing, Jawa National Rubber Research, 4(1), 22-40.

Chattopadhyay,S. (1985). Deforestation in parts of Western ghat region (Kerala). India, Journal of Environmental Management, Vol.2, Pp. 229-230.

Chattopadhyay,S., Velayudhan,S. and Salim,M.B. (1986). Trends of Deforestation in Kerala, Indian Environmental Problems and Prospective, Geological Society of India, Bangalore, Pp. 289-298.

Chick,W.H. (1972). Initial studies of BOD from latex concentrate factories. Dunlop Estate Berhad Research Department Communication, Malaysia, Pp. 41-42.

Chick,W.H. (1973). Methods of pollution control for latex concentrate factory effluents, Dunlop Estate, Berhad Research Department Communication, Malaysia, Pp 15-18.

Canel,E. and Young,M. (1980). Solid state fermentation systems. Process Biochemistry, Vol. 15:2-7.

Chuwla,O.P. (1973). Winter and cowdung gas plant. Indian Farming, Vol.23, Pp. 29-30.

Daliya,P.K. and Vasudevan,P. (1986). Biogas Plant slurry as a alternative to chemical fertilizers, Biomass, Vol.9, Pp. 67-74.

De Renzo,D.J. (1977). Energy from bioconversion of waste materials, Noyes Data Co., New Jerssey, Pp. 178-181.

Deepika - The Daily News Paper (1997). February, 12th P.1 .

Dolmat, M.T. (1978). Agricultural Utilization of Rubber Factory Effluent, A Review of its Potential, IRRDB Symposium, Kulalumpur, Malaysia, Pp. 337-339.

Dolmat,M.T., Karim,M.Z. and Pillai,K.R. (1979). Land disposal of rubber factory effluent: It's effects on soil properties and performance of rubber and oil palm.

Fang,R.M., Situ,H., Deng,H. and Li, A.L. (1985), A research on biogas from typical rubber processing effluents. Environmental Pollution Control Board, Lie Ping, Vol.7, Pp. 18-22.

FAO (1981). A Report on Forest Resource of Tropical Asia. Rome, U.N. Pp.1-3.

FAO (1990). Interim Report on Forest Resource Assessment, Project Committee on Forest, 10th Session Rome, U.N. Pp 23-25.

George Tharian, K., Haridasan,V. and Sree Kumar, B. (1988), Role of Government and Structural Changes in Rubber Plantation Industry, Economic and Political Weekly, November, Pp. M. 158-M.116.

George,C.M. (1996). Global Development in Processing of Centrifugal Latex, Seminar on Latex Processing and Pollution Control, Thie Department of Processing and Product Development, Kottayam, Pp. 1-2.

Gupta, S.P. (1991). Statistical Methods, Sultan Chand and Sons Publishers, Delhi, Pp. E 4.3 - 4.9

Hashimate,A.G. (1989). Effect of Inoculum/substrate ratio on methane yield and production rate from straw, Biological waste, Vol.28:247-255.

Hobson,P.H. (1982). Production of biogas from agricultural wastes. In advances in Agricultural Microbiology, Oxford and IBH Publishing Co. Mew York, Pp. 523-525.

Hobson,P.H. and Shaw,B.G. (1976). Inhibition of Methane Production by Methano Bacterium Formicium. Water Research, Vol.10 : Pp.849-850.

Hobson,P.H., Bas field,S. and Summers,R. (1981). Microbilogy and Biochemistry of Anaerobic digestion. Methane Production from Agricultural and Domestic Wastes. Applied Science Publishing Ltd. London, Pp. 10-28.

HUDCO (1994). Housing and Finance, Publishing Division, Patiala House, New Delhi, Pp. 371.372.

Janne,J. (1992). Changing face of families in Modern Era. St. Joseph Publishers, Pala, Pp. 42-43.

Jesger,D.E. Dolue D.A. and Chynoweth,D.P. (1982). Bioconversion of woody biomass as renewable source of energy Biotechnology and Bioengineering symposium, Vol. 12, 233-334.

Jinghua,W. (1990). Regional Geochemistry of Rubber Plantation in Hainan Island of China, The Journal of Chinese Geographer, Vol.1, Pp. 79-81.

