# ANAEROBIC DIGESTION OF POULTRY WASTES FOR BROODING APPLICATION

*Thesis submitted in part fulfilment of the requirement for the award of the degree of*
***MASTER OF ENGINEERING (AGRICULTURE)*** *to the*
*Tamil Nadu Agricultural University, Coimbatore*



By

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# CERTIFICATE

This is to certify that the thesis entitled **"ANAEROBIC DIGESTION OF POULTRY WASTES FOR BROODING APPLICATION"** submitted in part fulfillment of the requirements for the award of the degree of **MASTER OF ENGINEERING (BIO ENERGY)**, faculty of Agricultural Engineering to the Tamil Nadu Agricultural University, Coimbatore is a record of bonafide research work carried out by **R. MAHENDIRAN** under my supervision and guidance and that no part of this thesis has been submitted for the award of any other degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journal or magazine.

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**Mahendiran R.**

# Abstract

## ABSTRACT

# ANAEROBIC DIGESTION OF POULTRY WASTES FOR BROODING APPLICATION


By

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| | | |
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Unscientific methods of collection and disposal of waste has unfortunately led to increase in pollution and environmental degradation, posing a serious hazard to public health and environment. The problem is getting worst in the case of waste generated from the poultry industries. The poultry industries are also struggling to pay the rising cost of the electricity which is mainly used for brooding and incubation operations. Sometimes the poultry industry is facing heavy losses because of frequent power failure. The biomethanation of various substrates for energy production has to come to stay as a viable solution for energy crisis.

Even though poultry waste had also tried as alternate feedstock for biogas production, the main constraint was reported as due to inhibition of ammonia since the ratio of poultry waste and cowdung has to be optimized. An attempt was made to estimate the gas production potential by optimizing the poultry waste and cowdung mix

combination at various level of water mixing. The different types poultry waste such as poultry manure, poultry deep litter and poultry droppings were mixed with cowdung in 39 different combinations at 5 per cent, 10 per cent 15 per cent and 20 per cent total solid content level. Among the different types of waste, the maximum total solids (TS) content of 89.32 per cent was obtained in the poultry deep litter, whereas the minimum total solids was noticed in cowdung of 13.79 per cent. The poultry droppings was found to have lowest volatile solids (VS) content of 10.6 per cent whereas the highest volatile solids content was noticed in poultry deep litter of 65.64 per cent.

Among all cowdung and poultry mix combinations, the maximum methane production of 0.1470 $m^3$ per kg of TS added and 0.3182 $m^3$ per kg of VS added was obtained with 10 per cent TS in the combination of poultry droppings mixed with cowdung in 1:1 ratio, whereas the lowest methane production of 0.0085 $m^3$ per kg of TS added and 0.0474 $m^3$ per kg of VS added was noticed in cowdung mixed with poultry deep litter in 1:1 ratio with 10 per cent TS. The maximum average methane content of 76 per cent was obtained in the combination of cowdung and poultry manure mixed with 1:1 ratio at 5 per cent TS.

In order to utilize the biogas for the same poultry industry, an effective biogas brooder was developed. The biogas brooder developed with direct burning arrangement (burner type) has an advantage of eliminating the frequent mantle replacement noticed in the earlier mantle type brooder. The developed brooder provided the required temperature of 36 $^0$C at 75 cm height from the ground level, which is sufficient for the first week of brooding. At the burner height of 100 cm from the ground level and biogas flow optimization of 0.36 $m^3$/hr provided the required temperature of 32 $^0$C and 30 $^0$C for the second and third week respectively. The illumination obtained in the biogas brooder was 58 lux against the requirement of 54 lux, whereas the illumination of 34 lux only obtained in the case of conventional LPG brooder. The energy demand of brooding and incubation for 10,000 birds has been estimated 600 kg of LPG and 560 kWh of electricity and it can be fully replaced by the biogas brooder which requires 1,385 $m^3$ for brooding and 2,129 $m^3$ for incubation. In total, the energy production potential from poultry waste was 20,952 $m^3$ of biogas against the requirement of 7,076 $m^3$ of biogas for 10,000 birds. The cost of operation for brooding (21 days) was Rs.1.73 per bird in biogas brooder whereas it was Rs.3.20 per bird in the case of LPG brooder.

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## ABBREVIATIONS USED

| | | |
|---|---|---|
| APB | - | Anaerobic Packed Bed |
| ASBR | - | Anaerobic Sequencing Batch reactor |
| BOD | - | Biochemical Oxygen Demand |
| $^0C$ | - | Degree centigrade |
| CD | - | Cowdung |
| $CH_4$ | - | Methane |
| cm | - | Centimeter |
| COD | - | Chemical Oxygen Demand |
| d | - | Day |
| ft | - | Feet |
| g | - | Gram |
| GI | - | Galvanised Iron |
| HDPE | - | High density poly ethylene |
| hr | - | Hour |
| HRT | - | Hydraulic retention time |
| Kcal | - | Kilo calories |
| Kg | - | Kilogram |
| KVIC | - | Khadi and Village Industries Commission |
| kWh | - | Kilowatt hour |
| l | - | Litre |
| LB | - | Leached blanket |
| m | - | Metre |
| M.S | - | Mild steel |
| $m^3$ | - | Cubic meter |
| mg | - | Milligram |

| | | |
|---|---|---|
| min. | - | Minutes |
| ml | - | Milliliter |
| mm | - | Millimeter |
| N | - | Nitrogen |
| $NH_3$ | - | Ammonia |
| No. | - | Number |
| PVCP | - | Polyvinyl chloride plugs |
| Rep. | - | Replication |
| Rs. | - | Rupees |
| t | - | Tonne |
| TS | - | Total solid |
| UASB | - | Upflow Anaerobic Sludge Bed |
| VFA | - | Volatile Fatty Acid |
| VS | - | Volatile solid |
| w.g. | - | Water gauge |

# Introduction

# CHAPTER I

# INTRODUCTION

The realization that conventional fossil fuels are dwindling has prompted renewed interest in recovering energy through renewable sources and particularly by the bioconversion of waste organic materials. Bio based energy sources have been identified as attractive alternatives to imported oil whenever supplies were seriously threatened. Biomass is any organic material such as wood, crop residues and animal wastes and can be burnt directly to heat, fermented to alcohol fuels, gasified to produce high energy gas or anaerobically digested for biogas production.

Generation of waste is inevitable in many human activities. In nature, a balance is maintained as the waste generated by animals and human beings serve as nourishment for the plant life. So long as this natural cycle is maintained, the question of pollution due to waste does not arise. However, with increasing industrialization, urbanization and changes in the pattern of life, which are inevitable in any process of economic growth, waste causes damage to environment unless it is very carefully managed.

Unscientific methods of collection and disposal of these wastes has unfortunately led to increase in pollution and environmental degradation, posing a serious hazard to public health and the environment. Good waste management planning together with appropriate system design will ensure safe, reliable and effective waste handling.

The biomethanation of various substrates for energy production has come to stay as viable solution for energy crisis. For a country like India where energy continues to be precious, with oil prices continuing to rise, with the risk involved in nuclear energy, anaerobic digestion has far greater relevance that it has to many other regions to the world. Conversion of organic matter to methane by anaerobic digestion has several advantages over gasification procedures since it is applicable to most types of high moisture content organic feeds and is operated at low temperature and pressure with relatively high overall thermal efficiencies. The biogas technology is a relatively simple one and research on the utilization of biogas for thermal, electrical and mechanical power generation is well advanced.

Though cowdung is used traditionally, non conventional substrates including poultry waste also tried as alternate feed stock. Cattle dung alone does not fulfill all the necessary requirement of the society and there is a scope for widening this technology by tapping other organic materials like plant biomass, municipal wastes, industrial effluent and also poultry industrial wastes (Mallik *et al.* 1990).

Poultry farming is one of the most intensive and mechanized livestock operations in current agriculture (Webb and Hawkes, 1985). India is the fifth largest egg producing country in the world (Butland, 1999). TamilNadu, Andhra Pradesh and Punjab account for a significant traction of the poultry farms in the country. In TamilNadu state, Namakkal district alone has over 500 hatcheries with the smallest amongst them having about 10,000 birds and the largest in excess of 50,000 birds. Although poultry wastes are organic materials, their character itself must suit the potentiality for usage of these waste for anaerobic digester. The poultry industry is growing rapidly along with the world human population. The growth is increasing in such a way that huge amount of waste is produced. The waste management of this industry is directed towards minimization of negative impact of the health and comfort of birds, workers, the atmosphere, water and soil environment.

Poultry litter which is rich in nitrogen must be mixed with wastes and dung to relieve the dependence of dung alone for gas production (Mallik *et al.* 1990). The other advantages are that the microbial growth rate in the poultry litter was greater than the other manures (Hill, 1983) with high gas production rate, high methane content and high COD reduction rate (Yao *et al.* 1989).

Biogas has often been hailed as an appropriate technology as it satisfies several criteria of appropriateness. It meets the basic need of a cooking fuel, makes optimal use of local resources such as cowdung and other organic wastes, helps to promote indigenous growth using local skills and technologies, provides relief from drudgery, and leads to environment improvement. Scientifically, biomass conversion is an excellent technology that provides both fuel and manure. Without biogas plant, only either one of these is possible. The realization of its undoubted potential led to the promotion of biogas plants in a major way in the late 1970's as an answer to growing fuel crisis. Today, India has the second largest biogas programme in the world after China.

Biogas is a mixture of methane and carbon-di-oxide which can be produced by anaerobic decomposition of cowdung, poultry droppings, pig manure, human waste etc. This can be used for cooking and lighting, replacing the current sources of energy apart from reducing environmental pollution due to the dumping of these wastes. In the poultry industry, two main energy consuming operations are incubation and brooding. In both operations electricity can be used to generate heat. There are about 10,000 poultry farms in India (Bhattu, 2000). It becomes necessary to use other forms of energy since the gap between the supply and demand is increasing for the conventional energy source. Biogas can be produced from poultry as an additional energy and it can be utilized in the same poultry industry, in meeting its total energy demand including incubation and brooding

The important stages in layering of chicks are brooding and incubation. Brooding refers to the rearing of day old chick to an age of 4 week, protecting them from inclement weather and other problems, so as to give them a good growing start by inducing them a power of adjustability to new environment. In case of conventional brooding, electricity, coal, LPG and kerosene are used as fuels for maintaining the temperature in the brooder unit.

The estimated equivalent energy of waste materials from poultry having a live weight as 1000 kg is 6.2 kwh/day of electricity (Mittal, 1996). This energy would be a good replacement in the place of electricity for brooding and incubation. Hence an attempt was made for utilizing the energy from biogas obtained from poultry waste in brooders and incubators in layerstock raising with the following objectives:

1. To study the gas production potential of the poultry waste and to optimize the poultry and cowdung mix combination for getting maximum biogas production.
2. Design and development of biogas burner type brooder.
3. To explore the effective utilization of biogas for brooding
4. To study the energy inflow and outflow of poultry industry.

# Review of Literature

# CHAPTER II

# REVIEW OF LITERATURE

In the near future, the present energy conversion system will change drastically due to lack of conventional fuels. Production of biogas from poultry waste and utilization of gas for brooding in the same poultry industries are the needs of urgent research priorities especially in these days of energy crisis. This chapter deals with the past research works carried out in utilizing various wastes for biogas production, characteristics of feedstocks, gas production rate, methane content of gas, biogas plant designs and utilization for brooding operation.

## 2.1. Biogas production from different organic wastes

Aller (1979) studied the anaerobic digestion of organic matter of urban solid waste at 55 to 60°C and reported that methane production increased with increasing retention time, pH and concentration of volatile solids.

Hill and Dysktra (1980) conducted laboratory studies to assess the feasibility of converting solid waste into methane gas *via* conventional mesophilic digestion. They reported the methane yield as 0.15 litre/g of volatile solids (VS) added.

Shelef *et al.* (1980) reported that the digestion efficiency of cotton plants were found to be very low as 0.01 to 0.06 litre/g but the poultry manure combined with cow manure resulted in better digestion efficiency. They indicated that poultry manure might be used in practice as an additional substrate.

Kamaraj *et al.* (1981) carried out experiments in five litre capacities to study the effect of incorporation of various agricultural wastes of chopped maize cob, cotton stalk, paper pulp parthenium weed and calortropis weed along with cow dung. They reported that the combination of parthenium weed along with cow dung gave the maximum gas production of 1756 cc/day.

Radhika *et al.* (1983) reported that a mixture of coir pith and cattle waste at 3:2 ratio gave a better gas output with methane content range of 80-85 per cent.

Singh *et al.* (1984) studied the biogas production from cattle waste using daily fed digester and they reported that digestion can be carried out efficiently at 13.5 per cent TS and a retention time of 30 days without affecting digester efficiency or gas productivity.

Potential of biogas production from different feedstocks (Khendelwal and Mahdi, 1986).

| Feed stock | Availability (kg/animal/day) | Gas yield ($m^3$/kg) |
|---|---|---|
| Cattle waste | 10 | 0.36 |
| Buffalo waste | 15 | 0.54 |
| Piggery waste | 2.25 | 0.18 |
| Chicken waste | 0.18 | 0.011 |
| Human excreta | 0.40 | 0.028 |

Nallathambi (1988) studied the anaerobic digester of gliricidia leaves in 3 litre batch digesters at room temperature ($32 \pm 13^0C$). He reported that the gas yield of gliricidia leaves was 165-180 ml $CH_4$ $g^{-1}$ VS added and a VS ..reduction of 37-39 per cent.

Sarada and Krishnanand (1989) studied the anaerobic digestion of tomato processing waste. They reported that the biogas yield was 0.597 $m^3$ per kg VS added, with a 72 per cent methane content.

Frison and Carrotte (1989) studied a continuous digester for cattle slurry and monitored for a period of 2 years. They predicted that 0.42 $m^3$ of biogas per kg of organic matter introduced could be obtained with a hydraulic retention time of 9 days and a digester temperature of 41$^0$C, which allows approximately 3 $m^3$ of biogas to be obtained per $m^3$ of the digester.

Madamwar *et al.* (1990) studied the effect of various residues and found that sugarcane bagasse, banana stem, poultry waste, cheese whey and algal powder showed more than 100 per cent increase in gas production with 5-10 per cent higher methane content.

Jamila and Sayigh (1990) reported that laboratory scale digesters were operated at 30 $^0$C and 34 $^0$C on poultry slurry at 6 per cent and 10 per cent of total solids and with a digester retention time of 15, 22 and 30 days. The best results were achieved with 6 per cent total solids influent concentration at a temperature of 34 $^0$C and a retention time of 15 days.

Ranade *et al.* (1990) conducted tests on anaerobic digestion in six 25 litre laboratory floating dome biogas plants, each filled initially with 25 litres of cattle slurry at 10 per cent TS. Best performance was observed at 8 per cent TS but there was little variation in absolute methane yield at 8, 10 and 12 per cent TS (6.14-6.54 litres/d). Findings indicated that reasonably good methane yields were possible even at 14% TS and that 2:1 dilution of cattle dung is sufficient when water is scarce.

Aklaku and Sayigh (1990) carried out continuous digestion tests with poultry manure and guinea grass and they reported that substrate blends of pure poultry manure and guinea grass gave higher methane, energy out than manure alone and methane production decreased with increasing HRT.

Yaldiz *et al.* (1990) carried out a investigation on methane production from beef and poultry manure in unheated biogas digesters and reported that more methane was produced with poultry manure than beef manure at 18-26°C temperature and short term variation of fermentation temperature in the range of 18-26°C did not affect the methane production.

Neelakantan *et al.* (1992) studied about using livestock excreta as a source of biogas. They reported the biogas yield from cow, buffalo, goat and poultry dung litter as 113.55, 116.75, 158.5 and 392 litres/kg of dry matter respectively and the dry matter degradability were found as 22.0, 23.5, 29.0 and 52 per cent respectively.

Chanakya *et al.* (1993) studied solid phase fermentation of untreated leaf biomass to biogas and they reported that dry and fresh feed stocks gave gas yields of 295 and 343 litres of biogas/kg of total solids respectively, at levels upto 0.5-0.6 litre/litre digester per day.

Chatterjee *et al.* (1994) evaluated the performance of night soil based biogas digesters made of high density polyethylene and reported that the generation of methane (0.6 $m^3$ per $m^3$ of slurry per day) was higher than conventional digester (0.15 $m^3$ per $m^3$ of slurry per day) and methane content of biogas was 70 per cent.

Chowdhury *et al.* (1994) evaluated the potentiality of tree leaves for biogas production. They reported that the digester slurry with leaves and cowdung at 8 per cent total solids concentration was found to be best.

Sanchez *et al.* (1995) studied the anaerobic treatment of poultry waste by an Upflow Anaerobic Sludge Blanket (USAB) and Anaerobic Packed Bed (APB) reactors. They reported that the chemical oxygen demand (COD) removal range of 65-85 per cent was obtained in Anaerobic Packed Bed where as it was 80-85 per cent in the Upflow Anaerobic Sludge Blanket at organic loading rate in the range of 1.3-11.0 kg COD/$m^3$

reactor day. They also observed that the methane yield was high in Anaerobic Packed Bed (0.4-2.0-$m^3$ reactor day) than in the Upflow Anaerobic Sludge Blanket (0.4-1.7 $m^3$ reactor day).

Yeole *et al.* (1996) reported that a loading rate of 0.7 kg COD per $m^3$ per day was optimum for biogas production of 13 $m^3$ per $m^3$ of waste per day from the liquid waste originated from liver and beef extract industry.

Behmel *et al.* (1997) gave an overview of biogas production and presented a two stage process for the production of biogas from dairy sludge. Dairy sludge had an average decomposition rate of 85 per cent with biogas production of 700 litres/kg of decrease in chemical oxygen demand.

Ibrahim *et al.* (1997) tested the performance of a Upflow Anaerobic Sludge Blanket reactor for waste-water with chicken manure under a constant temperature of 35 $^0$C. During steady state operation, the biogas production rate was 9.83 $m^3/m^3$ per day at a loading rate of 28.85 kg COD/$m^3$ per day.

Dugba and Zhang (1997) studied a two stage anaerobic sequencing batch reactor (ASBR) in a laboratory for dairy waste-water treatment. The performance of each treatment system depended on the hydraulic retention time and organic loading rate. The volatile solids (VS) removal of the 3 systems tested varied from 26.1 to 44.2 per cent.

Yeole and Ranade (1997) studied the biogas production from mycetial waste and they reported that the process was stable at 50 days hydraulic retention time yielding 0.652 $m^3$ biogas per $m^3$ of digester, degradation of volatile solids was 60 per cent.

Chen TenHong *et al.* (1998) studied the performance of mesophilic anaerobic digestion systems treating poultry mortalities and reported that system performed very well with few operational problems. Overall, the system that started with 10 litres of water in the leached bed performed better.

Fernandez (1999) carried out two set of experiments on mesophilic anaerobic treatment of waste water from citric acid industry. In the first set Up flow Anaerobic Sludge Blanket reactor (UASB) of 1 litre volume and in the second set fluidized bed anaerobic reactor of 3.25 litres volume were taken for the study. He reported that COD conversion in two phases were as high as 95 per cent with an average methane yield of 6 $m^3$ $CH_4$ / $m^3$ of waste water.

**2.2. Biogas production from poultry wastes**

Bansel *et al.* (1977) studied the anaerobic digestion of pig dung, poultry litter, cattle dung and goat dung and reported that higher gas yield from pig dung and poultry litter might be due to higher volatile matter in the excreta. The biogas yield from 500 g of dry matter of the above excreta was 81.4 l from cattle dung, 118.5 l from goat dung, 157.5 l from pig dung and 161.2 l from poultry litter. The higher rate of gas production was observed in the first month of digestion.

Khan (1977) reported that addition of poultry excreta was useful to speed up the reaction and to increase the methane gas production.

Arokiasamy (1978) observed that most of the vegetable wastes, weeds, algae, poultry, sheep and fish wastes, carcasses etc., could be digested in biogas plants.

Bousfield *et al.* (1979) reported that the digestion of cattle and poultry wastes showed significant reduction in polluting power, reduction in odour, etc., at the end of digestion. Gas production and methane content of cattle wastes were lower than that of poultry wastes. Cattle waste was found to be better at higher than lower solid contents, while the reverse was true for poultry wastes. These effects were probably caused by ammonia content of the wastes (4900 mg per l at 12 per cent total solids in poultry waste and 500 mg per l in the cattle waste of 5 per cent total solids).

Shivappa Shetty *et al.* (1980) studied the anaerobic digestion of different animal wastes like cattle dung, sheep manure, poultry wastes, piggery waste and silk worm larval waste. Among the different wastes, piggery waste gave maximum combustible gas production of 40 l per 2 l of slurry over a period of 6 months. This was almost more than 2.5 times of gas produced from cattle dung (14.6 l per 2 l slurry in 6 months) and poultry waste (18.5 l per 2 l slurry in 6 months). Minimum gas production had been obtained in silkworm larval waste (3.3 l per 2 l slurry in 6 months).

Shih and Huang (1980) reported that broiler chicken litter was used for anaerobic digestion at 60°C. Wood chips, the bedding materials used as carbon source for methane biosynthesis and broiler chicken litter has a desirable content of 3 to 4 per cent level similar to that of cattle waste.

Mahadevasamy and Venkataraman (1986) studied the biogas production from poultry droppings and utilization of the effluent for the production of blue-green algae *Spirulina platensis*. They observed that poultry droppings produced 0.54 $m^3$ of biogas per kg of TS and 2 per cent TS biogas plant effluent as sole nutrient medium for *Spirulina* yielded 7-8 g dry algae daily.

Ilamurugu and Rajasekaran (1986) studied potential of poultry manure for biogas production added with and without cattle or biodigested slurry. They found that without cattle of biodigested slurry yields maximum biogas production (5225 ml) over a period of 8 weeks compared with cattle slurry (3250 ml).

Safley *et al.* (1987) briefly described a full-scale (587 $m^3$) anaerobic digester, large enough to process the waste from 70 000 caged layers. They reported that digester operated on a 22-24 days HRT, biogas production averaged 0.38 $m^3$ per kg of VS added (0.58 $m^3$ per kg of VS destroyed) and methane content of gas was 58 per cent.

Pechan *et al.* (1987) studied the methanogenic fermentation of poultry manure on a laboratory scale at mesophilic temperature and they reported no adverse effect on biogas production was observed due to high ammonia nitrogen concentration in the effluent. (Mean ammonia nitrogen 4.07-5.85 g per litre and extreme values as high as 7.5 g per litre were used for this study).

Hidalgo *et al.* (1988) studied biogas production from poultry waste with two manure: water ratios and at various ambient temperature. They observed that poultry manure: water ratio of 1:3 produced more biogas than a ratio of 1:8 despite lower ambient temperature.

Kalia (1988) developed a 3 $m^3$ fixed dome plug flow anaerobic digester and its performance was compared with that of a Janata biogas digester in a cold, hilly region.. Gas production rate per unit of effective digester volume for the plug flow digester was 30 per cent higher due to the horizontal plug flow of the digesting slurry and due to modifications of the inlet and outlet slurry displacement tanks.

Yao *et al.* (1989) studied a pilot biogas system using chicken manure which had two reactors each with 3.5 $m^3$ volume and a 4-layered screen used for liquid-solid separation of manure. After 4 months of starting-up, the steady state operated at an average daily loading rate of 10 kg COD/$m^3$, biogas production rate of 3.57 $m^3/m^3$, methane content of 65.4 per cent and COD reduction of 80.07 per cent.

Shinnawi *et al* (1989) studied different combination of feed stock like rice straw, maize, cotton stalk and poultry dropping with or without either wheat straw litter or saw dust litter for biogas production in laboratory biogas digesters for 90 days at 35°C. They found that maximum cumulative volumes of biogas and methane were respectively

30 and 14 litre/litre with rice straw and wheat straw poultry dropping and minimum volume were 15 litre biogas with cotton stalks and sawdust poultry dropping and 8 litre methane/litre with rice straw and saw dust poultry droppings.

Jamila and Sayigh (1990) studied biogas production from poultry manure with multiple combination of laboratory scale digester operated in 30°C and 34°C temperature, poultry slurry at 6 and 10 per cent TS with a HRT of 15, 22 and 30 days. They observed that gas yield varied between 0.2 and 0.4 $m^3$ of biogas per kg of VS and best results achieved with 6 per cent TS influent concentration at a temperature of 34°C and HRT of 15 days.

Edwards and Daniel (1992) reviewed the disposal of on-farm poultry wastes such as manure, litter, dead birds and the effects of poultry waste disposal methods on environmental quality, which included refeeding to animals, biogas production, composting and land application.

Desai *et al.* (1994) found improvement in gas production and enriched methane content when a mixture of cattle dung, poultry waste and cheese when in the ratio of 2:1:3 (dry weight basis) was used as substrate.

Chandran (1997) studied anaerobic digestion of various proportions of poultry litter and cow dung wastes through lab scale experiments. He reported that combination of feed stock having cow dung (75 per cent) and poultry litter (25 per cent) yielding maximum methane production of 7650.37 ml compared to 3836.43 ml in cow dung (25 per cent) + poultry litter (75 per cent) and 3075.61 ml in cow dung (50 per cent) + poultry litter (50 per cent) when no actimycin was added.

A plant having treating capacity of 600 kg of poultry waste was installed in western hatcheries, Naigoan in which 60 $m^3$ of biogas produced per day and in addition the chemical oxygen demand (COD) and biological oxygen demand (BOD) in the treated water reduced by 89 and 90 per cent respectively (Anonymous 1997).

Venkatachalam (1998) studied biogas production potential of various animal wastes like pig manure, poultry droppings and goat droppings. He reported that 75 per cent of pig manure and poultry droppings, 100 per cent of poultry and goat droppings with maximum biogas production of 0.29, 0.30 $m^3$ per kg of total solids (TS) destroyed and 0.30, 0.28 $m^3$ per kg volatile solids (VS) destroyed respectively.

Kamaraj (2000) studied various wastes of poultry industry and characterized the physical properties of poultry litter and quail litter. He assessed in 21 combinations added with and without cowdung for their suitability to produce biogas. Total solids and volatile solids ranged between 20 to 66 and 3.25 to 34 per cent respectively. The poultry litter based combination, a mix of poultry litter, cowdung and quail litter in the ratio of 1:1:1 produced a maximum gas of 26,140 ml during the bottle experiment.

Benjamin *et al.* (2001) performed anaerobic batch tests using hog and poultry waste in various proportions. Treatments that received both waste produced higher yields of biogas upto 206 $\pm$ 30 ml/g volatile solids (VS) destroyed, and methane upto 130 $\pm$ 20 ml/g VS destroyed compared to either waste alone.

**2.3. Biogas plant description**

Balsari *et al.* (1987), studied 15 different types of synthetic sheets jointed by machine or manually and with or without fabric reinforcement, for use in anaerobic digesters. All sheets showed low permeability to biogas. In general, the fabric reinforced sheets showed better resistance to mechanical damage than the non-reinforced sheets with the exception of the chloro-sulphonated polyethylene.

Kamaraj and Swaminathan (1987) compared the different designs of biogas plants in terms of cost skill requirements and other benefits and reported that the fixed dome type biogas plants was suitable for feeding agricultural waste material and its cost of construction was the least.

Nakagawa and Honquilada (1987) described the potentiality of Chinese biogas digester for small scale rural application. The basic structural features, construction, operation and maintenance of the Chinese biogas digester were presented. The 8 main components of the design are the mixing pit or inlet, inlet pipe, digester/gas storage, outlet chamber removable manhole, gas outlet pipe, stirrer/mixer and backfill. The construction is entirely underground and materials flow is by gravity; it has no moving parts or metal components, except structural reinforcement.

Kalia (1988) reported the development and evaluation of fixed dome plug flow anaerobic digesters. In the report, a $3m^3$ fixed dome plug flow anaerobic digester was developed and its performance was better compared to that of Janata biogas digester in a cold, hilly region.

Safley and Westerman (1989) studied biogas recovery systems from anaerobic lagoon. They placed a floating cover on two anaerobic lagoons. One cover was approximately 370 $m^2$ in size placed over poultry lagoon and the second was 155 $m^2$ placed over pig anaerobic lagoon. The poultry and pig lagoons had mean daily volumetric biogas production rates of 0.07 and 0.05 $m^3/m^3$ respectively. The daily biogas production rates were 0.16 and 0.13 $m^3/m^3$ for poultry and pig lagoons respectively and the temperatures were of 13-15 $^0$C.

Sandhya and Krishnanand (1990) conducted a preliminary study on biogas production from cowdung using fixed bed digesters and reported the biogas production from cowdung in digesters with and without polyvinyl chloride plugs (PVCP). A maximum yield of 0.419 $m^3$ of biogas/kg of volatile solids (VS) added, with 62 per cent methane content was attained in the digesters packed with polyvinyl chloride plugs and fed with cowdung slurry or 8 per cent TS at a 30 day HRT. The use of polyvinyl chloride plugs suggested the possibility of improving the performance of commercial digesters, which are commonly employed in India, with a slight increase in the overall cost of fabrication and installation.

Nazir (1991) studied biogas plant construction technology for rural areas and reported the suitability of number of different anaerobic digesters designs for use in rural regions. He also reported that French type biogas plants worked efficiently in cold weather and was recommended for those areas where the atmospheric temperature drops below $0^0$C. Plastic and rubber bag biogas plants were found cheap but deteriorated rapidly and could not be recommended.

Kanwar and Guleri (1994) compared the performance of 92 $m^3$ rubber balloon biogas plant with a fixed dome type Deenbandhu biogas plant. They reported that the daily average biogas production in rubber balloon plant was 0.92 $m^3$ / day compared to 1.23 $m^3$ / day in the Deenbandhu plant and the methane content of the biogas of both the plants were identical. They also observed that the changes in the ambient temperature affected the rubber balloon plant more than they affected the conventional plants.

Aburas *et al.* (1995) studied the design, construction and operation of a low cost, small, farm scale digester in which cattle waste were used. They reported that the biogas produced contained about 65 per cent methane by volume.

Liang and Paquin (1997) designed and constructed a waste treatment system of high density polyethylene (HDPE) bioreactors for a small pig farm.

Chen Tenhong *et al.* (1998) studied the performance of mesophilic digestion systems. They tested a closed loop anaerobic digestion system consisting of a three leached bed (LB) and three upflow anaerobic sludge blanket. Upflow Anaerobic Sludge Blanket (UASB) for an alternative disposal of poultry moralities. They reported that methane production rates from Upflow Anaerobic Sludge Blanket decreased quickly while that from each leached bed reached peak levels.

Dugba *et al.* (1999) studied computer simulation of a two stage anaerobic sequencing batch reactor system for animal wastewater treatment and reported that a thermophilic-mesophilic two stage anaerobic sequencing batch reactor (ASBR) system was a promising animal waste treatment system for energy recovery, odour control and faecal bacteria destruction.

Kalia and Singh (1999) conducted a case study on 85 $m^3$ floating drum biogas plant under hilly conditions. They considered the biogas and manure obtained from the plant. The income and cost ratios during the period 1989-91 and 1992-97 were 1.44 and 1.15 respectively.

**2.4. Methane content in biogas**

Wong-chong (1975) reported the variations of methane concentration between 60 per cent and 65 per cent.

Barnett *et al.* (1978) stated that anaerobic digestion of cowdung, chicken manure, pig manure, farm wastes, sewage sludge and elephant grass produced gas that contained 65, 60,65 to 70, 60 to 70, 68 and 60 per cent of methane respectively.

Biogas from agro wastes usually contain 60-70 per cent methane (Cowley and Wise, 1981).

Kumar and Biswas (1982) reported that the methane concentration was between 56 and 58 per cent during fourth to sixth week of digestion.

Murugesan (1982) reported that the biogas produced from the poultry droppings and rumen fluid incorporated treatments contained about 55 to 63 per cent of methane during third to seventh week of digestion.

Hills and Nakana (1984) observed that the rate of methane gas production varied universally linear to the product of the substrate and average particle diameter. The methane content of biogas varied from 58.2 to 62.3 per cent.

Jamila and Sayigh (1990) conducted experiment on poultry slurry and reported that gas yield varied between 0.2 and 0.4 $m^3$ of biogas per kg of volatile solids and gas had a methane content of 44.83 per cent to 73.86 per cent.

Raju *et al.* (1991) reported that a methane content of 62 per cent with a yield of 0.49 $m^3$/kg volatile solids (VS) added was obtained from mango peel.

Sarapatka (1994) studied anaerobic fermentation of farmyard manure and reported that during summer the average methane content was 56.96 per cent, it decreased to 49.39 and 50.85 per cent in the transitional period and in winter respectively.

Sudhir kumar (1996) studied the biogas production potential of presumed in Khadi and Village Industries Commission (KVIC) type digesters. He reported that methane content of biogas was 60 per cent.

Yeole and Ranade (1997) conducted study on anaerobic digestion of antibiotic mycelial waste in lab scale of digester of floating dome design. They found that digestion of waste from a medium size penicillin factory would produced 300 $m^3$ of biogas with 62 per cent methane.

Chandran (1997) reported that the addition of actizyme at the rate of 500 mg/kg concentration in cowdung (75%) and poultry litter (25%) resulted in the maximum biogas production of 19,995 ml and the methane production of 9611.51 ml respectively.

Chen-Tenhong *et al.* (1998) conducted experiments on the performance of mesophilic anaerobic digestion systems treating poultry mortalities and reported that methane yields ranged from 0.484 to 0.554 $m^3$/kg TS.

Venkatachalam (1998) reported that anaerobic digestion of goat droppings had the highest methane content of 66.45 per cent in 2nd week and lowest in the 14th week as 53.58 per cent.

Lomas *et al.* (1999) conducted experiments on treating piggery slurry in the mesophilic range and reported that the gas composition displayed a uniformity in methane and carbon dioxide content, with little variation in nitrogen, and traces of hydrogen.

## 2.5. Utilization of biogas for different applications

Ram Bux Singh (1974) reported norms of biogas consumption in operating various plastic moulding machines were given below.

**Table 2.1. Biogas consumption in operating various moulding machines**

| S. No. | Machine | Machine capacity (ounce) | Rounds per hour | Gas consumption $ft^3$/hr | Power consumption (watts per hour) |
|---|---|---|---|---|---|
| 1 | Button making machine | 2.25 | 120 | 4.8 | 500 |
| 2 | Plastic moulding machine | 0.50 | 100 | 5.0 | 600 |
| 3 | Toy making machine | 1.00 | 85 | 5.5 | 650 |
| 4 | Toy making machine (large) | 1.50 | 75 | 8.5 | 1000 |

Kothandaraman (1977) investigated on the use of Gobar gas in petrol engine and observed that the compression ratio of 6:1 for petrol and 8 to 11:1 for biogas was suitable.

Dhussa (1983).reported the rate of biogas consumption for different types of burners were given below

**Table.2.2. Consumption Norms for Burners under different combinations**

| S.No. | Type of burner | Gas flow rate ($ft^3$ / hour) |
|---|---|---|
| 1. | One large standard burner | 16 |
| 2. | One large and one small burner or one large burner and two lamps | 24 |
| 3. | Two large burners or one large and one small burners and two lamps | 32 |
| 4. | Three large burners | 48 |
| 5. | Four large burners | 64 |

Darmora (1984) found that the engine could be operated totally on biogas and the engine started on petrol for initial warm up. He reported that brake thermal efficiency of engine was slightly higher on biogas than on petrol.

Camargo (1986) reported that the vehicles using the fuel as compressed methane was produced from sewage waste.

Palaniswamy and Dakshnamurthy (1986) studied the usuage biogas to control rice storage pests and they reported the insects that were exposed to gas at rate of 20 litres per min in the presence of 1 kg of rough rice, 100 per cent mortality was observed in 4-6 hrs.

Safley *et al.* (1987) reported that biogas from poultry manure was used as fuel for an engine/generator set and the operating temperature of digester was maintained at 35°C by utilizing waste heat from engine.

Zhengou *et al.* (1987) studied three types of biogas operated brooders and a thermocouple was used for measuring floor temperature when brooders were operated at high (12.7 $MJh^{-1}$), medium (7.6 $MJh^{-1}$) and low (5.3 $MJh^{-1}$) heat out rate and hanging height for testing of brooders was 31 cm. They reported that heating efficiencies were 13-30 per cent.

In a co-operative dairy farm, 15000-16000 $m^3$ of biogas was produced from 50 $m^3$ liquid manure with 10 per cent dry matter content, in which 16-200 $m^3$ gas was used for continuation of the processes and the rest used in winter months for heating and in summer for crop drying by using 110 kW electric biogas generator (Anon, 1988).

Waddell (1988) developed a poultry biogas demonstration project in Georgia, United States of America. A biogas fired boiler supplied with hot water was circulated through an internal double-pipe stainless heat exchanger to maintain a 95 $^0$F digester operating temperature.

Komendant and Shapovlov (1991) discussed the maintenance of optimum temperatures in poultry houses exposed to varying ambient conditions which is in relation to the supply of heat from biogas installations. Monthly energy requirements, met by various fossil fuels, electricity and biogas, are compared in a graph, and formulae for the calculation of fuel oil and diesel fuel requirement were given as a basis for the assessment of biogas requirements

Ramajeyam *et al.* (1994) developed a biogas operated incubator with size of 1500 eggs capacity and studied different gas flow rates for obtaining required temperature in biogas operated incubator. They reported that the total energy requirement for 21 days of incubation was 1,27,694.3 kcal and daily energy requirement for incubation was 6,373 kcal for first day, 5685 kcal for second day onwards.

The biogas generated as a result of anaerobic degradation could be coupled to a gas engine to produce electricity and approximately 2.2 kWh of electricity could be generated from 1 $m^3$ of biogas (Anon, 1996).

Mittal (1996) reported the rate of biogas consumption for various appliances.

**Table 2.3. Biogas consumption in operating various appliances**

| Application | Specifications | Rate of biogas consumption ($ft^3$/hour) |
|---|---|---|
| Cooking | 2" dia burner | 11.5 |
| | 4" dia burner | 16.5 |
| | 6" dia burner | 22.5 |
| Lighting | 1 mantle lamp | 2.5 |
| | 2 mantle lamp | 5.0 |
| | 3 mantle lamp | 6.0 |
| Refrigerator | 10" x 18" x 12" | 2.5 |
| Incubator | 18" x 18" x 18" | 2.0 |
| Boiling water | per gallon | 10.0 |
| Running IC Engine | per BHP | 16-18 |
| Running table fan | Gas pressure 2" water column | 3.5 |
| Running heater | Gas pressure 2" water column | 5.5 |

Mapuskar (1997) reported that biogas produced from vegetable market waste distributed by gas distribution system to consumers provided with 0.91 $m^3$, 1.13 $m^3$ and 2.83 $m^3$ biogas per hour capacity burners depending upon their needs.

The 60 m$^3$ of biogas obtained from cow dung in Khadi and Village Industries Commission (KVIC) plant was utilized in a dual fuel engine and it consumes 70 per cent gas and 30 per cent diesel to generate power. He reported that engine was operated for 16 hours a day to generate 130 kWh i.e 40,000 kWh per year and which was utilized for operating chaff cutter and submergible pumps and lighting (Anon, 1999).

**2.6. Brooders**

Drury et *al.* (1959) studied different types of brooders *viz.,* electrical hover, heat lamps with hover, cool room gas hovers, warm room gas brooder and coal chick brooder. He reported there was no difference in chick performance under these brooder, but the energy requirement varied marked with type of brooder.

Hardwood and Reece (1975) studied the liquefied petroleum gas brooders (hover types) and reported that it provided an environment for day old chick where air temperature under the brooder was 32 to 35°C and radiant heat flux was between 270 and 800 w/m$^2$.

Nesheim *et al.* (1979) reported that the basic requirement in animal brooding was to provide a comfortable temperature for young chicks i.e 27-37°C at a height of 6.4 cm above the floor.

Zhenghou *et al* (1987) stated that three kinds of commercial brooders namely, aluminium hood (Model 47 LR), hot-rock (Model 26689) and infrared (Model 2456) were commonly used and they all generated radiant heat by the combustion of gaseous fuel. They also studied use of biogas in three types of brooders and reported that heating efficiency were 13 to 30 per cent.

Ramesh (2000) developed the three types of biogas operated brooders (hexagonal, rectangular and circular shapes) for brooding of quail chicks and tested their performance. He reported that the heat requirement of chicks for the first three weeks of brooding was met by fixing the biogas lamp at different heights namely, 25, 20, and 35 cm respectively from the ground level.

### 2.6.1. Parameter requirements for brooding of chicks

In any type brooding method the common factors which affect the achievements of brooding were temperature, ventilation, floor space, light intensity, humidity.

North (1972) reported that the intensity of light during the growing period was not an important factor as long as it has a minimum of 1 foot candle.

Hughese and Weaver (1979) suggested that the light program consisted of continuous light during the first three weeks, intensities were 54 $lm/m^2$ (5 foot candles) for a week followed by two weeks of gradually lower light.

Zhenghou *et al.* (1987) evaluated biogas production from a poultry waste digester system for in situ utilization. Overall efficiency of the system was 55 per cent. In use as regular animal brooders, stable combustion of biogas and comfortable floor temperature could be maintained with proper mechanical adjustments. The use of biogas for brooding young chicks on a poultry farm could significantly reduce the natural gas or propane fuel cost. The results of these studies offered alternative uses of biogas energy to electricity generation.

Reddy (1991) noted that quails were very sensitive to lowered temperature and he reported the optimum brooder temperature as given below and he suggested space requirement per quail in litter system up to 3 weeks was 150 cm.

| Age | Brooding temperature |
|---|---|
| I Week | 35-37.8 |
| II Week | 32.2-35 |
| III Week | 26.6-32.2 |

Jadhav and Siddiqui (1992) found that effects of ill ventilation were exhibited in the form of loose feathers, restlessness and anemic conditions resulting in the outbreak of respiratory diseases. They reported that relative humidity 50 to 60 per cent facilitates the desired growth of feathers, too low humidity causes dust litter leading to poor feather growth and too high humidity creates wet litter and wattage required per chick was 2 to 2.5 candle power.

The brooding temperature should be about 39°C which could be reduced gradually to 35°C for first week and second week onwards at the rate of 5°C per week the temperature was lowered to 25°C (Anon, 1992).

For every 30 square feet house atleast 1 square feet ventilation should be provided (Ajay Singh, 1994).

Kannan and Singh (1994) reported that fresh air flow rate of 3 litres/min/chick should be provided in oil burning, coal burning or wood burning brooders.

Khanna (1994) found that higher intensity of light may induce blindness, picking of feathers and restlessness in the chicks.

Singh (1997) reported that the brooding temperature required for various age groups of chicks as follows.

| Age of chicks | Brooder temperature (°C) |
|---|---|
| I Week | 34-35 |
| II Week | 31-32 |
| III Week | 28-29 |

Ramesh (2000) reported that the biogas consumption in each type of biogas operated brooder (hexagonal, rectangular and circular shapes) was 62 $m^3$ for 21 days of brooding period for 200 numbers of quail chicks.

# Materials and Methods

# CHAPTER III

# MATERIALS AND METHODS

The waste materials *viz.*, cowdung, poultry deep litter, poultry manure, poultry droppings were selected as feedstock for gas production. In this chapter materials and methodology adopted in the study are discussed. The details of the experiment are explained under the following headings.

1. Characterization of feedstocks
2. Bottle scale experiment
3. Details of 85 cum of KVIC model biogas plant
4. Development of biogas burner type brooder
5. Performance evaluation of biogas burner type brooder
6. Cost economics of brooders
7. Energy inflow and outflow of poultry industry

## 3.1. Characterization of feedstocks

### 3.1.1. Collection of raw materials

The raw materials used for the study were cowdung, poultry deep litter, poultry cage manure, poultry droppings. These raw materials were collected from Pioneer Breeding Farms, Pongalur, Tirupur. Coimbatore.