Jimenez,S., Categena,M.C. and Aree,A. (1990). Influence of Lignin on the methanisation of Lignocellulosic wastes, Biomass, Vol.21, Pp.43-45.

Jose Paul,M. and Pothan,K. (1996). Latex quality, A glove manufacturer's view. AVT Rubber product Ltd. Seminar in Latex Processing and Pollution Control, October, Pp.3-5.

John,C.K. Ponniah,C.D., Lee,H. and Ibrahim,A. (1974). Treatment of effluent from Block Rubber Factories, Proceedings of RRIM planters conference, Kualalumpur, Malaysia, Pp.229-231.

John,C.K. Ping,L.C. Wony,K.Y. (1975). Treatment of Rubber Factory Effluent Using Rotation Bio-disc system.P. 14-20.

John,C.K., Wahab,W.H.H., Kasim,M.Z., Pushparaj,E. (1977). Utilizaton of waste from rubber producing factories, Planter, Vol.53. Pp. 449-450.

Kalia,V.C., Kumar,A., Jai,S.K. and Joshi,A.P. (1992). Biomethane of Plant materials, Bioresource Technology, Vol.41, Pp. 209-211.

Karim,M.Z., Beelik, A.T. and Judi,A.W.M. (1989). Effect of land application of rubber factory effluent in ground water and stream water. Qualities Proceedings of RRIM Rubber Growers Conference, Mekaca, Malaysia, Pp. 565-567.

Karthikakutty Amma, Suresh,P.R., Valsala,G., Aiyer,R.S. and Mathew,M. (1996). Effect of continuous cultivation of rubber on total available nitrogen status of soil. Proceedings of VIII Kerala Science Congress, Pp. 80-82.

Kerala State Land Use Board (KSLUB) 1996. Land Resource of Kerala State Thiruvanandapuram, Pp 80,81.

Kothandaraman,R. and Nair,M.K.B. (1978). Natural Rubber Processing and Environmental Pollution, Rubber Board Bulletin. Kottayam, Vol.13, Pp. 41-42.

Kothari, C.R. (1997). Research Methodology, Methods and Techniques, Wishwa Prakashan, Delhi, Pp. 128-129.

Kulkarni, P.R. and Stalin,W.R. (1973). Utilization of Rubber Effluent. Planter, Vol.49, Pp 359-361.

Malayala Manorama Year Book (1995). Malayala Manorama, Cochin, Pp. 238-239.

Mathew,J. Kothandaraman,R. and Joseph, K. (1987). Economic utilization of effluent from sheet rubber processing factories, AIWPAC Technical Annual, Vol.14, Pp. 23-26.

Mathew,J., Kothandaraman, R. (1991). Airation and Algal culturing, A method of Biological treatment fro crumb rubber processing factory effluent, Journal of Plantation Crops, RRIM, Kottayam, Vol.18, Pp 328-331.

Mathew,J., Kothandaraman,R. and Kochutheresiamma, J. (1996). Environmental impact of natural rubber processing waste and waste management, Seminar on Latex Processing and Pollution Control, Rubber Board, Kottayam, Pp. 28-29.

Naimah,I., Zainele,E. and Yoon, P.K. (1992). Rubber, A social economic environment friendly industrial product. Paper Presented at Third World Organisation of Women Science Conference, Cairo, Egypt, January, Pp.39-40.

Nair,B. and Sebastian, J. (1996). Production of crepe rubber from latex coagulation. Seminar on latex processing and pollution control, Rubber Board, Kottayam, P.28.

Natural Rubber (1994). Rubber Board, Kottayam, Pp. 2-48.

Natural Rubber (1996). Rubber Board, Kottayam, Pp. 3-75.

NEERI (1991). Report of director, NEERI, Nagpur, P. 20.

Polhamus,L.G. (1992). Rubber Production and Utilization, Rubber Botany, London, P.18.

Rajammal,P. (1989). A Hand book of Methodology of of Research, Sri Ramakrishna Mission Vidyalaya, Coimbatore, Pp. 22-23.

Redclift,M. (1987). Sustainable Development, Exploring the condition, Methun, London, P. 217.

Repetto,R. (1987). Pollution, Resources, Environment and Uncertain future. Pollution Bulletin, Vol.42, Pp.11-24.