The waste collected for this study were

i) Poultry deep litter (Poultry droppings along with bed material)

ii) Poultry manure (Poultry droppings collected from manure yard)

iii) Poultry droppings

iv) Cowdung

### 3.1.2. Physico-chemical analysis

The physical and chemical properties of the collected sample were analyzed as per the methods described here under.

The total solids (TS) and volatile solids (VS) were estimated using hot air oven and muffle furnace respectively for the different raw materials.

#### 3.1.2.1. Total solids (TS)

Freshly collected sample was weighed in a crucible. The crucible was placed inside an electric hot air-oven maintained at 105°C. The crucible was allowed to remain in oven for 24 hours and then taken out, cooled in a desiccator and weighed. The weight of the sample which was left in the oven gives the total solids and it is represented in percentage basis (Anon., 1989).

$$\text{Total solids} = \frac{\text{Final weight}}{\text{Initial weight}} \times 100$$

#### 3.1.2.2. Volatile solids (VS)

Volatile solid content of the raw material was determined by drying the samples at 645°C for three hours in a muffle furnace. Then volatile solids content in per cent was determined by using the formula (Anon., 1989).

$$\text{Volatile solids} = \frac{\text{Loss in weight due to removal of volatile matter}}{\text{Weight of sample taken}} \times 100$$

#### 3.1.2.3. Total organic carbon

The organic carbon was analysed by wet digestion of Walkey and Black method (Piper 1966).

### 3.1.2.4. Total Nitrogen

The samples were pretreated with 1ml of 25 per cent $KMnO_4$ at $80^0$ C for 30 minutes and then with 0.5 ml of conc.$H_2SO_4$ and 0.3 g of reduced iron, again at $80^0$ C for 30 minutes. This was followed by the usual digestion with the diacid mixture. A known quantity of nitrogen was estimated. (Mahimairaja *et al,* 1990)

### 3.1.2.5. Carbon/Nitrogen ratio

The carbon/nitrogen (C/N) ratio was calculated from the total organic carbon and total nitrogen content of the samples.

## 3.2. Bottle scale experiment

### 3.2.1. Batch digestion

Batch digestion was carried out in experimental set up of 2.5 litre amber coloured bottles with a sealed lid and glass bend tubes as outlet, and rubber tube extension as outlet. The rubber tube is closed by a pinch clip. Seventy-eight numbers of bottles were taken for the batch experiments with 39 treatments with two replications. The loading of the feedstock in bottle digester and experimental set up were shown in Plate 3.1 and 3.2. respectively. Water was added to the feed stock and filled in batch digester. The experiment was repeated again with the same treatments for confirmation of results. The different treatments were shown in table 3.1.

### 3.2.2. Measurement of gas production

The amount of gas produced was measured daily by using water displacement method as shown in plate 3.3. The daily gas production was recorded for different treatments until the gas production ceased

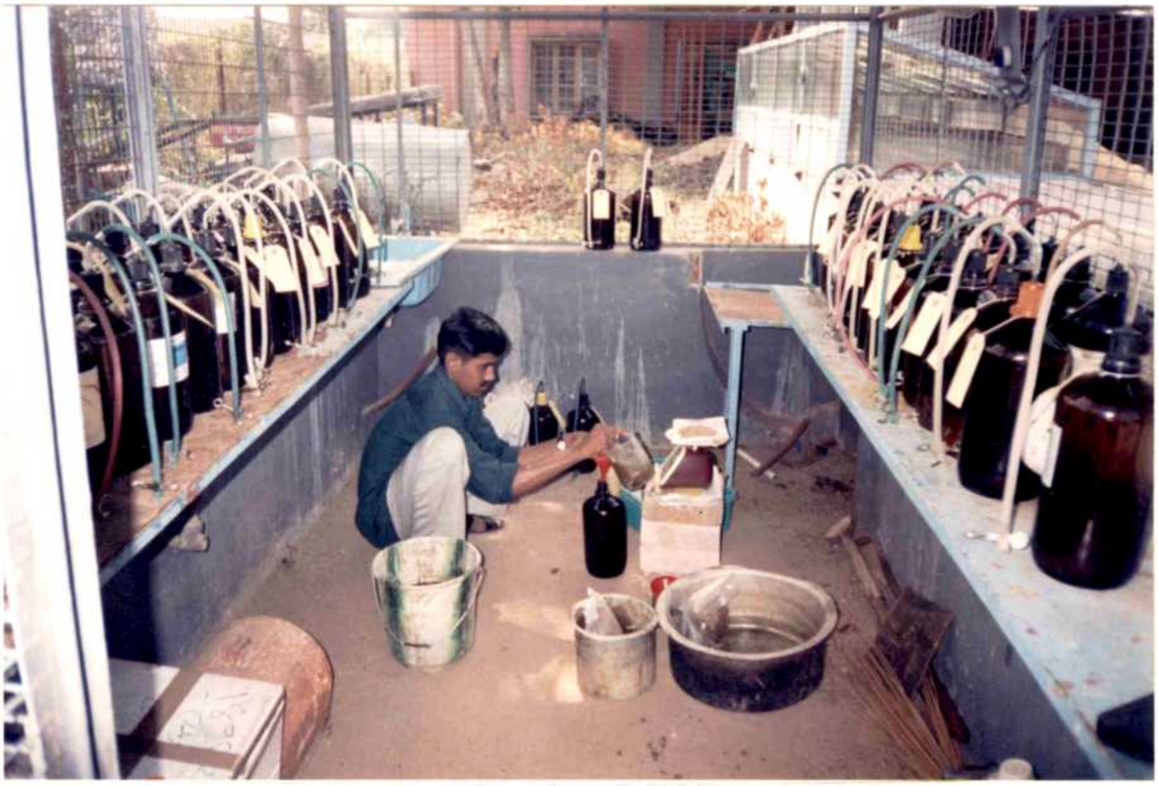


Plate No. 3.1 Loading of feedstock in bottle digesters

Plate No. 3.2 Experimental setup of batch digestion

**Table 3.1. Experimental scheme**

| Treatments | Combinations | Feed material ratio | Water mix ratio |
|---|---|---|---|
| $T_1$ | Cowdung | 100% | 1:2 |
| $T_2$ | Cowdung | 100 % | 1:1 |
| $T_3$ | Cowdung | 100 % | 1: 0.5 |
| $T_4$ | Cowdung : Poultry manure | 1:1 | 1:8 |
| $T_5$ | Cowdung : Poultry manure | 1:1 | 1:4 |
| $T_6$ | Cowdung : Poultry manure | 1:1 | 1:2 |
| $T_7$ | Cowdung : Poultry manure | 1:1 | 1:1 |
| $T_8$ | Cowdung : Poultry manure | 1:2 | 1:11 |
| $T_9$ | Cowdung : Poultry manure | 1:2 | 1:5 |
| $T_{10}$ | Cowdung : Poultry manure | 1:2 | 1:3 |
| $T_{11}$ | Cowdung : Poultry manure | 1:2 | 1:2 |
| $T_{12}$ | Cowdung : Poultry manure | 2:1 | 1:6 |
| $T_{13}$ | Cowdung : Poultry manure | 2:1 | 1:2.5 |
| $T_{14}$ | Cowdung : Poultry manure | 2:1 | 1:1.5 |
| $T_{15}$ | Cowdung : Poultry manure | 2:1 | 1:1 |
| $T_{16}$ | Cowdung : Poultry Deep Litter | 1:1 | 1:9 |
| $T_{17}$ | Cowdung : Poultry Deep Litter | 1:1 | 1:4 |
| $T_{18}$ | Cowdung : Poultry Deep Litter | 1:1 | 1:2.5 |
| $T_{19}$ | Cowdung : Poultry Deep Litter | 1:1 | 1:1.5 |
| $T_{20}$ | Cowdung : Poultry Deep Litter | 1:2 | 1:12 |
| $T_{21}$ | Cowdung : Poultry Deep Litter | 1:2 | 1:5.5 |
| $T_{22}$ | Cowdung : Poultry Deep Litter | 1:2 | 1:3.3 |
| $T_{23}$ | Cowdung : Poultry Deep Litter | 1:2 | 1:2 |
| $T_{24}$ | Cowdung : Poultry Deep Litter | 2:1 | 1:7 |
| $T_{25}$ | Cowdung : Poultry Deep Litter | 2:1 | 1:3 |
| $T_{26}$ | Cowdung : Poultry Deep Litter | 2:1 | 1:1.7 |
| $T_{27}$ | Cowdung : Poultry Deep Litter | 2:1 | 1:1 |
| $T_{28}$ | Cowdung : Poultry Droppings | 1:1 | 1:3.6 |
| $T_{29}$ | Cowdung : Poultry Droppings | 1:1 | 1:1.3 |
| $T_{30}$ | Cowdung : Poultry Droppings | 1:1 | 1:0.5 |
| $T_{31}$ | Cowdung : Poultry Droppings | 1:2 | 1:4 |
| $T_{32}$, | Cowdung : Poultry Droppings | 1:2 | 1:1.5 |
| $T_{33}$ | Cowdung : Poultry Droppings | 1:2 | 1:0.7 |
| $T_{34}$ | Cowdung : Poultry Droppings | 2:1 | 1:3 |
| $T_{35}$ | Cowdung : Poultry Droppings | 2:1 | 1:1 |
| $T_{36}$ | Cowdung : Poultry Droppings | 2:1 | 1:0.3 |
| $T_{37}$ | Poultry Droppings | 100 % | 1:5 |
| $T_{38}$ | Poultry Droppings | 100 % | 1:2 |
| $T_{39}$ | Poultry Droppings | 100 % | 1:1 |

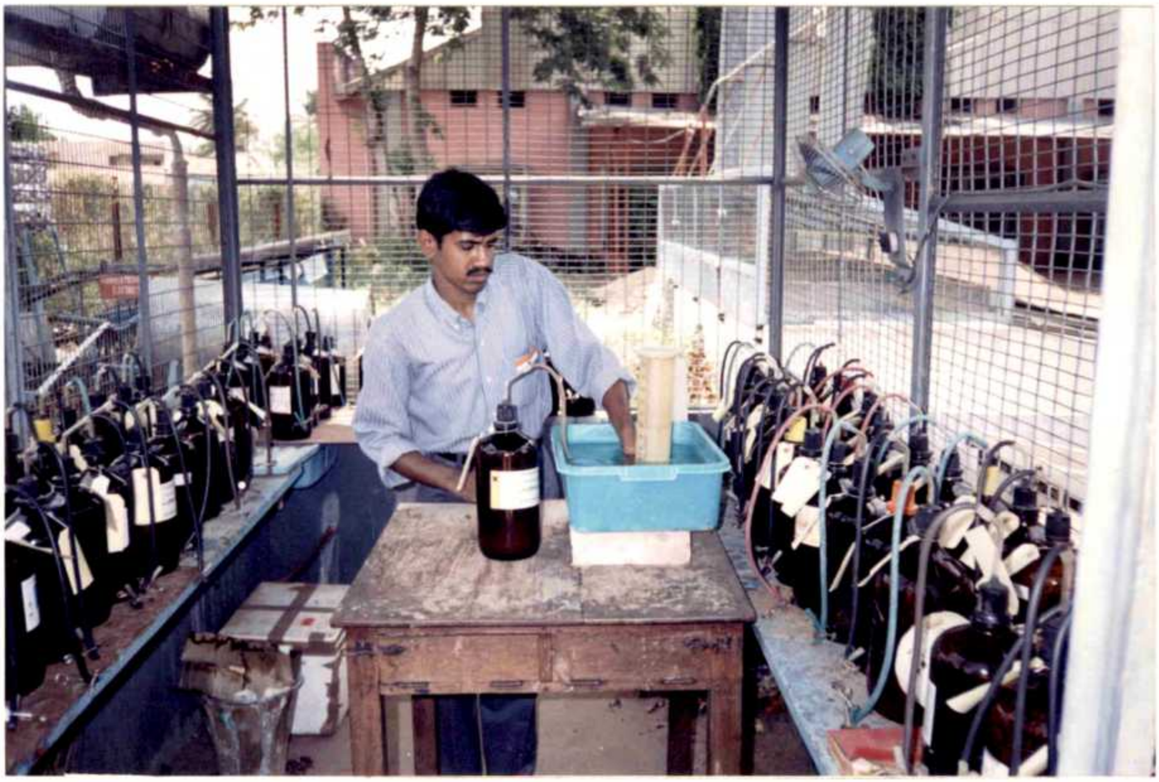


Plate No. 3.3 Quantification of biogas by water displacement method

Plate No. 3.4 Saccharometer setup for methane measurement

### 3.2.3. Measurement of methane content

The methane content was measured by using a saccharometer as suggested by Ellegard and Egneus (1984). A 5 ml saccharometer was used for this purpose as shown in plate 3.4.

$$\text{Methane content \%} = \frac{\text{Volume of undissolved gas}}{\text{Volume of gas injected}} \times 100$$

### 3.3. Details of 85 $m^3$ KVIC model biogas plant

The basic design of biogas plant includes anaerobic tank (digester) and a gas holder. The different designs, differs depending upon many factors like its geometry, materials used, durability and cost of construction. The performance of the brooder was evaluated in the poultry litter based 85 $m^3$ Khadi and Village Industries Commission (KVIC) model biogas plant (Plate 3.5) erected at Namakkal district of Tamilnadu state. The design details of the plant are as follows.

| | | |
|---|---|---|
| Gas production of the plant | = | 85 $m^3$/day |
| Daily loading of the plant (@ 25 kg of dung + 25 litres of water) per $m^3$ | = | 4.250 $m^3$ |
| Retention period | = | 40 days |
| Digester volume | = | 170 $m^3$ |
| Diameter of the digester | = | 7.00 m |

Height of the digester ($h_l$) :

$$\frac{\pi\, d^2\, h_l}{4} = 170$$

$$h_l = \frac{4 \times 170}{\pi\, d^2} = 4.4 \text{ m}$$

$$h_l = 4.4 \text{ m}$$

**Plate No. 3.5 85 m$^3$ KVIC model biogas plant**

Storage volume of drum (@ 50% storage) = $42.5\ m^3$

Diameter of the drum = 6.85 m

Height of the drum ($h_2$)

$$= \frac{\pi\ d^2\ h_2}{4} = 42.5$$

$$h_2 = \frac{4 \times 42.5}{\pi \times 6.85 \times 6.85}$$

$$= 1.15\ m$$

By adding 10 cm for the height of drum in the slurry,

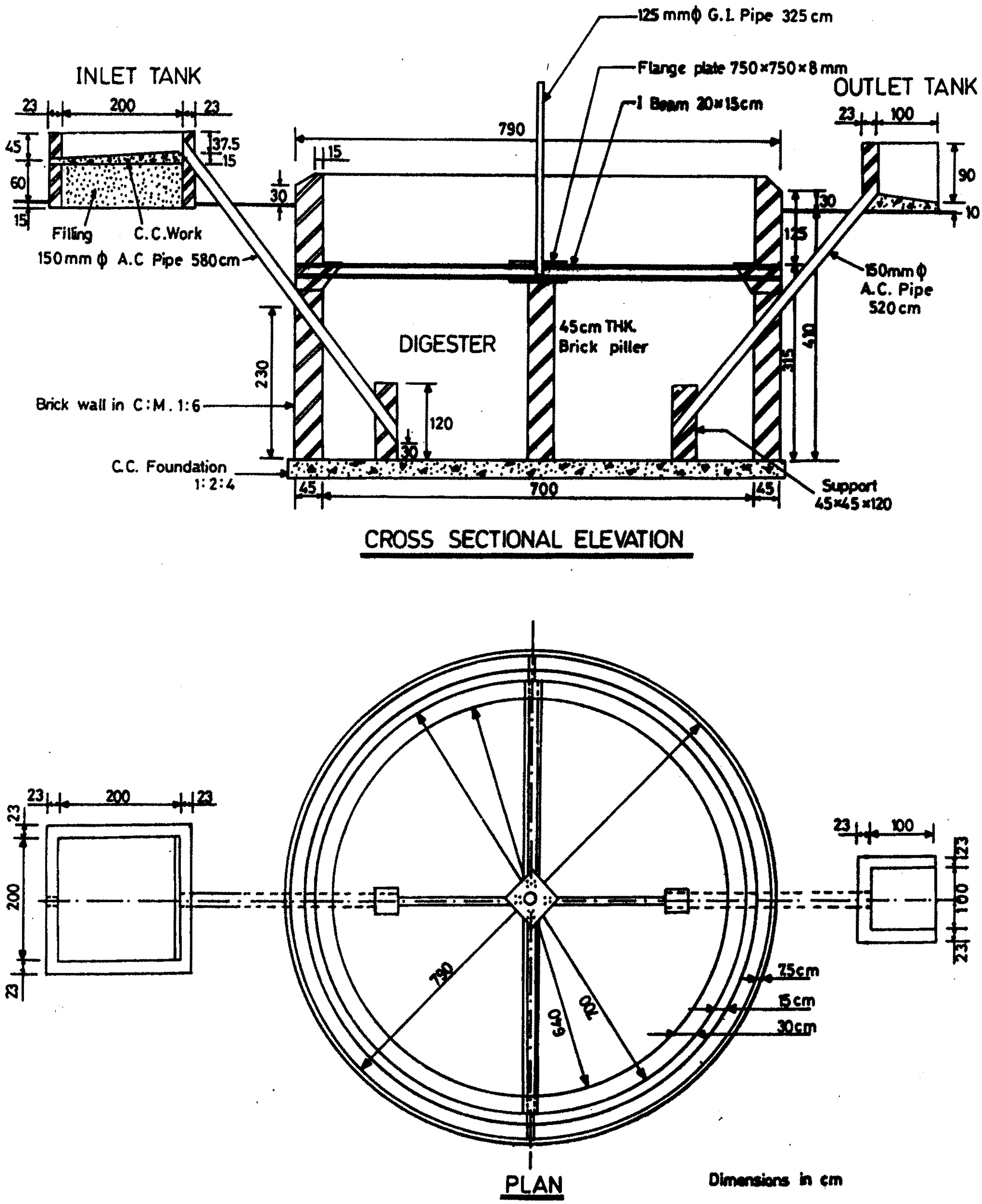
The total height of the drum = 1.15 + 0.10 = 1.25 m

The sectional and plan view of the 85 $m^3$ KVIC biogas plant is given in the drawing number 3.1 and the floating drum is given in the drawing number 3.2.

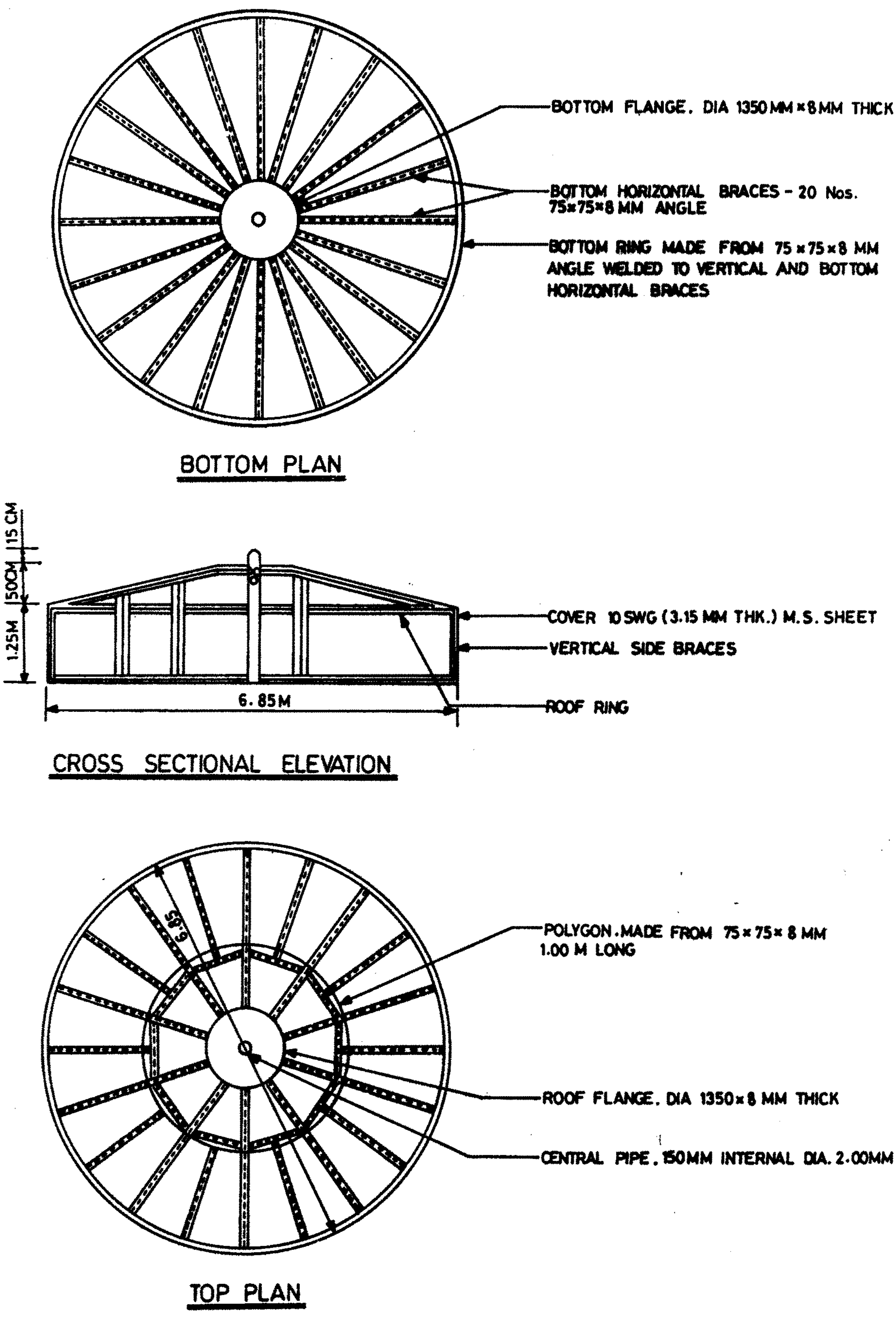
### 3.4. Development of Biogas Burner Type Brooder

Brooders for supplying heat to young animals are common equipment on the poultry farm. They usually use propane gas or natural gas as fuel. They all generate radiant heat by the combustion of gaseous fuel. Since combustion characteristics of biogas are quite different from those of propane and natural gas, all these brooder heaters needed refitting in order to maintain a stable biogas flame in the burner of the brooders. Since the brooder of mantle type necessitates frequent change of mantles and the replacement of mantles during the night time was very difficult, it has been proposed to develop burner type brooder.