Rubber Board (1993). Rubber and its cultivation VIIIth Rubber Growers Conference, Kottayam, Pp.94.

Satheesan,K.V., Gururaj,R. and Sethuraj,M.R. (1984). Canopy photosynthesis in rubber, Advances in photosynthesis research, Rubber Board, Kottayam, Pp. 125-128.

Satheesan,K.V. Jayakumar,M., Varadan,K.M. and Unni,R. (1993). Effect of conversion of natural forest into plantation crops and water use in western ghats, Proceeding of Vth Kerala Science Congress, Pp. 71-73.

Saravanave,P. (1996). Research Methodology, Kithab Mahal, Allahabad, Pp. 142-143.

Sivanandyan, K. and Gandimathi and Haridas, G. (1991). Rubble, A unique crop, Rubber Board, Kottayam, Pp.41-42.

Sivanadyan,K. and Norhayati Moris (1992). Consequence of transforming tropical rain forests to Hevea Plantation, Paper presented at FADINAP Regional Seminar on Fertilisation and Environment, Chiang Mai, Thailand, September, Pp. 19-25.

Soman,M.K., Krishnakumar,K., Singh,N. (1988). Decreasing Trend in the rainfall of Kerala. Current Science, Vol.57, Pp 7-12.

Soman,M.K., Mahamaya,C., Ouseph,P.P. (1996). Status of Rivesrine pollution in South Kerala and its Relation to Physiography and Land Use Paper Communicated for Xth Kerala Science Congress, Pp. 18-20.

The Rubber Growers Companion (1995). Rubber Board, Kottayam, Pp. 1-178.

Turjanma,K. (1993). Latex protein allergy. The present position of production, Gramin Communication and Rubber Consultants, U.K. Pp-111.

Varma, H.P. (1993). Educational Research, V.H.M. Publishers, Agra, Pp. 141-144.

Zanner, E. (1986). Methane production from Esiled Plant Materials. Biomass, Vol. 10 : 207-210.

Appendix

APPENDIX - I

AN INTERVIEW SCHEDULE TO ELICIT INFORMATION ON LATEX PROCESSING UNITS AT ERNAKULAM DISTRICT IN KERALA STATE

Name of the interviewee:

Date :

Name of the interviewer

Address

I General Details

1. Size of the family

Small (1 - 3 members)	Medium 4 - 6 members)	Large (above 6)

2. Family type

Nuclear   Joint

3. House structure

RCC   Tiles   Thatched

4. Religion

Hindu   Muslim   Christian

II Socio-economic Background :

S. No	Name of the members	Relation-ship to the head of the family	Sex	Education	Occupation	Income in Rs.

1. Income from other sources :
   Investment
   Rent
   Subsidiary occupation
   Poultry
   Piggery
   Dairy
   Vegetable gardening
   Any other

2. Total income per month :

III Details About Land Holdings

Type of land	Area in acre		Total land in acres
	Plain	Hilly	
Wet			
Dry			
Total			

1. Whether you have owned the land property through:

   Heridity
   Self earning

IV Crops Cultivated by Farmers :

Major crops cultivated	Area cultivated		
	Wet land	Dry land	Total
Perennial crops			
Rubber			
Coconut			
Cocoa			
Nut omica			
Food crops :			
Paddy			
Wheat			
Millet			
Cash crops :			
Banana			
Tapioca			
Pineapple			

V. Details about Rubber Farming:

1. How did you prepare land area for rubber cultivation?

2. Method of propagation

   Seed
   Budding
   Grafting
   Cutting

3. Method of cultivation of rubber

4. Where did you procure the seedling/sapling?

5. Details about rubber plantation crops

S. No	Name of rubber species	No. of rubber trees/ acres	Frequency of irrigation				Year of cultivation	App. amount of latex produced/ tree
			Once in month	Once in 6 month	Once in a year	Depend upon rain		

6. Type of pests attacking the rubber crops

7. Nature of diseases and its causes

Name of the disease	Causes

8. Protective measures for rubber crops

Measures adopted	Time	Frequency
Spraying		
Bark coating		
Rain guarding		
Manuring		
Basal manure		