Biogas burner type brooder was developed with a brooding capacity of 750 chicks, considering the following points:




DRG.3.1. 85 cum FLOATING DRUM MODEL (KVIC) BIOGAS PLANT




DRG.3.2. FLOATING DRUM

1) The mode of biogas application for brooding
2) Position of the heat source in the brooder
3) Size, shape, brooding capacity and safety to the birds
4) Provision for burning of heat source
5) Heat distribution by canopy of the brooder unit
6) Easy of operation
7) Material cost
8) Minimising the cost of brooding operation
9) Temperature requirement of chicks.

**3.4.1. Design of Biogas Burner type Brooder**

Several factors need to be kept in view while designing biogas burner. These include desired efficiency, available fabrication facilities, ease of maintenance and ease of fitting etc. While designing biogas burner type brooder, aspects like temperature distribution, mechanical strength, flame stability and thermal efficiency need to be considered. A well designed burner should have ease of replacement of its parts, easiness to lighting by a match-stick, quick and complete flame-travel the moment flame is applied to any burner port, supports to prevent any undue movement, and corrosion resistant properties.

The presence of $CO_2$ as an inert gas results in a reduced burning velocity and flame propagation speed. Therefore, biogas could not be burned in propane or natural gas burners without the adjustment of the primary air inlet and addition of a metal sieve to the burner heads. By reducing the primary air mixed with the biogas, the flame stability was improved and the tendency of the flame to lift or blow off the burner was reduced. The use of the metal sieve on the burner head to increase the flame impingement effect also helped to produce a more stable flame.

Since the calorific value and specific density of biogas are different from those of other gaseous fuels, the gas orifice should be enlarged or the gas pressure at the burner increased to achieve the rated heat input, when other gas burner were used. Heat transfer efficiency is an important performance indicator of a burner, it presents the ratio of heat derived from gas for heating and heat actually available. For a reasonably efficient burner, its value is around 70 per cent.

The developed biogas burner type brooder (Plate 3.6) was shown in drawing number 3.3. It consists of an orifice for injecting biogas, an adjustable port for air entry, a chamber for thorough mixing of gas and air, and ports for exit and burning of gas-air mixture.

The burner design involves selection of requisite size of burner tube, injector orifice, venture tube, ports, aeration facilities etc. Dimension of burner tube determines time needed to allow air and gas mixing and to bring it near flame port. If the diameter of the burner tube is too small, combustion mixture tends to travel faster destabilizing the flame. A long tube on the other hand tends to limit aeration.

A injector is used to deliver gas for burning. The following mathematical relationship can be used for determining the diameter of injector orifice.

$$Q = 1300\, Cd^2 \sqrt{\frac{P}{S}}$$

Where, Q = gas flow rate $ft^3$/hour

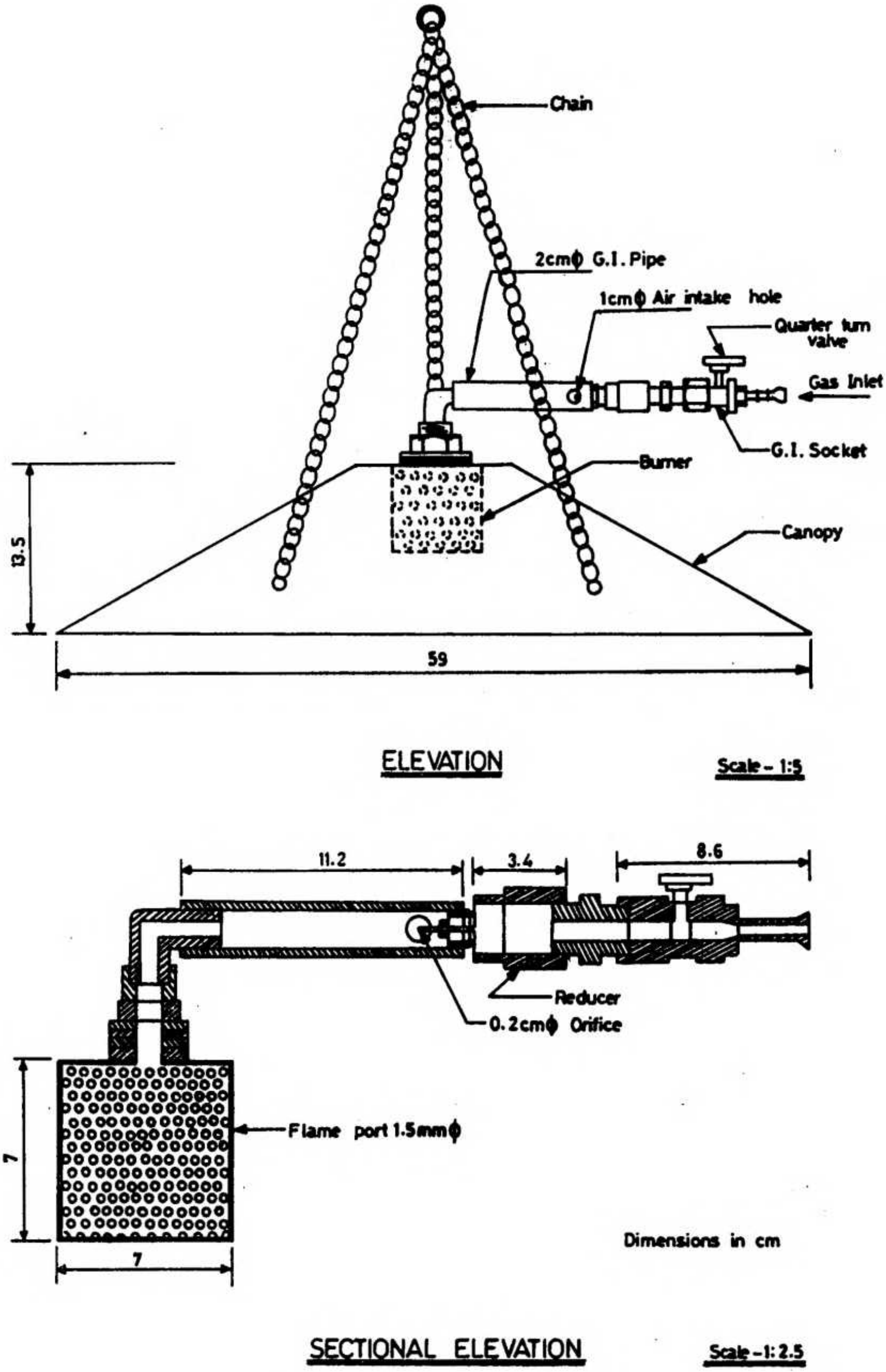
C = discharge coefficient

D = diameter of injector orifice in inches (to be determined)

P = pressure in water gauge (w.g)

S = specific gravity of gas

**Plate No. 3.6 Biogas brooder (burner type)**




DRG.3.3. BIOGAS BROODER (BURNER TYPE)

Rearrangement of above equation,

$$d^2 = \frac{Q}{1300\,c}\,\frac{\sqrt{S}}{P}$$

where,

$Q = 0.36\ m^3/hour$

$C = 0.86$

$P = 8$ w.g

$S = 0.92$

Following substitution, we get

$$d^2 = \frac{0.36 x 35.315\ (ft^3/hr)}{1300 \times 0.86}\ \sqrt{\frac{0.92}{8}}$$

$d^2 = 3.856 \times 10^{-3}$

$d = 0.06$ inch

$= 0.15$ cm

$d = 1.5$ mm.

Area of injector orifice $= \frac{\pi d^2}{4} = \frac{3.14 \times 1.5^2}{4}$

$= 1.7671 = 1.77\ mm^2$

### 3.4.2. Gas flow rate in Biogas burner

Total LPG consumption for Brooding period of 21 days = 91 Kg

Biogas equivalent, 1 $m^3$ of Biogas = 0.433 kg of LPG

Total Biogas requirement for Brooding period of 21 days $= \frac{1\ m^3}{0.433} \times 91$

$= 210.16\ m^3$

Biogas requirement per day for brooding operation $= \frac{210.16}{21}$

| | | |
|---|---|---|
| | = | $10.0076\ m^3$. |
| Average biogas requirement per day | = | $10\ m^3$ |
| Average flow rate per hour | = | $0.416\ m^3/hr$. |

During the first week of Brooding operation the temperature requirement is high. Hence attaining required temperature the gas flow rate will be high.

| | | |
|---|---|---|
| Biogas consumption for $1^{st}$ week | = | 110.85 |
| | = | $111\ m^3$ |
| Biogas requirement per day in $1^{st}$ week of Brooding | = | 111/7 |
| | = | $15.84 = 16\ m^3$ |
| Gas flow rate | = | 0.659 |
| | = | $0.66\ m^3/hr$. |

Therefore the burner of $0.66\ m^3/hr$ gas consumption was designed and tested during the brooding.

**3.5. Performance evaluation of brooders**

**3.5.1. Temperature distribution under brooder unit**

Temperature was measured at a radial distance of 0, 15, 30, 45, 60, 75, 90, 105, 120 and 150 cm from biogas burner for temperature distribution at different heights of 75, and 100 cm from the ground level. The temperature was measured by means of 302 K thermometer with thermocouple type K (NiCr- NiAl).

**3.5.2. Temperature distribution under heat source**

Temperature was measured at the ground level for different heights of heat source (biogas burner) *viz,* 75 and 100 cm from the floor level for obtaining optimum temperature requirement for chicks. But for the heat source height of 75 cm, the temperature was recorded only at the ground level. In the grid, the temperature was noted by 302 K thermometer with K type thermocouple. The observation of temperature was restricted to 300 x 300 cm. Since the higher temperature may cause danger to the chicks, the region is to be identified to prevent such damage. Surfer package (Golden microsoft Inc. 1989, version 4.07) was used for drawing the isothermal contour lines for heat distribution under the heat source in the selected brooders.

### 3.5.3. Illumination measurement

The light intensity (illumination) was measured at a distance of 0, 15, 30, 45, 60, 75, 90, 105, 120 and 150 cm from the biogas burner at different heights of 75 and 100 cm from the ground level and for control, the illumination was measured from centre of brooder unit. The illumination was measured by using Luxtron $L_x$ – 101 Lux meter (Sl. No 437603).

### 3.5.4. Fuel consumption in brooders

The biogas consumption in biogas brooder (burner type) and butane consumption in LPG brooder for 21 days was studied in order to evaluate the performance of biogas brooder in comparing with LPG brooder. The study was carried out in the poultry industry for 1500 number of chicks and the gas consumption was measured by using the following instruments/meters.

1. Biogas consumption : By using wet type gas flow meter
2. LPG consumption : Based on the total LPG consumption by weight basis

### 3.6. Cost economics for brooding of chicks

The cost economics was worked out for brooding a bird in conventional LPG brooder and newly developed biogas brooder. The cost analysis was carried out by incorporating fixed and variable cost of the operation. Standard straight line method was followed for cost analysis.

### 3.7. Energy inflow and outflow of poultry industry

A detailed energy audit study was carried out in the Pioneer Breeding Farms, Pongalur to estimate the energy use from hatching to layering. Each unit operations *viz.*, hatching, brooding and growing and layering in the poultry production process were studied for energy inflow and outflow. The study was carried out for one year period and the average value is presented.

#### 3.7.1 Energy input

The energy input by different sources was separately quantified. To calculate the energy input, the equivalent energy co-efficients (Panesar and Bhatnagar, 1987) were used as follows.

| Input form | equivalent Energy MJ |
|---|---|
| Human labour | |
| Man-hour | 1.97 |
| Woman–hour | 1.57 |
| Diesel, l | 50.31 |
| LPG, Kg. | 45.56 |
| Electricity, kWh | 11.93 |
| Firewood, Kg. | 18.9 |

$$\text{The equivalent energy for electric motors} = \frac{\text{Installed capacity, kWh X 11.93}}{0.85}$$

#### 3.7.2. Actual electricity and fuel use

The actual fuel and electricity used for each unit operation of the poultry production process were assessed and quantified for the capacity of 80,000 chicks. The actual electricity consumption for electric motors was obtained using the following relationships.

$$\text{Power (P), kW} = \frac{VIF}{1000} \text{ for single phase}$$

$$= \frac{1.73\ VIF}{1000} \text{ for 3 phase}$$

$$\text{Energy consumption, kWh} = \text{P, kW X h}$$

Where,

V= Voltage, I = current

F = Power factor, h = Hours of use

The current was measured using a clamp on ammeter (make Yu Fung, model:Fy-300) and voltage with voltmeters. In cases, where the actual current could not be estimated, it was assumed that, the motor is working at 80 percent of its installed capacity. The LPG consumption was measured by weight basis per day and noted for total period of brooding operation (21 days).

# Results and Discussion

# CHAPTER IV

# RESULTS AND DISCUSSION

In this chapter, the results of the tests carried out with poultry wastes and cowdung in different proportions for biogas production through anaerobic digestion and its application for brooding are described and discussed under the following headings.

1. Characterization of feedstock.
2. Estimation of biogas production from poultry wastes and cowdung.
3. Performance evaluation of biogas brooder.
4. Cost economics for brooding of chicks.
5. Energy inflow and outflow of the poultry industry.

## 4.1. Characterization of feedstock

### 4.1.1. Total solids and volatile solids content

The physical and chemical properties of different feedstocks were found and summarized in Table 4.1.

It can be clearly seen from the Table 4.1 that the maximum total solid content of 89.32 per cent was present in poultry deep litter because of presence of bed material which have non combustible material along with the poultry deep litter. The minimum total solid content was present in cowdung as 13.79 per cent. It could also be seen that maximum and minimum volatile solid content was present in poultry deeplitter (65.64 per cent) and cowdung (10.66 per cent) as feedstock respectively.

### 4.1.2. Volatile solid content in total solids

The per cent of volatile solid content in total solids of different feedstock is summarized in Table 4.1. The volatile solid content in total solids falls in the range of 22 to 69 per cent. The maximum value was 68.90 per cent in poultry manure as feedstock and the minimum value was 22.70 per cent in cowdung alone as feedstock.

**Table 4.1. Physical and chemical properties of different feedstocks**

| Feedstocks (samples) | Total Solid Content in per cent | VS (as per cent of TS) | Volatile Solid Content in per cent | Total organic carbon in per cent | Total nitrogen in per cent | Carbon Nitrogen ratio |
|---|---|---|---|---|---|---|
| Cowdung | 13.79 | 22.70 | 10.66 | 45.80 | 1.86 | 24.62 |
| Poultry manure-yard | 79.99 | 68.90 | 24.88 | 14.20 | 1.90 | 7.47 |
| Poultry deep litter | 89.32 | 26.51 | 65.64 | 21.70 | 1.40 | 15.50 |
| Poultry droppings | 30.96 | 65.79 | 10.60 | 24.00 | 2.45 | 9.80 |

### 4.1.3. Total Organic Carbon and Total Nitrogen

The cowdung sample significantly contains higher amount of total organic carbon as 45.80 percent compared to the other waste samples and poultry manure contains lower amount of organic carbon, because of combustible material present with manure. The table 4.1 clearly shown the nitrogen content of poultry droppings maximum value as 2.45 per cent and minimum total nitrogen was found in the case of poultry deep litter because of bed material contains dry matter of non combustible organic materials.

### 4.1.4. Carbon Nitrogen ratio

Table 4.1.clearly indicated the maximum carbon nitrogen ratio was obtained in the cowdung sample as 24.62 and followed by the poultry deep litter as 15.50 and poultry droppings as 9.80. The lowest C:N ratio was recorded in the poultry manure as feedstock.

### 4.2. Estimation of biogas production potential from different wastes

The daily biogas production recorded from above wastes is given in the appendix A. The total biogas production of these wastes is tabulated in Table 4.2 as given below.

**Table 4.2. Total biogas production for different combinations of feedstocks**

| Treatment | Total Solids, per cent | Total biogas production, ml | Max gas yield/day | Average gas yield/day |
|---|---|---|---|---|
| 1 | 5 | 5378 | 230 | 60 |
| 2 | 10 | 6783 | 450 | 81 |
| 3 | 15 | 16073 | 550 | 172 |
| 4 | 5 | 1925 | 140 | 26 |
| 5 | 10 | 4540 | 200 | 53 |
| 6 | 15 | 10593 | 415 | 118 |
| 7 | 20 | 15905 | 860 | 181 |
| 8 | 5 | 1698 | 530 | 24 |
| 9 | 10 | 2555 | 110 | 31 |
| 10 | 15 | 11898 | 570 | 121 |
| 11 | 20 | 7670 | 325 | 91 |
| 12 | 5 | 5173 | 200 | 62 |
| 13 | 10 | 11545 | 520 | 151 |
| 14 | 15 | 18058 | 790 | 208 |
| 15 | 20 | 18073 | 575 | 207 |
| 16 | 5 | 11708 | 570 | 120 |
| 17 | 10 | 5428 | 1150 | 73 |
| 18 | 15 | 8048 | 1455 | 124 |
| 19 | 20 | 12088 | 1825 | 161 |
| 20 | 5 | 11833 | 600 | 130 |
| 21 | 10 | 6200 | 2085 | 91 |
| 22 | 15 | 9153 | 1775 | 135 |
| 23 | 20 | 13225 | 2168 | 165 |
| 24 | 5 | 11750 | 2365 | 119 |
| 25 | 10 | 14838 | 1275 | 160 |
| 26 | 15 | 8683 | 1770 | 31 |
| 27 | 20 | 20655 | 1545 | 179 |
| 28 | 5 | 14710 | 425 | 156 |
| 29 | 10 | 33640 | 1155 | 357 |
| 30 | 15 | 41333 | 1450 | 410 |
| 31 | 5 | 15360 | 520 | 157 |
| 32 | 10 | 24908 | 750 | 253 |
| 33 | 15 | 29128 | 1210 | 267 |
| 34 | 5 | 16855 | 755 | 166 |
| 35 | 10 | 34873 | 1215 | 312 |
| 36 | 15 | 47273 | 1685 | 457 |
| 37 | 5 | 7770 | 275 | 83 |
| 38 | 10 | 16448 | 1235 | 123 |
| 39 | 15 | 30655 | 1225 | 303 |

Table 4.2 reveals the total gas production from all combinations. The highest gas production was recorded from the combination of cowdung and poultry droppings ($T_{36}$) in the ratio of 2:1 with 15 per cent total solids as 47273 ml and lowest was recorded from the combination of cowdung and poultry manure ($T_8$) in 1:2 ratio with 5 per cent total solids as 1925 ml .

The gas production was analyzed with different types of poultry industry wastes and cowdung was chosen as a control for estimation for biogas production.

### 4.2.1. Biogas production from different combination of feedstocks

#### 4.2.1.1. Poultry Manure based material combinations

The total biogas production obtained from the poultry manure based material combinations with ratios 1:1, 1:2 and 2:1 ratios with the addition of desired quantity of water to have the 5 per cent total solids are summarized in Table 4.3.

**Table 4.3. Total Gas Production from Poultry Manure combinations in 1:1, 1:2 and 2:1 ratios with 5 per cent TS**

| Treatment | Combination | Gas production, ml |
|---|---|---|
| $T_4$ | Cowdung : Poultry manure (1:1) | 1925 |
| $T_8$ | Cowdung : Poultry manure (1:2) | 1698 |
| $T_{12}$ | Cowdung : Poultry manure (2:1) | 5173 |
| $T_1$ | Cowdung (100 per cent ) | 5378 |

The highest gas production was achieved in the combination of cowdung and poultry manure ($T_{12}$) in the ratio of 2:1 as 5173 ml followed by cowdung and poultry manure ($T_4$) in the ratio of 1:1 as 1925 ml and subsequently by cowdung and poultry manure ($T_8$) in 1:2 ratio as 1698 ml. All these combination produced lower biogas as compared to cowdung alone as feed material as 5378 ml..

The weekly and cumulative gas production from different poultry manure based material combination mixed in the ratios of 1:1 and 1:2 and 2:1 with 5 per cent total solids are given in figure 4.1 and 4.2 respectively.

Among all the combinations, the cowdung and poultry manure in the ratio of 2:1 at 5 per cent total solids produced maximum biogas per week during 6$^{th}$ week as 1305 ml, but suddenly fell down in the consecutive weeks. This is because the production of gas from cowdung which favoured optimum C:N ratio caused this increased as stated by Gadre *et al.* (1990). The gas production ceased between 12$^{th}$ and 15$^{th}$ week in all the combinations.

Figure 4.2 shows that the stability was achieved in the combination of cowdung and poultry manure in 1:1 ratio ($T_4$) and cowdung and poultry manure in 1:2 ratios ($T_8$) after eighth week which shows that effective gas production have been achieved during first eight weeks. Where as in the case of cowdung and poultry manure ($T_{12}$) in the ratio of 2:1 and cowdung ($T_1$) the gas production gradually reduced from 1$^{st}$ week to 12$^{th}$ week and then attained stability after 12$^{th}$ week.

The total biogas production obtained from the poultry manure based material combinations with 1:1, 1:2 and 2:1 ratios with the addition of desired quantity of water to have the 10 per cent total solids are summarized in Table 4.4.

**Table 4.4. Total Gas Production from Poultry Manure based material combinations in 1:1, 1:2 and 2:1 ratios with 10 per cent TS**

| Treatment | Combination | Gas production, ml |
|---|---|---|
| $T_5$ | Cowdung : Poultry manure (1:1) | 4540 |
| $T_9$ | Cowdung : Poultry manure (1:2) | 2555 |
| $T_{13}$ | Cowdung : Poultry manure (2:1) | 11545 |
| $T_2$ | Cowdung (100 per cent ) | 6783 |

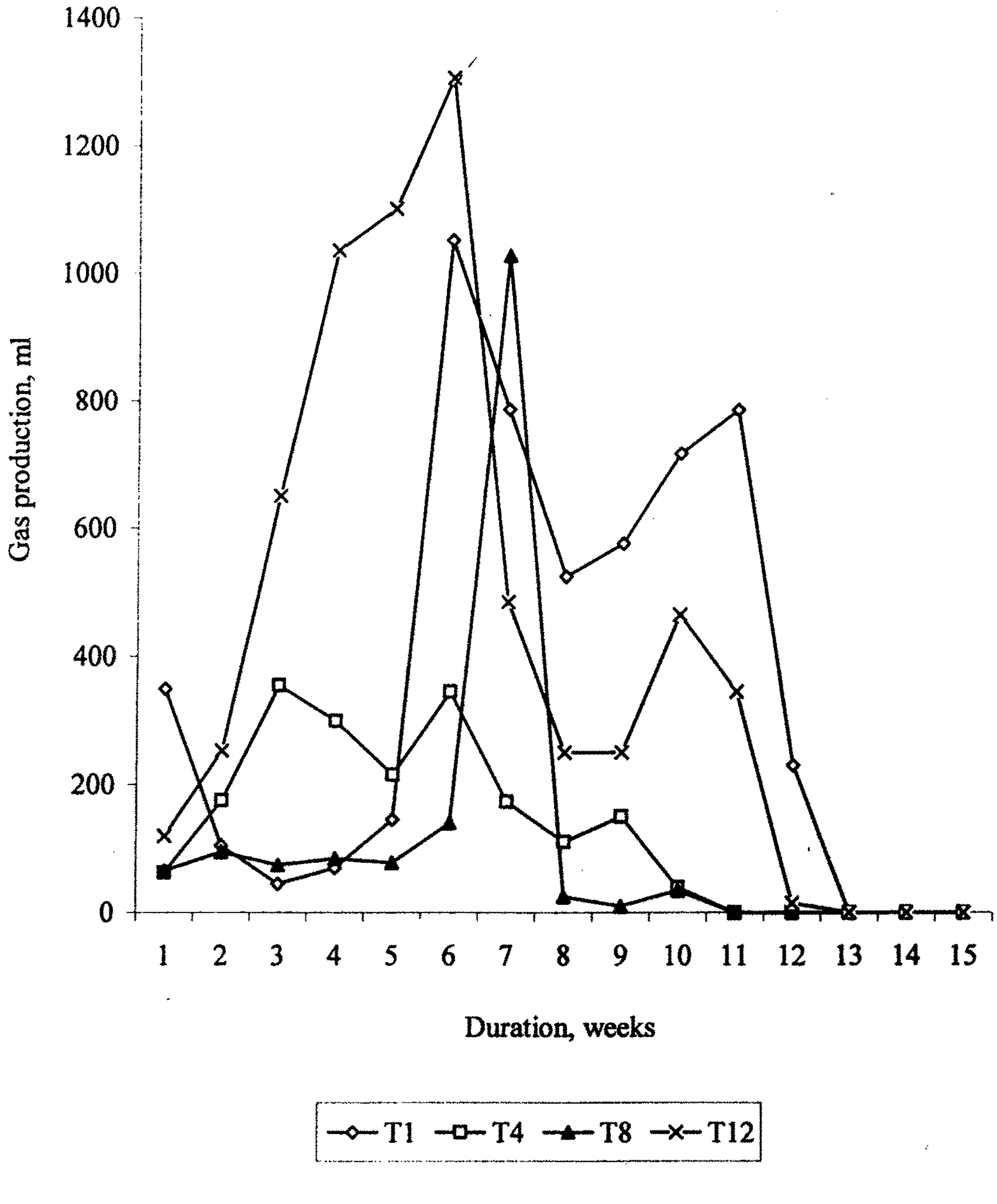



**Fig 4.1 WEEKLY BIOGAS PRODUCTION FROM POULTRY MANURE BASED MATERIAL COMBINATION WITH 5% TS**

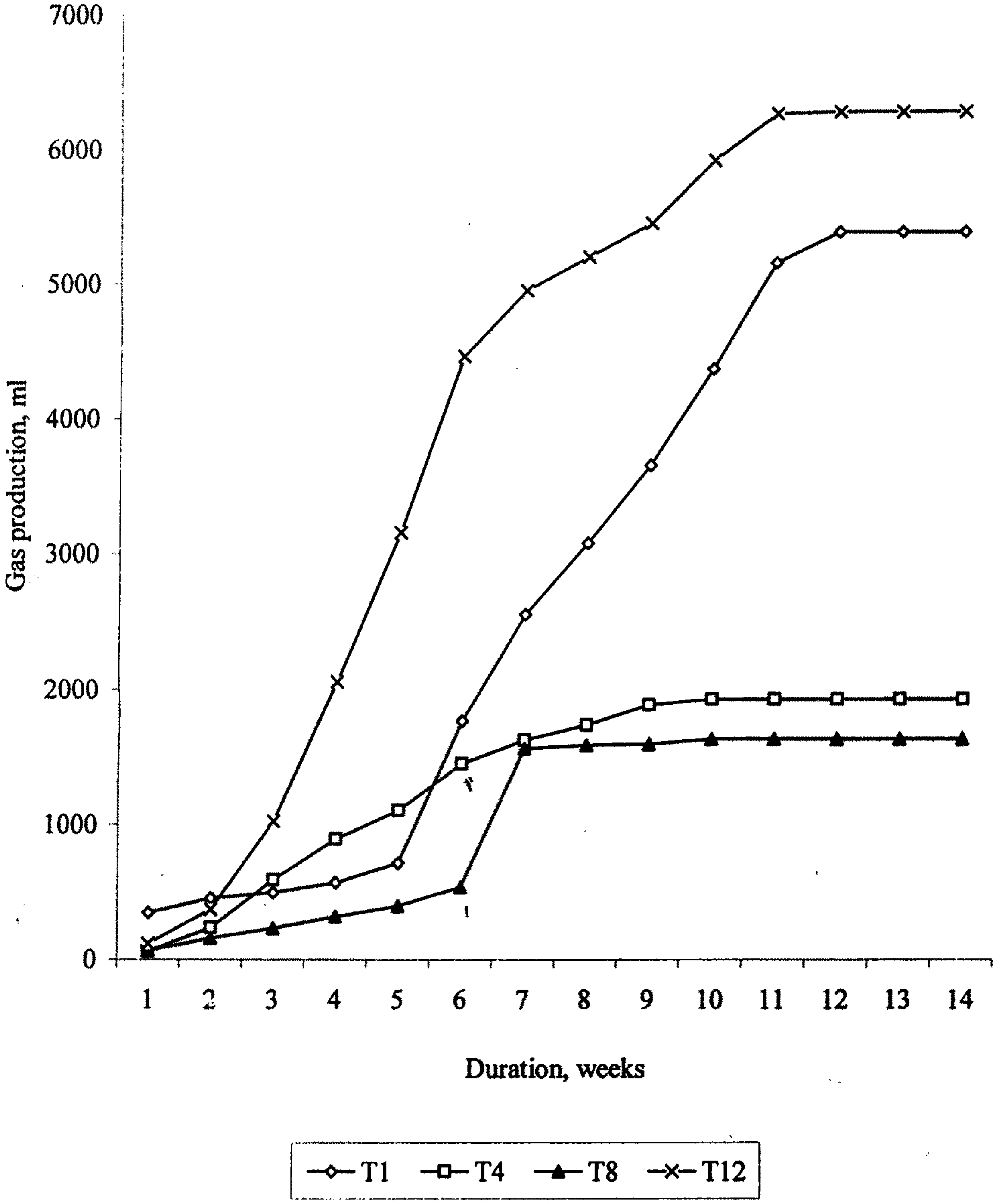



**Fig 4.2 CUMULATIVE BIOGAS PRODUCTION FROM POULTRY MANURE BASED MATERIAL COMBINATION WITH 5% TS**

The biogas production trend was similar to that of poultry manure material based combinations with 5 per cent. Table 4.4 reveals that the maximum total gas production was achieved in cowdung and poultry manure in 2:1 ratio as 11545 ml. All the combinations produced biogas more or less double the quantity of 5 per cent TS, whereas the cowdung in 100 per cent is not doubled.

Figures 4.3 and 4.4 reveal that the weekly and cumulative biogas production of different poultry manure based materials as feed stock respectively. Among all the combinations, cowdung and poultry manure in the ratio of 2:1 ($T_{13}$) produced maximum gas production throughout the period. The maximum gas production per week was achieved also in combination cowdung and poultry manure in the ratio of 2:1 ($T_{13}$) as 1720 ml. All other combination showed the same trend in 5 per cent TS.

From figure 4.4 which shows the stability of gas production was achieved in the combination of cowdung and poultry manure in the ratio of 1:1 ($T_5$) and cowdung and poultry manure ($T_9$) in 1:2 ratio after 7$^{th}$ week as in the case of 5 per cent TS, whereas in the case of cowdung and poultry manure in 2:1 ratio ($T_{13}$), the gas production increased from 1$^{st}$ week to 12$^{th}$ week and then stabilized during next three weeks.

The average gas production was recorded maximum as 151 ml/day when cowdung mixed with poultry manure ($T_{13}$) in 2:1 ratio followed by cowdung mixed with poultry manure ($T_5$) in 1:1 ratio and cowdung mixed with poultry manure ($T_9$) in the ratio of 1:2. The average gas production was recorded as 81 ml/day when cowdung alone as feedstock ($T_2$). The gas production lasted for 12 to 15 weeks in all the combination of poultry manure.

The total biogas production obtained from the poultry manure based material combinations with ratios 1:1, 1:2 and 2:1 ratios with the addition of desired quantity of water to have the 15 per cent total solids are summarized as given Table 4.5.

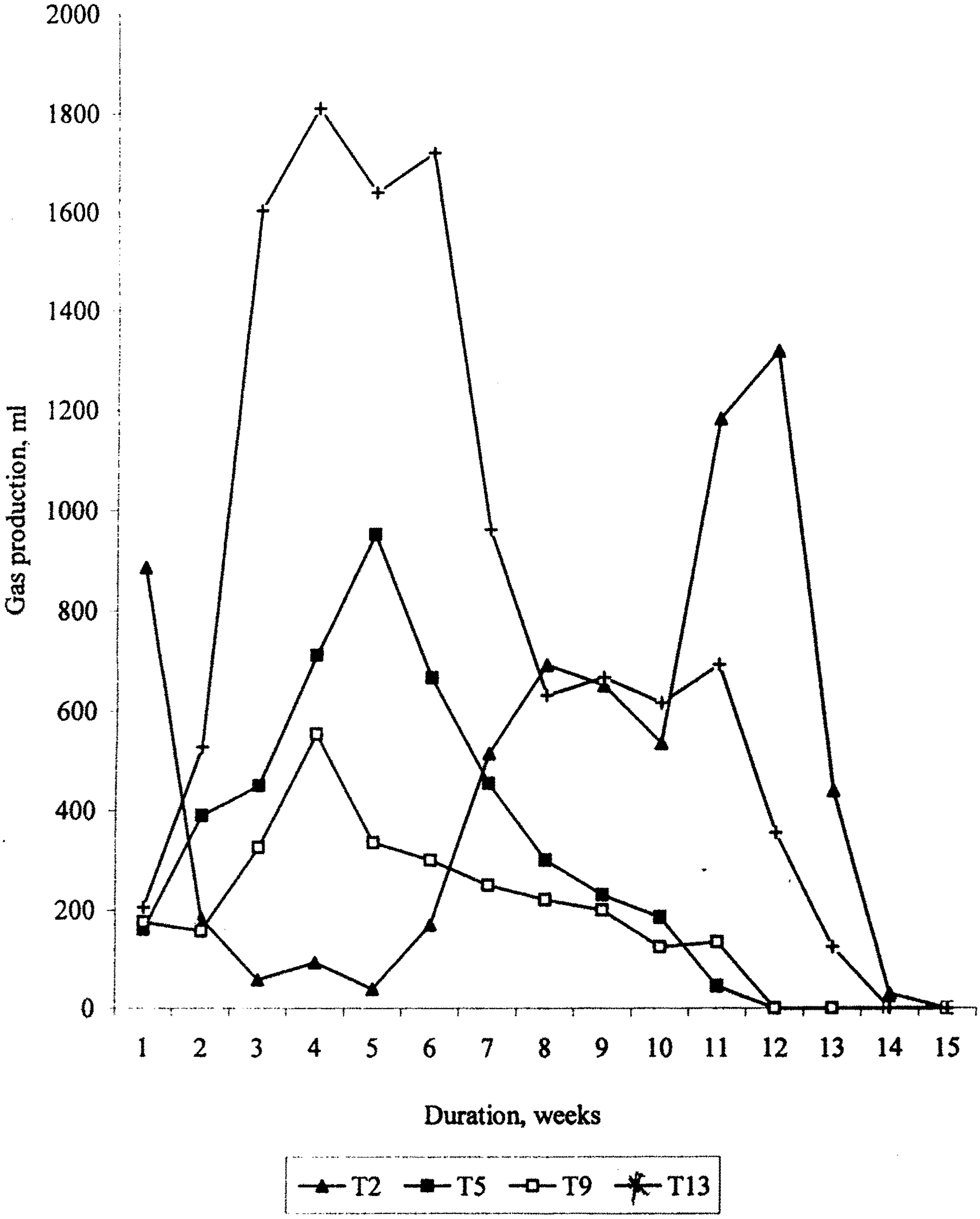



**Fig 4.3 WEEKLY BIOGAS PRODUCTION FROM POULTRY MANURE BASED MATERIAL COMBINATION WITH 10% TS**

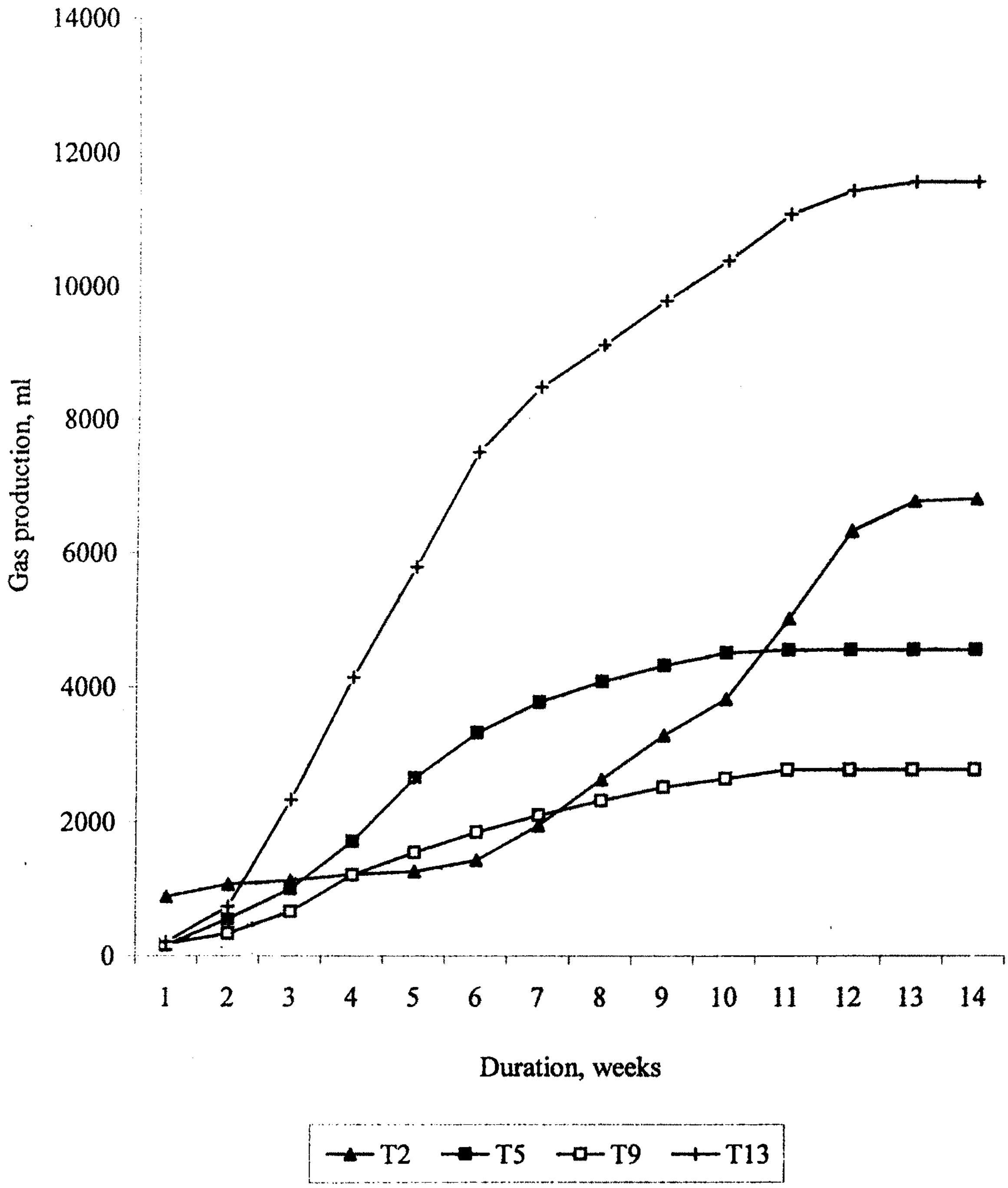



**Fig 4.4 CUMULATIVE BIOGAS PRODUCTION FROM POULTRY MANURE BASED MATERIAL COMBINATION WITH 10% TS**

**Table 4.5. Total Gas Production from Poultry Manure based material combinations in 1:1, 1:2 and 2:1 ratios with 15 per cent TS**

| Treatment | Combination | Gas production, ml |
|---|---|---|
| $T_6$ | Cowdung : Poultry cage manure (1:1) | 10593 |
| $T_{10}$ | Cowdung : Poultry manure (1:2) | 11898 |
| $T_{14}$ | Cowdung : Poultry manure (2:1) | 18058 |
| $T_3$ | Cowdung (100 per cent ) | 16073 |

The highest gas production was achieved in the combination of cowdung and poultry manure ($T_{14}$) in the ratio of 2:1 as 18058 ml. When the TS value increased from 5 per cent to 15 per cent the total biogas production also tripled i.e. from 5173 ml to 18058 ml. The lowest gas production was achieved in cowdung and poultry manure ($T_6$) in the ratio 1:1 with the TS content of 15 per cent as 10593 ml.

The weekly and cumulative gas production from different poultry manure based material combination mixed in the ratios of 1:1 and 1:2: and 2:1 with 15 per cent total solids are given in figure 4.5 and 4.6 respectively. The weekly biogas production reveals that the similar trend follows as in the case 5 per cent TS.

The maximum average gas production was recorded as 208 ml/day when cowdung mixed with poultry manure ($T_{13}$) in 2:1 ratio as compared to the average gas production as 172 ml/day when cowdung alone ($T_3$) as feedstock. This condition was very similar to 10 per cent total solids.

The total biogas production obtained from the poultry manure based material combinations with ratios 1:1, 1:2 and 2:1 ratios with the addition of desired quantity of water to have the 20 per cent total solids are summarized as given Table 4.6.