VI Details about the Collection of Latex

1. Person involved in the collection of latex
2. Frequency of collection

   Daily
   Alternate day
   Twice in a week

3. Quantity of collection/day in (l)
4. Do you adopt any protective measures during the collection of latex?

   Yes No

5. If yes mention it

VII Details about the Latex Processing Unit:

1. Whether the processing unit is a

   Private ownership
   Common unit
   Rented unit

2. Total capital investment of the processing unit

Particulars	Year of procuring	Rate/Cost
Area :		
Processing unit		
Drying unit		
Major equipment:		
Rolling machine		
Weighing machine		
Minor equipment :		
Any other		

3. Source of financial assistance

Bank
Co-operative society
Rubber board
Money lenders

4. Are you a member of co-operative processing unit?

Yes No

5. If yes, how much you paid as membership?

6. How many members are registered under this?

7. What are the advantages and disadvantages of this system?

Advantages:

Disadvantages:

8. If you are using a rented unit how much you are paying as rent per month?

9. Mention the advantages and disadvantages of a rented unit?

Advantages:

Disadvantages:

10. Do you have good water supply?

Yes No

If yes, is it a
hard water

Soft water

11. Which type of dishes you are using to set the latex

Plastic
Aluminium
Any other

VIII Indicate the Functions of the Processing and Drying Units

IX Particulars about the Workers:

1. No. of workers

Male :
Female :

2. Duration of working hours

Morning
Afternoon
Total hours/day

3. Wages of workers/day

Male :
Female :

4. Are the workers getting any help from the government?

Yes No

If yes, mention it

5. Are you giving any protective measures to the workers?

6. What are the main health problems of the workers?

7. What are the main causes for this health problems?

X Details about the Production of Sheets:

S. No	Latex needed/ one sheet	Rubber			Other product			
		Total No	Weight	Grade	Scrab	Black	Froath	Shell

1. What are the raw materials needed for the production of sheet?

XI Marketing Facilities Availed by the Farmers:

1. Direct selling to the purchaser
2. Through middle men
3. Through co-operatives
4. How often you market the products?

   Weekly
   Monthly
   Once in two weeks
   Once in six months
   Any other

5. Mode of transportation

Type of transportation	Quantity/trip	Transportation charges
Lorry		
Jeep		
Bycycle		

XII Profit Obtaining from the Processing Unit:

1. How much do you earn from your latex unit?

XIII Details about the Latex Effluent Water from the Processing Unit :

1. What are the main waste from the processing unit?

2. Give the approximate quantity of effluent water from the processing unit?

3. How do you collect the water from the processing unit?

4. What is the distance from the processing unit to the tank?

5. What is the capacity of the tank?

6. Do you have any provision to protect the tank from the surroundings?

   Yes No

   If yes, what is it?

7. Did you experience any harmful effect to the environment?

   Yes No

8. If you are not using any recycling method, What you will do with the effluent water?

9. What are the main pollutant you observed in effluent water?

10. Do you think that effluent water is useful for irrigation?

11. Are you aware of any latest technology of recycling effluent water?

    Yes No

APPENDIX II

ESTIMATION OF CHEMICAL CHARACTERISTICS OF EFFLUENT WATER

pH

The pH of the liquid samples was determined using a pH meter at the time of collection. For solid samples, 5 g of powdered residue was resuspended and mixed with 25 ml of distilled water and pH measured.

SETTLEBLE SOLIDS (DS)

The filtrate was evaporated in a tarred porcelain dish, preheated to $550^{o}C \pm 50^{o}C$ and cooled. The dish was heated at $105^{o}C$ for about 1 hour, cooled and weighed to determine the DS as,

$$\text{Dissolved solids, mgl}^{-1} = \frac{(A-B) \times 1000}{V}$$

where

A = Weight of dried residue with dish

B = Weight of dish

V = Volume of filtrate used in ml.

$$\text{Settleble solids, mgl}^{-1} = \frac{(A-B) \times 1000}{V}$$

Where

A = Weight of dried residue with dish

B = Weight of dish

C = Volume of filtrate used in ml.

SUSPENDED SOLIDS

A filter disc was placed in a Gooch crucible and washed with three changes each of 20 ml distilled water, vacuum suction was used to remove all traces of water.