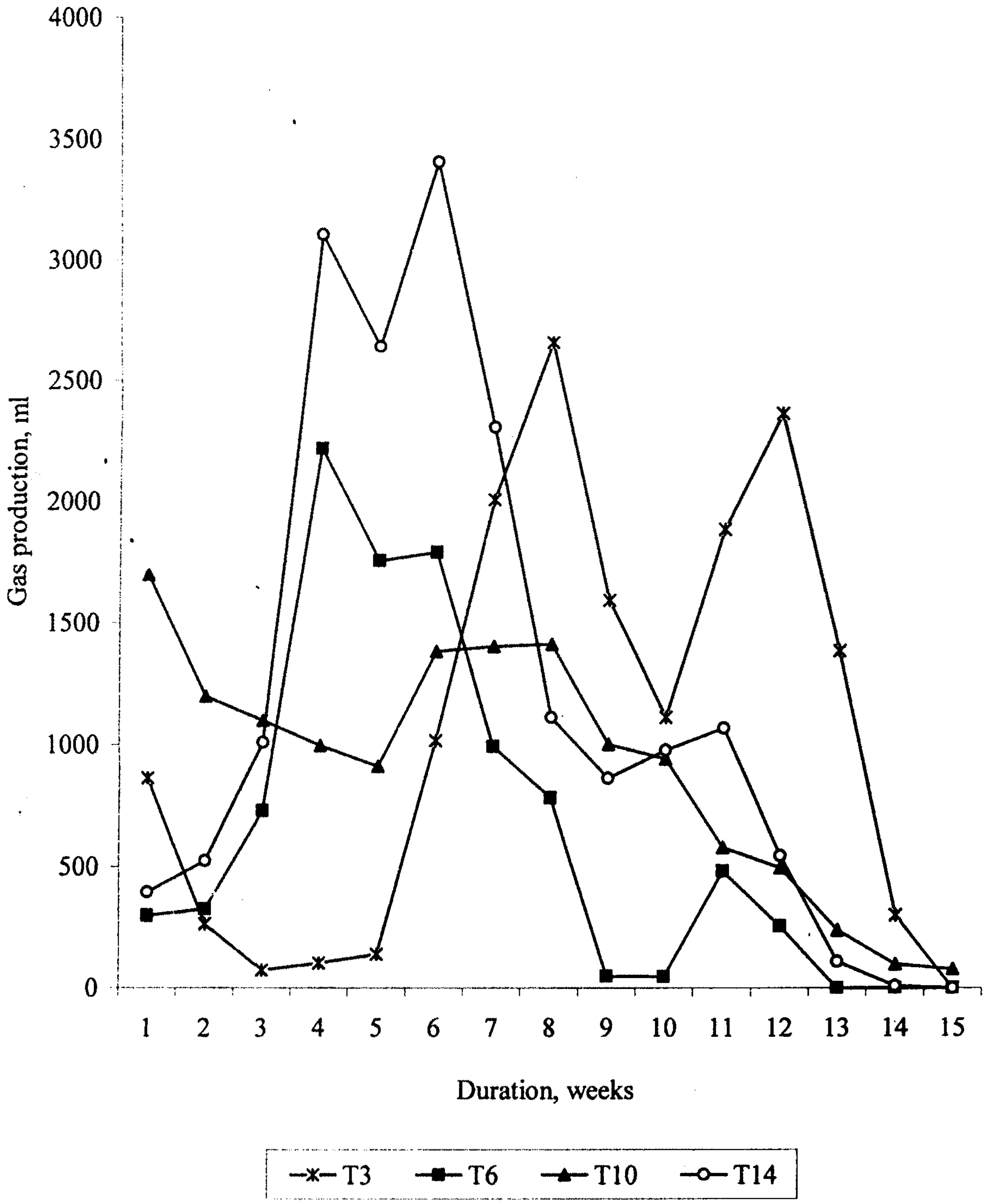



**Fig 4.5 WEEKLY BIOGAS PRODUCTION FROM POULTRY MANURE BASED MATERIAL COMBINATION WITH 15% TS**

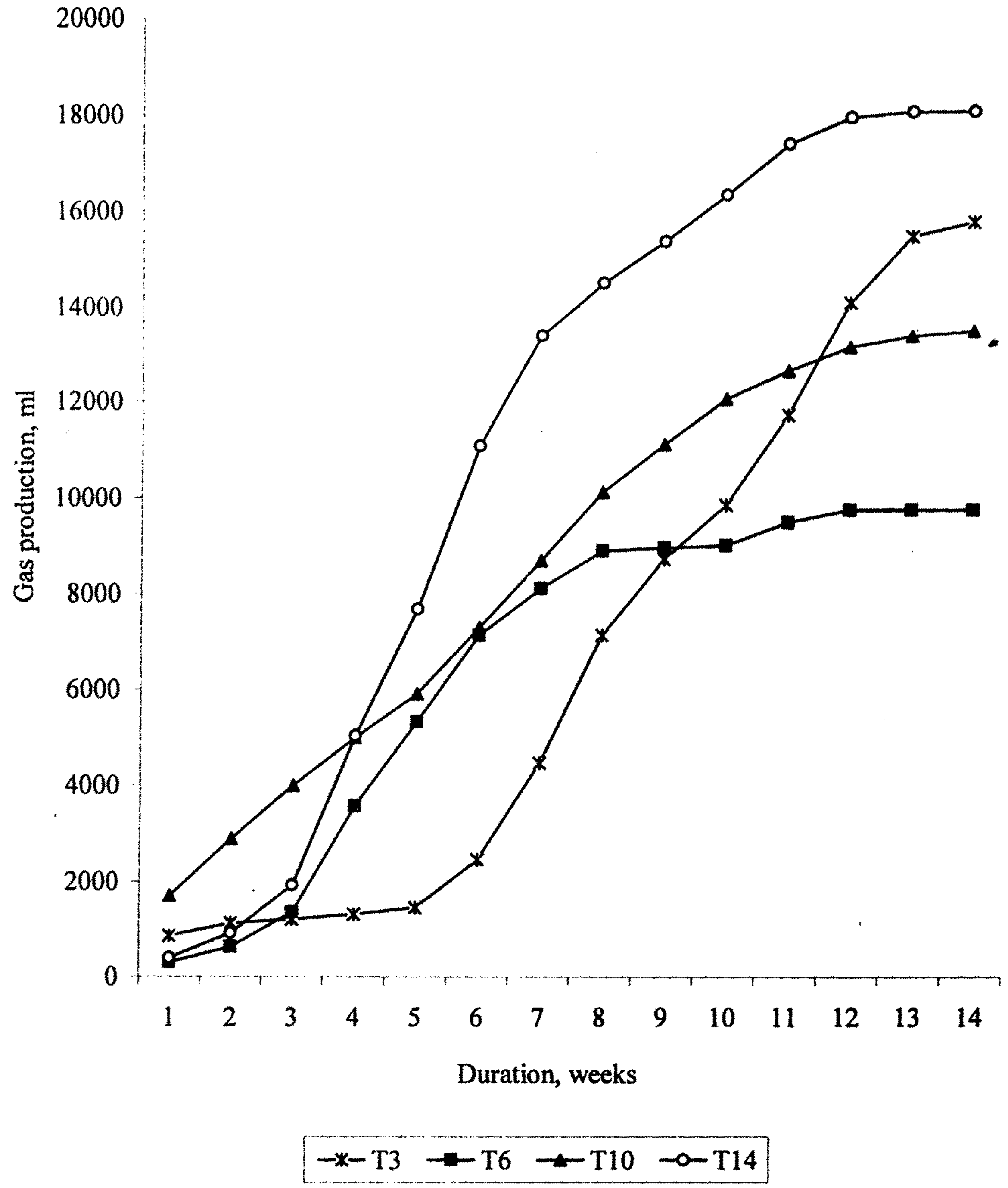



**Fig 4.6 CUMULATIVE BIOGAS PRODUCTION FROM POULTRY MANURE BASED MATERIAL COMBINATION WITH 15% TS**

**Table 4.6. Total gas production from Poultry manure based material combinations in 1:1, 1:2 and 2:1 ratios with 20 per cent TS**

| Treatment | Combination | Gas production, ml |
|---|---|---|
| $T_7$ | Cowdung : Poultry cage manure (1:1) | 15905 |
| $T_{11}$ | Cowdung : Poultry manure (1:2) | 7670 |
| $T_{15}$ | Cowdung : Poultry manure (2:1) | 18073 |

The maximum total biogas production was observed in the combination of cowdung and poultry manure ($T_{15}$) in the ratio of 2:1 as 18073 ml followed by cowdung and poultry manure ($T_7$) in the ratio of 1:1 as 15905 ml. The lowest total gas production was recorded with cowdung and poultry manure ($T_{15}$) in the ratio of 1:2 as 7670 ml.

The weekly and cumulative gas production from different poultry manure based material combination mixed in the ratios of 1:1 and 1:2: and 2:1 with 20 per cent total solids are given in figures 4.7 and 4.8 respectively. The weekly biogas production reveals that the similar trend follows as in the case 5 per cent TS. Among all the combinations, the cowdung and poultry manure in the ratio of 2:1 produced maximum biogas per week during 5$^{th}$ to 6$^{th}$ week as 3875 ml, but suddenly fell down in the consecutive weeks. This is because the production of gas from cowdung caused this increased as stated by Gadre *et al.* (1990). The gas production ceased during the 14$^{th}$ 15$^{th}$ week in all the combinations.

From all the combination of poultry manure based material with the ratios of 1:1,1:2 and 2:1 with the 5 per cent, 10 per cent, 15 per cent and 20 per cent TS, it can be seen that the total gas production was achieved in the 2:1 ratio.

Among these combinations of 2:1 ratio the total gas production increased as the TS content increases from 5 per cent to 20 per cent i.e. from 5173 ml to 18073 ml respectively.

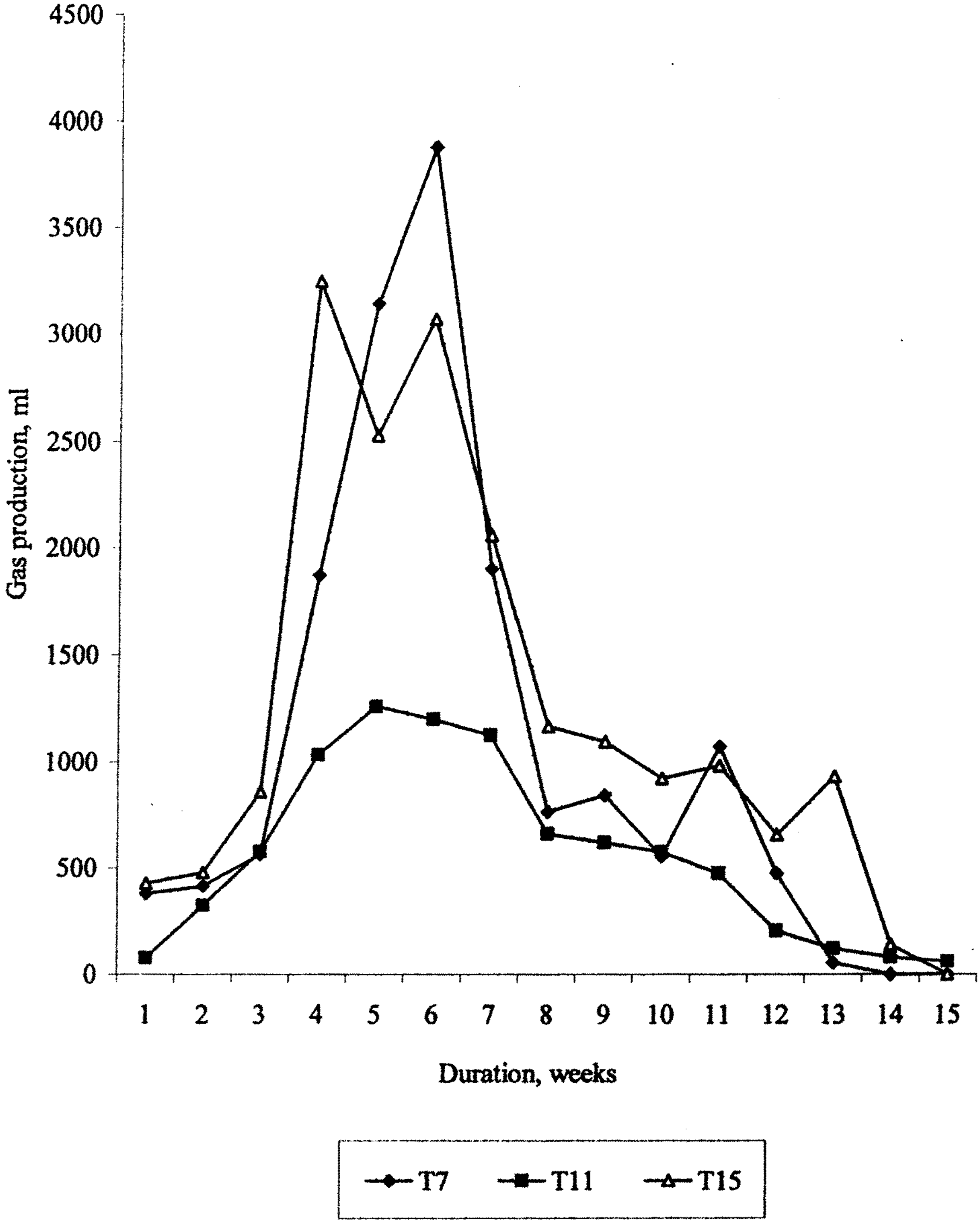



**Fig 4.7 WEEKLY BIOGAS PRODUCTION FROM POULTRY MANURE WITH 20% TS**

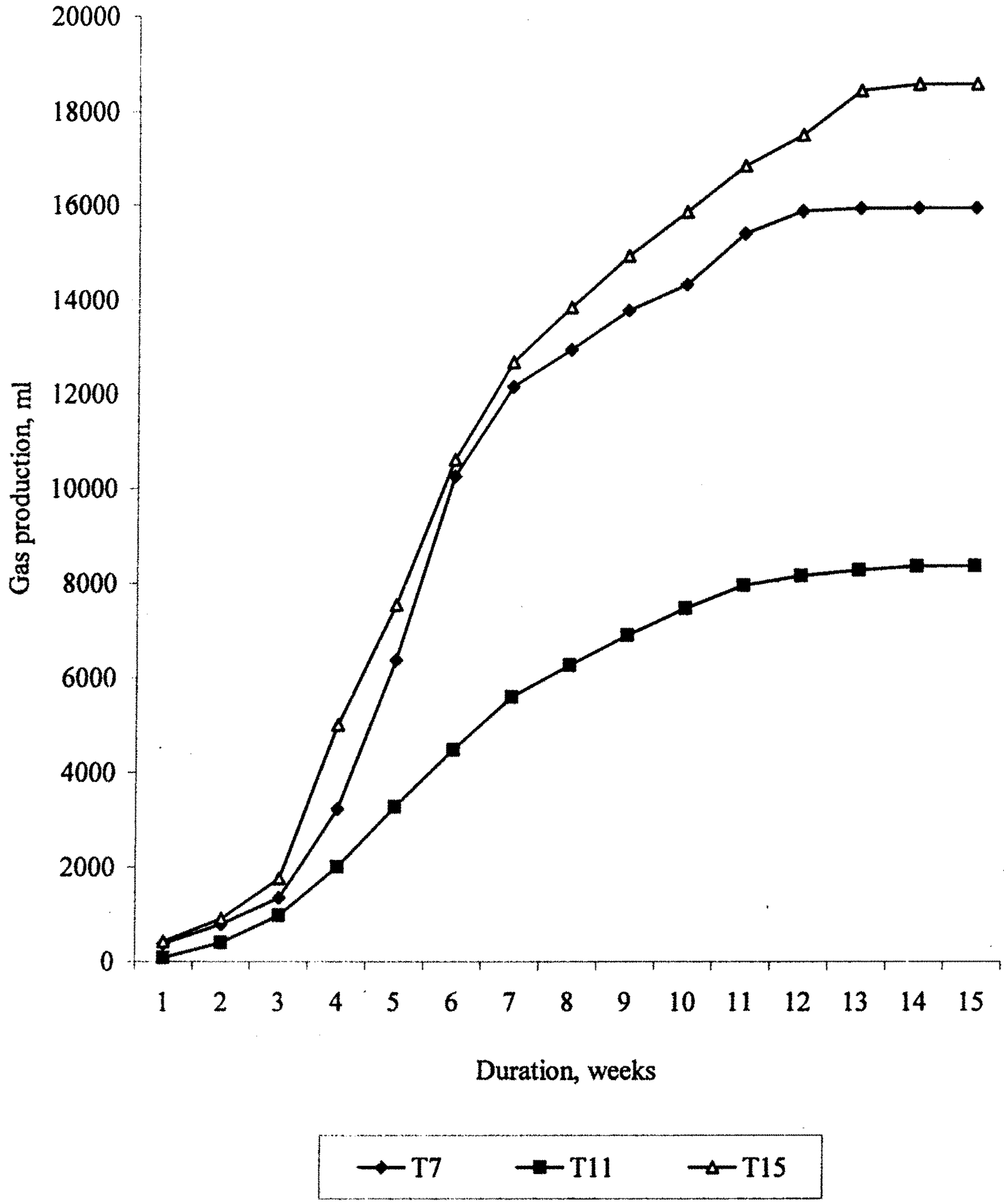



**Fig 4.8 CUMULATIVE BIOGAS PRODUCTION FROM POULTRY MANURE BASED MATERIAL COMBINATION WITH 20% TS**

#### 4.2.1.2. Poultry Deep Litter based material combinations

Total biogas production of the poultry deep litter based material combinations with the ratios of 1:1, 1:2 and 2:1 with the addition of desired quantity of water to have the 5 per cent total solids are summarized in Table 4.7

**Table 4.7. Total Gas Production from Poultry Deep Litter material combinations in 1:1, 1:2 and 2:1 ratios with 5 per cent TS**

| Treatment | Combination | Gas production, ml |
|---|---|---|
| $T_{16}$ | Cowdung : Poultry Deep Litter (1:1) | 11708 |
| $T_{20}$ | Cowdung : Poultry Deep Litter (1:2) | 11833 |
| $T_{24}$ | Cowdung : Poultry Deep Litter (2:1) | 11750 |
| $T_1$ | Cowdung (100 per cent ) | 5378 |

Cowdung and poultry deep litter produced almost equal volume of total biogas in the ratios of 1:1, 1:2 and 2:1 as 11,708 ml, 11,833 ml and 11750 ml respectively. The minimum total biogas production was recorded (5378 ml) with the cowdung ($T_1$) as feedstock.

The weekly and cumulative gas production from different poultry litter based material combination mixed in the ratios 1:1, 1:2 and 2:1 with 5 per cent TS are given in figures 4.9 and 4.10 respectively. In all the combinations, the daily gas production was high in the initial period which decreased during 3$^{rd}$ to 4$^{th}$ week and gradually increased during the 6$^{th}$ week and then gradually decreased to the end except cowdung as feedstock in 100 per cent ($T_1$). The total gas production recorded during the first week was maximum in the case of cowdung with poultry deep litter ($T_{24}$) in the ratio of 2:1 as 3445 ml followed by the combination of 1:2 ratios. Webb and Hawkes (1985), reported that the rate of gas production was very high immediately after start up but decreased sharply after approximately seven days which were confirmed in this experiment, because poultry litter easily digested anaerobically over a wide range of influent total solids..

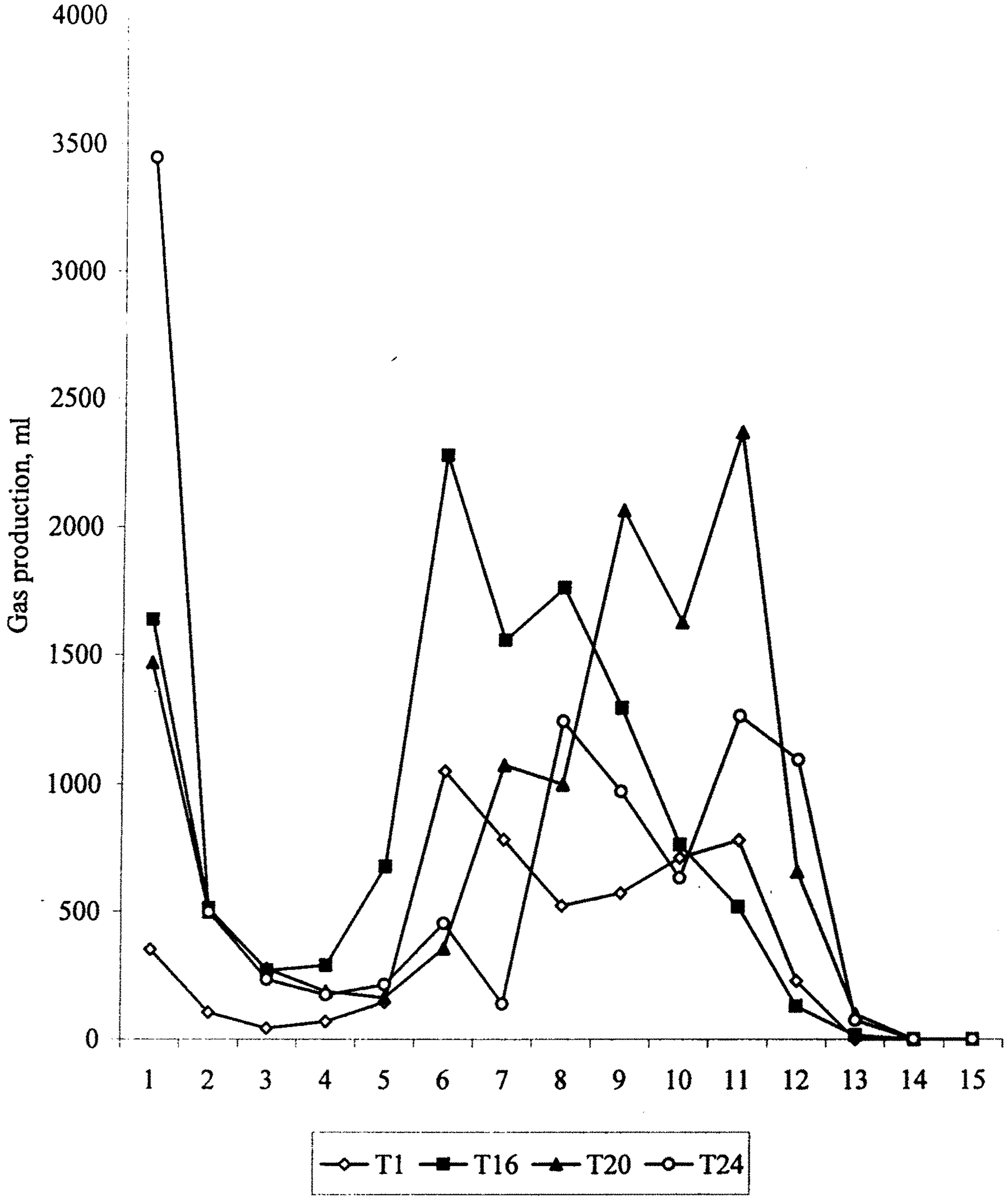



**Fig 4.9 WEEKLY BIOGAS PRODUCTION FROM POULTRY DEEP LITTER BASED MATERIAL COMBINATION WITH 5% TS**

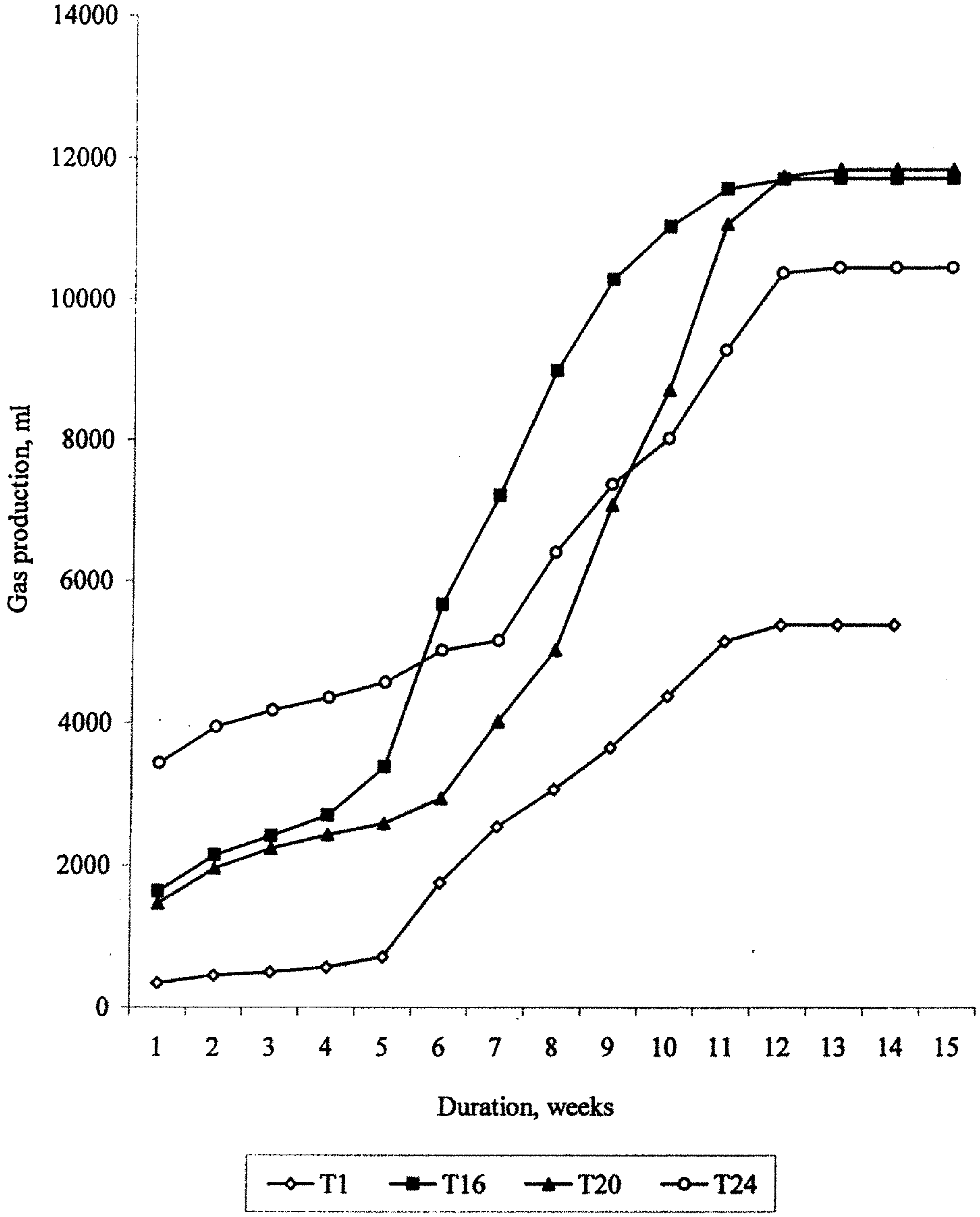



**Fig 4.10 CUMULATIVE BIOGAS PRODUCTION FROM POULTRY DEEP LITTER BASED MATERIAL COMBINATION WITH 5% TS**

This downward trend continued for first two weeks but had increased in the consecutive weeks of fifth and sixth and then decreased. The gas production lasted for about 13 to 15 weeks in all combinations. The average gas production per week was maximum in first week for all treatment except for cowdung and the higher value was 2365 ml/day in the second day of feeding in the combination of cowdung with poultry deep litter ($T_{24}$) in the ratio of 2:1. The minimum average gas production was observed in the cowdung alone as feedstock ($T_1$) as 60 ml/day.

Total biogas production of the poultry litter based material combinations with the ratios of 1:1, 1:2 and 2:1 with the addition of desired quantity of water to have the 10 per cent TS are summarized and given in Table 4.8.

**Table 4.8. Total Gas Production from Poultry Deep Litter material combinations in 1:1, 1:2 and 2:1 ratios with 10 per cent TS**

| Treatment | Combination | Gas production, ml |
|---|---|---|
| $T_{17}$ | Cowdung : Poultry Deep Litter (1:1) | 5428 |
| $T_{21}$ | Cowdung : Poultry Deep Litter (1:2) | 6200 |
| $T_{25}$ | Cowdung : Poultry Deep Litter (2:1) | 14838 |
| $T_2$ | Cowdung (100 per cent ) | 6783 |

The maximum total biogas production was observed in the combination of cowdung and poultry deep litter ($T_{25}$) in the ratio of 2:1 as 14838 ml. The lowest total gas production was recorded with cowdung and poultry deep litter ($T_{17}$) in the ratio of 1:2 as 5428 ml.

The weekly and cumulative gas production from different poultry deep litter based material combination mixed in the ratios of 1:1 and 1:2: and 2:1 with 10 per cent total solids are given in figure 4.11 and 4.12 respectively.

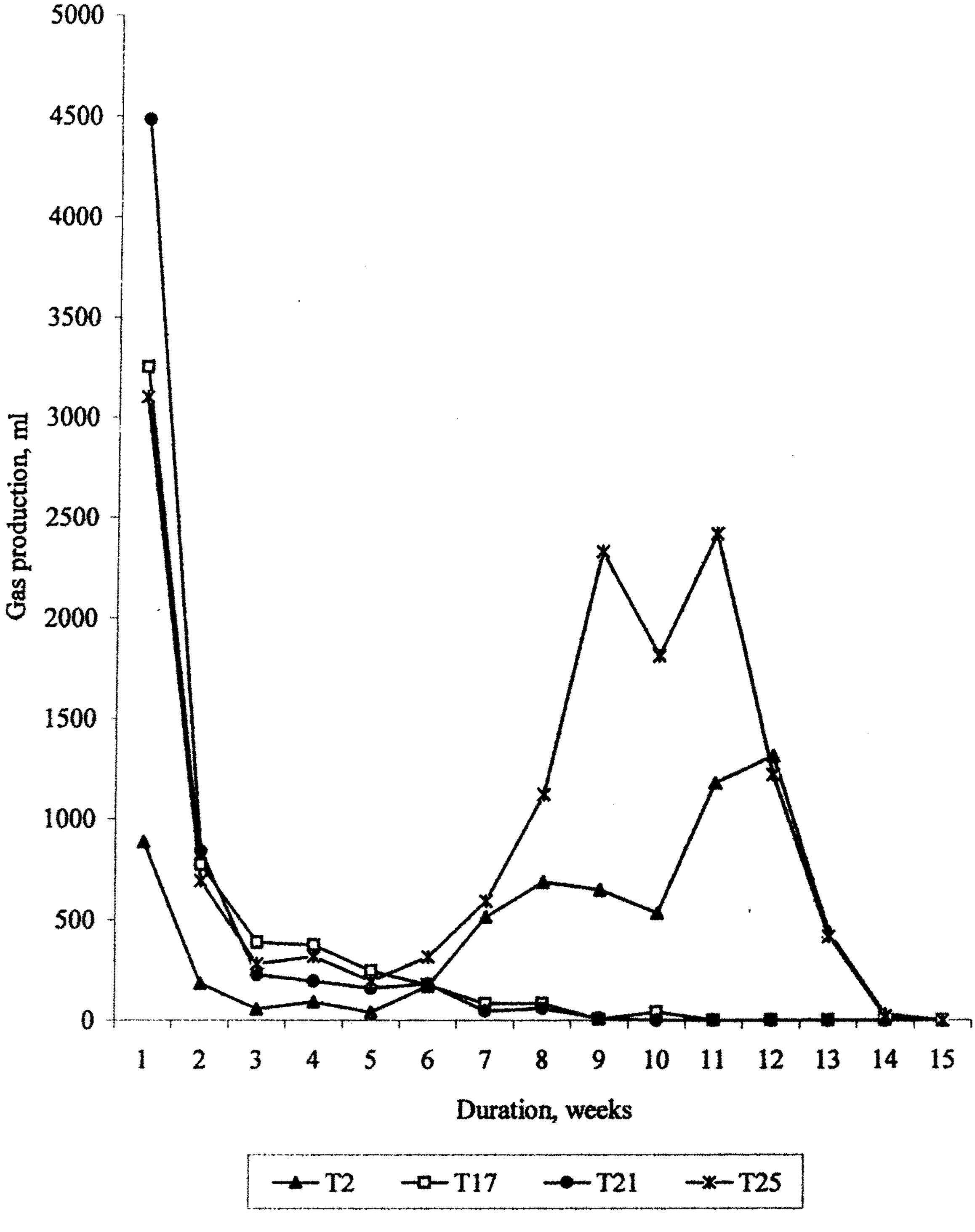



**Fig 4.11 WEEKLY BIOGAS PRODUCTION FROM POULTRY DEEP LITTER BASED MATERIAL COMBINATION WITH 10% TS**

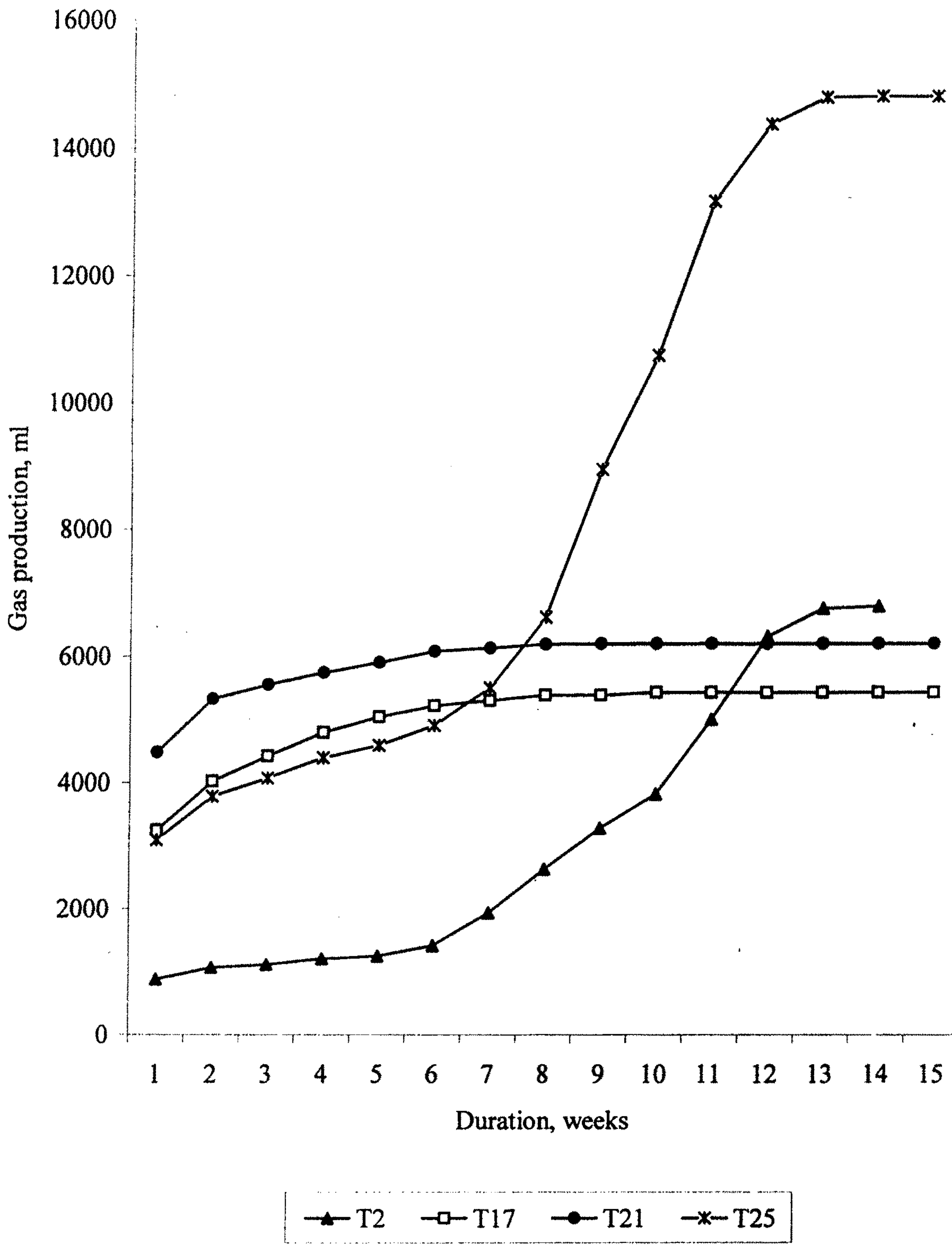



**Fig 4.12 CUMULATIVE BIOGAS PRODUCTION FROM POULTRY DEEP LITTER BASED MATERIAL COMBINATION WITH 10% TS**

From the figure 4.11 it is observed that the maximum gas produced in the first week of all combinations and it suddenly fell down in the consecutive weeks. The combination of cowdung and poultry deep litter ($T_{21}$) in the ratio of 1:2 produced maximum gas in the first week and falls in the next week. This is because of presence of cowdung and poultry deeplitter in the ratio of 2:1.

Figure 4.12 reveals that the gas production rate was increased in the combination of cowdung and poultry deep litter ($T_{25}$) in the ratio of 2:1.The maximum gas production per day (1275 ml/day) was recorded in the first day of feeding. The average gas production per week was lowest in the case of cowdung alone ($T_2$) as feedstock. The other two treatments cow dung and poultry deep litter mixed in 1:1 ratio ($T_{17}$), cow dung and poultry deep litter mixed in 1:1 ratio (T21) were shown the similar trend in the gas production rate.

Total biogas production of the poultry litter based material combinations with the ratios of 1:1, 1:2 and 2:1 with the addition of desired quantity of water to have the 15 per cent TS are summarized in Table 4.9.

**Table 4.9. Total Gas Production from Poultry Deep Litter material combinations in 1:1, 1:2 and 2:1 ratios with 15 per cent TS**

| Treatment | Combination | Gas production, ml |
|---|---|---|
| $T_{18}$ | Cowdung : Poultry Deep Litter (1:1) | 8048 |
| $T_{22}$ | Cowdung : Poultry Deep Litter (1:2) | 9153 |
| $T_{26}$ | Cowdung : Poultry Deep Litter (2:1) | 8683 |
| $T_3$ | Cowdung (100per cent ) | 16073 |

The maximum total biogas production was achieved in the combination of cowdung and poultry deep litter ($T_{22}$) in the ratio of 1:2 as 9153 ml except cowdung alone as feed material and minimum total gas production was recorded with cowdung and poultry deep litter ($T_{18}$) in the ratio of 1:1 as 8048 ml.

The weekly and cumulative gas production from different poultry deep litter based material combination mixed in the ratios of 1:1 and 1:2: and 2:1 with 15 per cent total solids are given in figures 4.13 and 4.14 respectively.

All the combinations of poultry deep litter based materials were having a higher gas production till the first week and it suddenly fell down in the following days. Webb and Hawkes (1985), reported that the rate of gas production was very high immediately after start up but decreased sharply after approximately seven days which were confirmed in this experiment, From the figure 4.13 it is observed that the gas production was maximum (7035 ml) in the first week itself in the combination of 1:2 ratio ($T_{22}$). The gas production lasted for about 12 to 13 weeks in all combinations. The biogas production was in the range of 4000 $\pm$ 500 ml in all combinations for the first two weeks except in cowdung. In the cumulative gas production the poultry deep litter based combinations shows similar trend in decrease in biogas production after first week. But this was reverse trend in cowdung ($T_3$) in the water mix ratio of 1:0.5.

Total biogas production of the poultry litter based material combinations with the ratios of 1:1, 1:2 and 2:1 with the addition of desired quantity of water to have the 20 per cent TS are summarized and given in Table 4.10.

**Table 4.10. Total gas production from Poultry Deep Litter material combinations in 1:1, 1:2 and 2:1 ratios with 20 per cent TS**

| Treatment | Combination | Gas production, ml |
|---|---|---|
| $T_{19}$ | Cowdung : Poultry Deep Litter (1:1) | 12088 |
| $T_{23}$ | Cowdung : Poultry Deep Litter (1:2) | 13225 |
| $T_{27}$ | Cowdung : Poultry Deep Litter (2:1) | 20655 |

The maximum total biogas production was observed in combination of cowdung and poultry deep litter ($T_{27}$) in the ratio of 2:1 as 20655 ml and minimum total gas

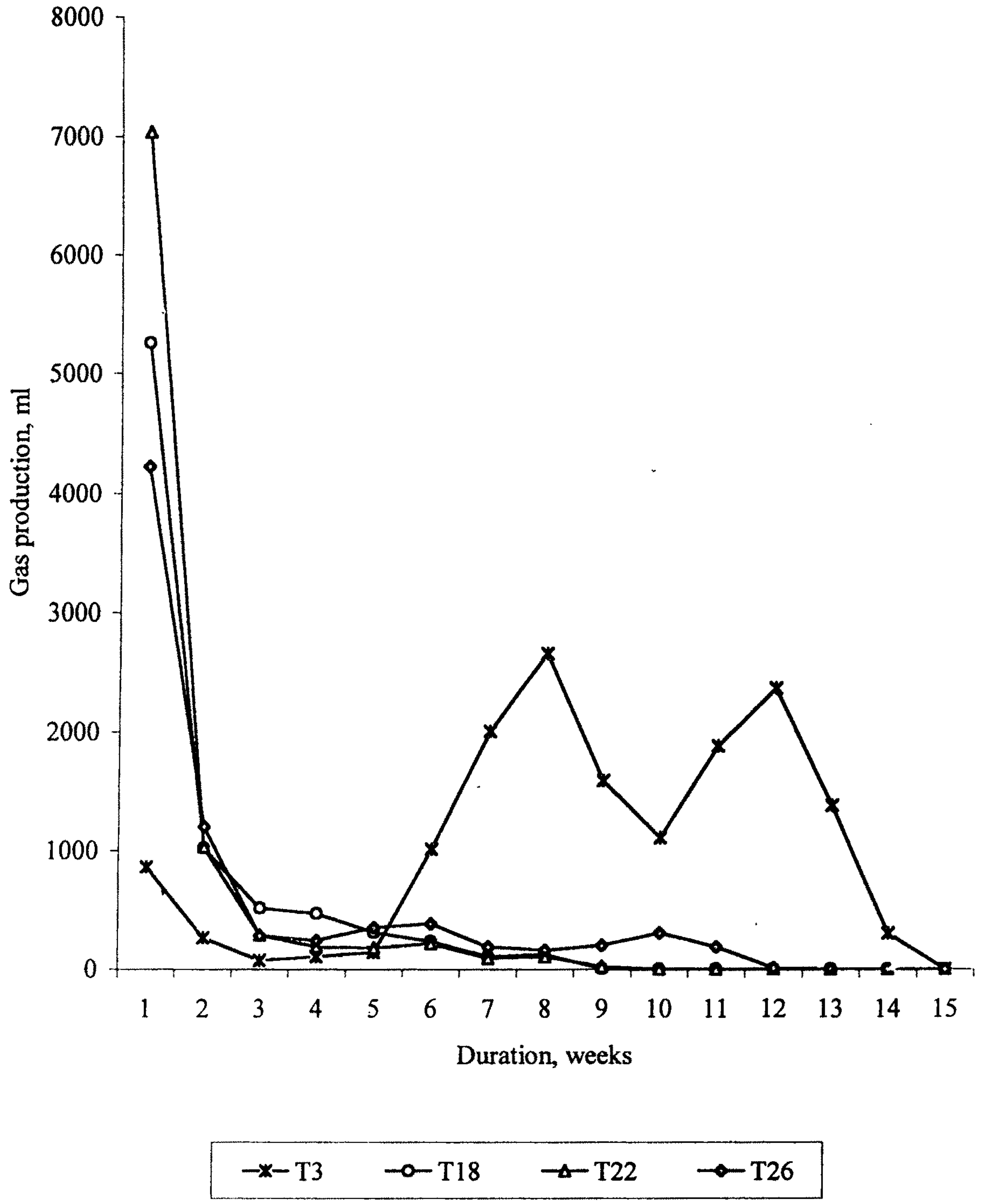



**Fig 4.13 WEEKLY BIOGAS PRODUCTION FROM POULTRY DEEP LITTER BASED MATERIAL COMBINATION WITH 15% TS**

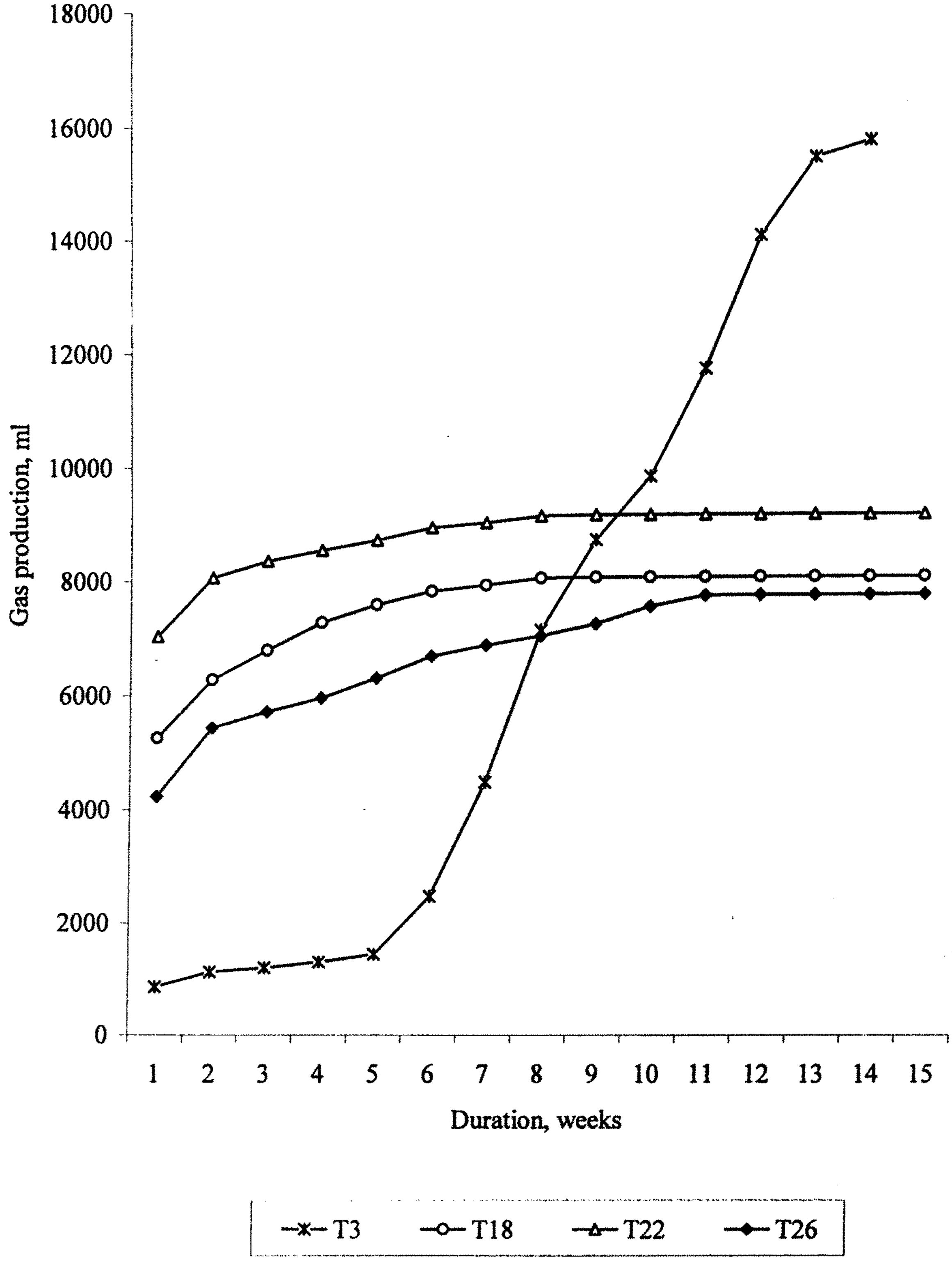



**Fig 4.14 CUMULATIVE BIOGAS PRODUCTION FROM POULTRY DEEP LITTER BASED MATERIAL COMBINATION WITH 15% TS**

production was recorded with cowdung and poultry deep litter ($T_{19}$) in the ratio of 1:1 as 12088 ml. The weekly and cumulative gas production from different poultry deep litter based material combination mixed in the ratios of 1:1 and 1:2: and 2:1 with 15 per cent total solids are given in figure 4.15 and 4.16 respectively. The weekly gas poultry gas production of poultry deep litter combinations with 20 per cent TS shows the similar trend followed with as 10 per cent TS during the first week the biogas production was very high in the combination of cowdung and poultry deep litter in 1:1 ratio has 8250 ml. Among all the combinations the maximum gas yield per day in the case of cow dung and poultry deep litter mixed with 1:2 ratio has 2168 ml.