Hundred ml of a well mixed sample was filtered through the dried and weighed crucible under vacuum, the crucible assembly dried at 104 + 1 C for h in an oven, cooled in a desiccator and weighed. The filtrate was preserved for the determination of dissolved solids. The weight of suspended solids was calculated as

$$\text{Suspended solids, mgl -1} = \frac{(A-B) \times 1000}{V}$$

Where

A = Weight of dried residue with dish

B = Weight of dish

C = Volume of filtrate used in ml.

TOTAL SOLIDS (TS)

A clean evaporating dish was heated at 550 + 50 C for 1 h in a muffle furnace, cooled, weighed and stored in a desiccator. Hundred ml of the sample was transferred to the dish and evaporated to dryness in a steam bach. The evaporated sample was dried for 1 h at 104 + 1 C. Then the dish was cooled in the desiccator and weighed. The weight of the TS content was determined as,

$$\text{Total solids, mgl -1} = \frac{(A-B) \times 1000}{V}$$

Where

A = Weight of dried residue with dish

B = Weight of dish

C = Volume of filtrate used in ml.

CHEMICAL OXYGEN DEMAND (COD)

In a round bottomed flask, 20 ml of the sample was taken and to this 0.4 g mercuric sulphate, 10 ml potassium dichromate solution and 30 ml silver sulphate-sulphuric acid solution were added. The contents of the flask were refluxed for 2 h, cooled and washed down the condenser with about 25 ml of distilled water. Then the contents of the flask were transferred to a 500 ml conical flask, washing out the reflux flask 4 to 5 times. Then the mixture was diluted to 140 ml and the excess dichromate was titrated against ferrous ammonium sulphate solution using ferrous indicator, the end point being given by the change of colour from bluish green to reddish brown. A blank was run in the same manner.

$$\text{COD (mgl -1)} \quad \frac{a - b \times N \times 8000}{V}$$

Where

a = Blank titre value

b = Sample titre value

c = Normality of ferrous ammonium sulphate

d = Volume of sample taken (ml)

BIOCHEMICAL OXYGEN DEMAND (BOD)

Dilution water was prepared by adding 1 ml each of phosphate buffer, calcium chloride, magnesium sulphate and ferric chloride solutions to 1 l of distilled water and saturating it with air for 24 h. One per cent solution of known volume of the sample was pipetted into BOD bottles which were filled with dilution water and stoppered avoiding entrapment of air bubbles. The DO in the effluent sample was determined previously. The diluted sample and a blank dilution water were incubated for 5 days at 20° C. After 5 days the DO in the incubated sample and blank was determined and the BOD was calculated.

AMMONICAL NITROGEN

Hundred ml of the sample was taken, pH was adjusted to 10.5 by adding 1 ml of zinc sulphate solution and 0.5 ml sodium hydroxide. After setting the supernatant was filtered through whatman No. 42 filter paper. Aliquot of sample of 2.0, 4.0, 6.0, 8.0, 10.0, 12.0, and 15.0 ml were taken and each diluted to 50 ml. One drop of EDTA was added and mixed well. Two ml Nessler's reagent was added and the volume made up to 100 ml, mixed well and after 10 min, percentage transmission was read at 410 nm in a Spectronic curve using suitable aliquots of standard solution was prepared.

ALBUMINATED NITROGEN

Hundred ml of the sample was taken in a Kjeldahl flask. Ten ml concentrated sulphuric acid and 1 ml copper sulphate solution were added to this and boiled under a hood until the solution became clear and was then allowed to cool.

The contents of the flask were transferred to a distillation flask and diluted to about 300 ml. This solution was made alkaline with sodium hydroxide using phenolphthaline indicator. The distillate was collected in 50 ml boric acid solution in a conical flask.

Two hundred ml of the distillate was collected and 0.5 ml mixed indicator solution added. This was titrated against 0.02 N sulphuric acid. End point was the colour change from pale green to lavender. A blank was also run simultaneously.

$$\text{Albuminated nitrogen} = \frac{(A-B) \times 280}{V}$$

Where

a = ml 0.02 NH2 SO4 required for sample

b = ml 0.02 NH2SO4 required for blank

v = Volume of sample