Among all the combinations of poultry deep litter based materials the maximum total biogas production was recorded in cow dung and poultry litter mixed with 1:2 ratio with 20 per cent TS as 20,655 ml. The maximum gas yield was recorded in cow dung and poultry deep litter mixed with 2:1 ratio as 2365 ml per day with 5 per cent TS..

#### 4.2.1.3. Poultry Droppings based material combinations

Total biogas production of the poultry Droppings based material combinations with the ratios of 1:1, 1:2 and 2:1 with the addition of desired quantity of water to have the 5 per cent TS are summarized in Table 4.11

**Table 4.11. Total gas production from Poultry Droppings material combinations in 1:1, 1:2 and 2:1 ratios with 5 per cent TS**

| Treatment | Combination | Gas production, ml |
|---|---|---|
| $T_{28}$ | Cowdung : Poultry Droppings (1:1) | 14710 |
| $T_{31}$ | Cowdung : Poultry Droppings (1:2) | 15360 |
| $T_{34}$ | Cowdung : Poultry Droppings (2:1) | 16855 |
| $T_1$ | Cowdung (100 per cent ) | 5378 |

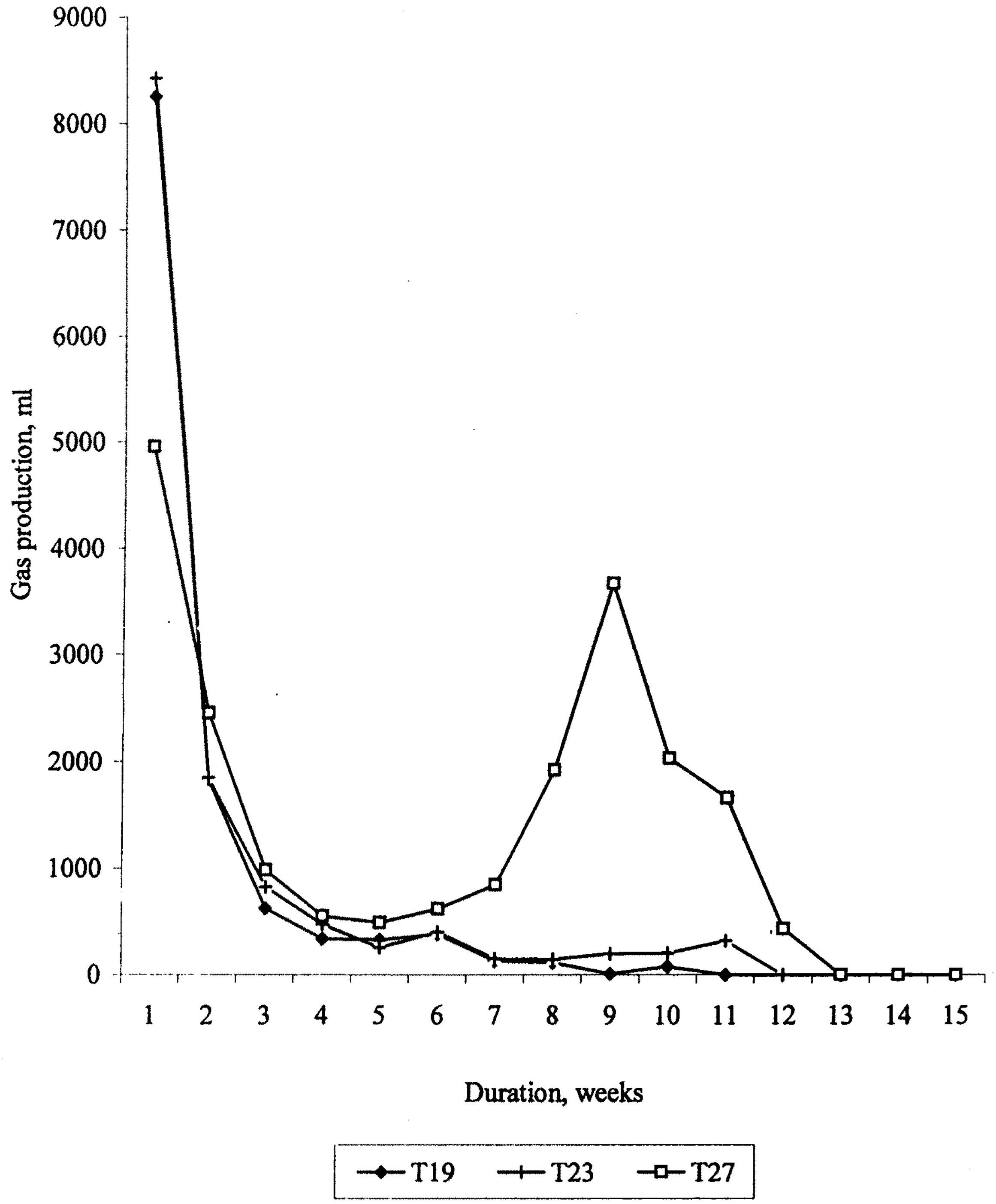



**Fig 4.15 WEEKLY BIOGAS PRODUCTION FROM POULTRY DEEP LITTER BASED MATERIAL COMBINATION WITH 20% TS**

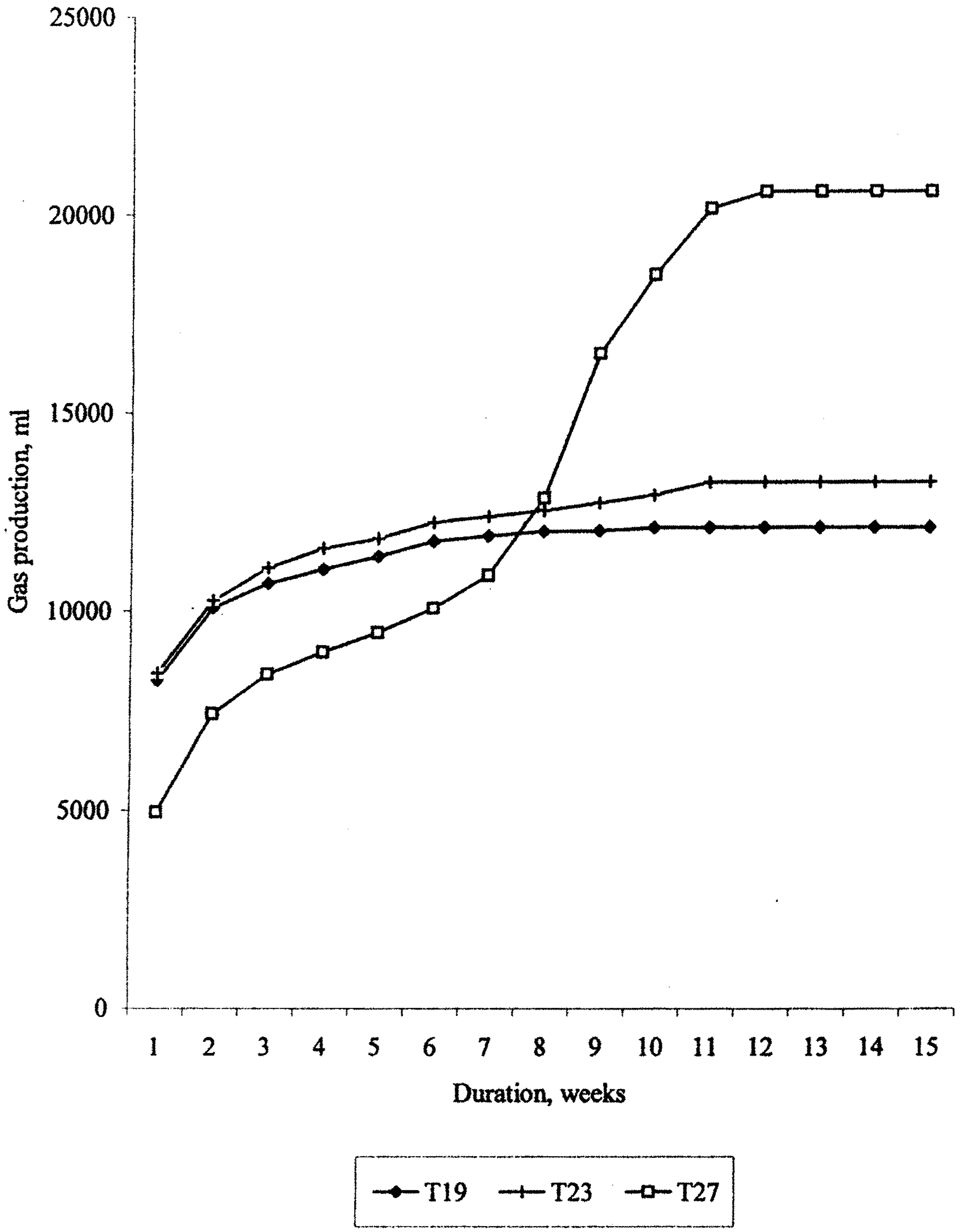



**Fig 4.16 CUMULATIVE BIOGAS PRODUCTION FROM POULTRY DEEP LITTER BASED MATERIAL COMBINATION WITH 20% TS**

It was clear from the Table 4.11 that the total biogas production has achieved maximum (16855 ml) from combination of cowdung and poultry droppings in 2:1 ratio followed by cowdung and poultry droppings in 1:2 ratio (15360 ml) and by cowdung and poultry droppings in 1:1 ratio (14710 ml).

The weekly and cumulative gas production from different poultry droppings based material combination mixed in the ratios of 1:1 and 1:2: and 2:1 with 5 per cent total solids are given in figures 4.17 and 4.18 respectively. The maximum weekly biogas production was obtained in the combination cowdung and poultry droppings as 2535 ml. All the combinations decreased during third week and increased during the following weeks. This trend is similar to that of batch digestion studied by Webb and Hawkes (1985).

Total biogas production of the poultry Droppings based material combinations with the ratios of 1:1, 1:2 and 2:1 with the addition of desired quantity of water to have the 10 per cent TS are summarized in Table 4.12.

**Table 4.12. Total gas production from Poultry Droppings material combinations in 1:1, 1:2 and 2:1 ratios with 10 per cent TS**

| Treatment | Combination | Gas production, ml |
|---|---|---|
| $T_{29}$ | Cowdung : Poultry Droppings (1:1) | 33640 |
| $T_{32}$ | Cowdung : Poultry Droppings (1:2) | 24908 |
| $T_{35}$ | Cowdung : Poultry Droppings (2:1) | 34873 |
| $T_2$ | Cowdung (100 per cent) | 6783 |

The trend of biogas production from poultry droppings based material combination in 1:1, 1:2 and 2:1 ratios with 10 per cent TS is similar to that of 5 per cent TS. Here the difference was seen in the total biogas production. As the total solid content doubled from 5 per cent to 10 per cent, the maximum total biogas production was also doubled from 16852 ml to 34873 ml.

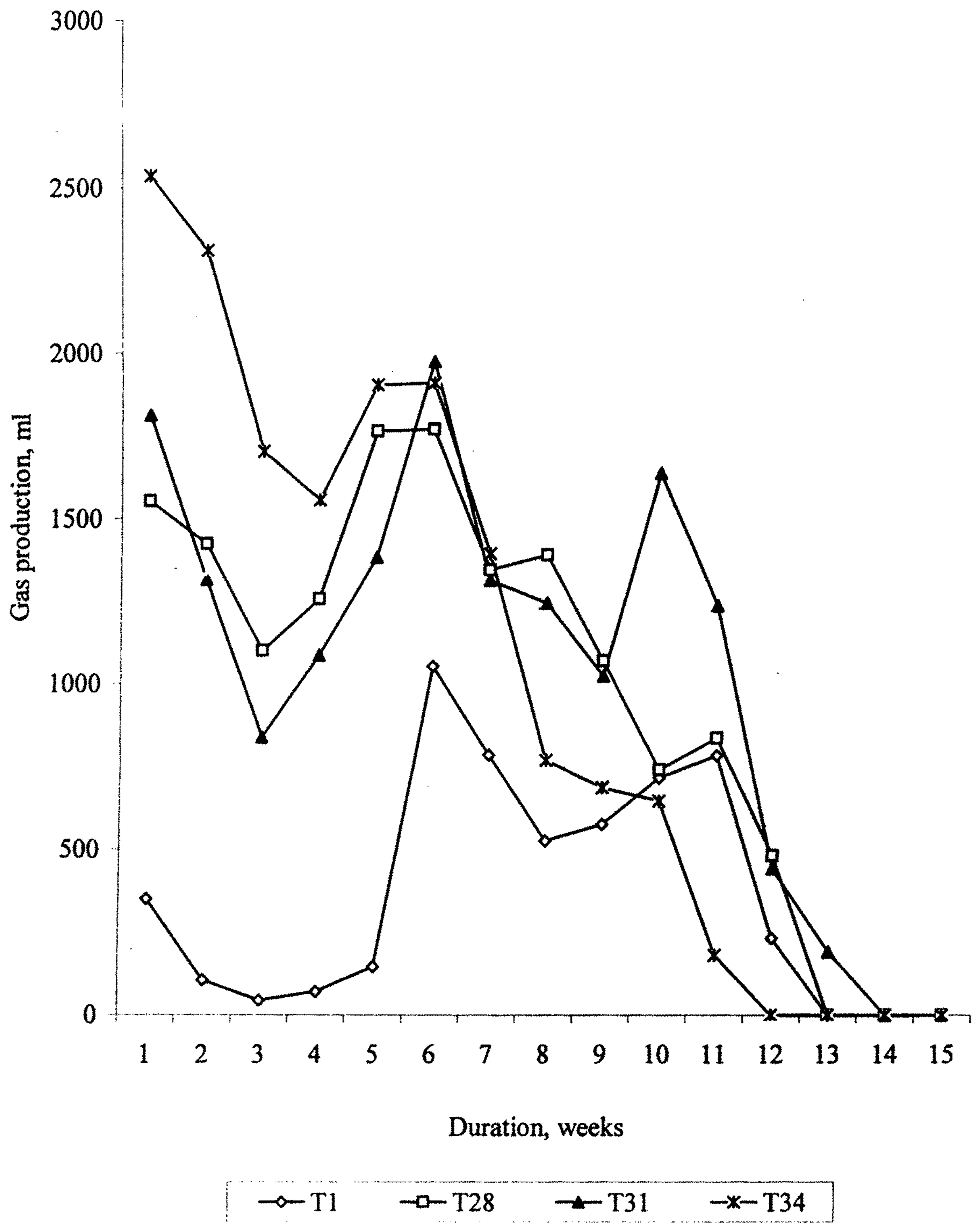



**Fig 4.17 WEEKLY BIOGAS PRODUCTION FROM POULTRY DROPPINGS BASED MATERIAL COMBINATION WITH 5% TS**

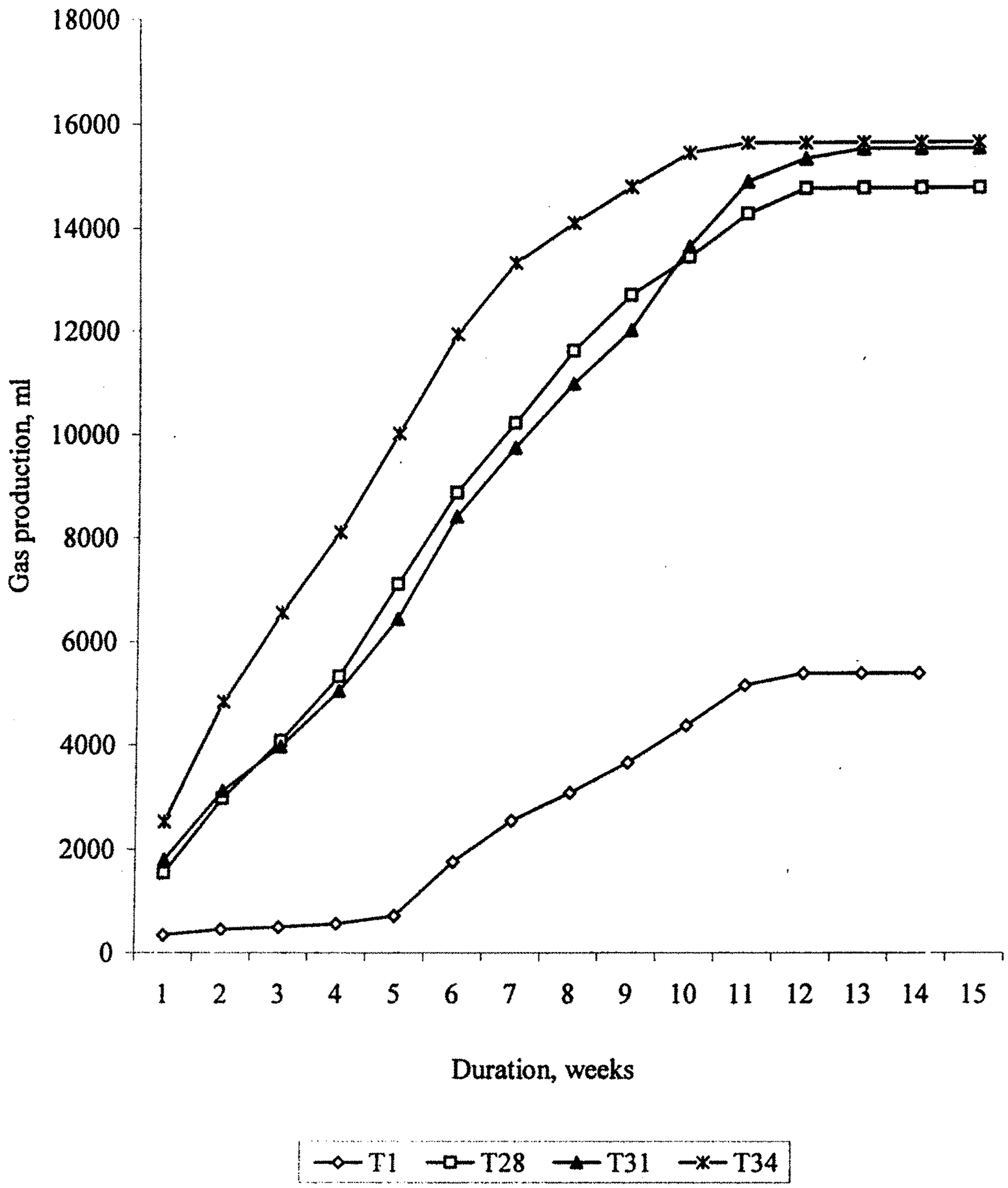



**Fig 4.18 CUMULATIVE BIOGAS PRODUCTION FROM POULTRY DROPPINGS BASED MATERIAL COMBINATION WITH 5% TS**

The weekly and cumulative gas production from different poultry droppings based material combination mixed in the ratios of 1:1 and 1:2: and 2:1 with 5 per cent total solids are given in figure 4.19 and 4.20 respectively. Here also the same trend as seen in figure 4.17 and 4.18 was followed.

Total biogas production of the poultry Droppings based material combinations with the ratios of 1:1, 1:2 and 2:1 with the addition of desired quantity of water to have the 15 per cent TS are summarized in Table 4.13

**Table 4.13. Total gas production from Poultry Droppings material combinations in 1:1, 1:2 and 2:1 ratios with 15 per cent TS**

| Treatment | Combination | Gas production, ml |
|---|---|---|
| $T_{30}$ | Cowdung : Poultry Droppings (1:1) | 41333 |
| $T_{33}$ | Cowdung : Poultry Droppings (1:2) | 29128 |
| $T_{36}$ | Cowdung : Poultry Droppings (2:1) | 47273 |
| $T_3$ | Cowdung (100 per cent ) | 16073 |

The trend of total biogas production from the combination of cowdung and poultry droppings in 1:1, 1:2 and 2:1 ratios with 15 per cent TS is similar to that of 5 per cent TS. As the total solid content tripled from 5 per cent to 15 per cent the maximum total biogas production also tripled from 16852 ml to 47273 ml. All these combination of cowdung and poultry droppings with 5 per cent, 10 per cent and 15 per cent total solids produced more biogas than cowdung alone as feed material.

The weekly and cumulative gas production from cowdung and poultry droppings based material combination mixed in the ratios of 1:1 and 1:2: and 2:1 with 15 per cent total solids are given in figure 4.21 and 4.22 respectively. Here also the same trend as seen in figure 4.17 and 4.18 was followed.

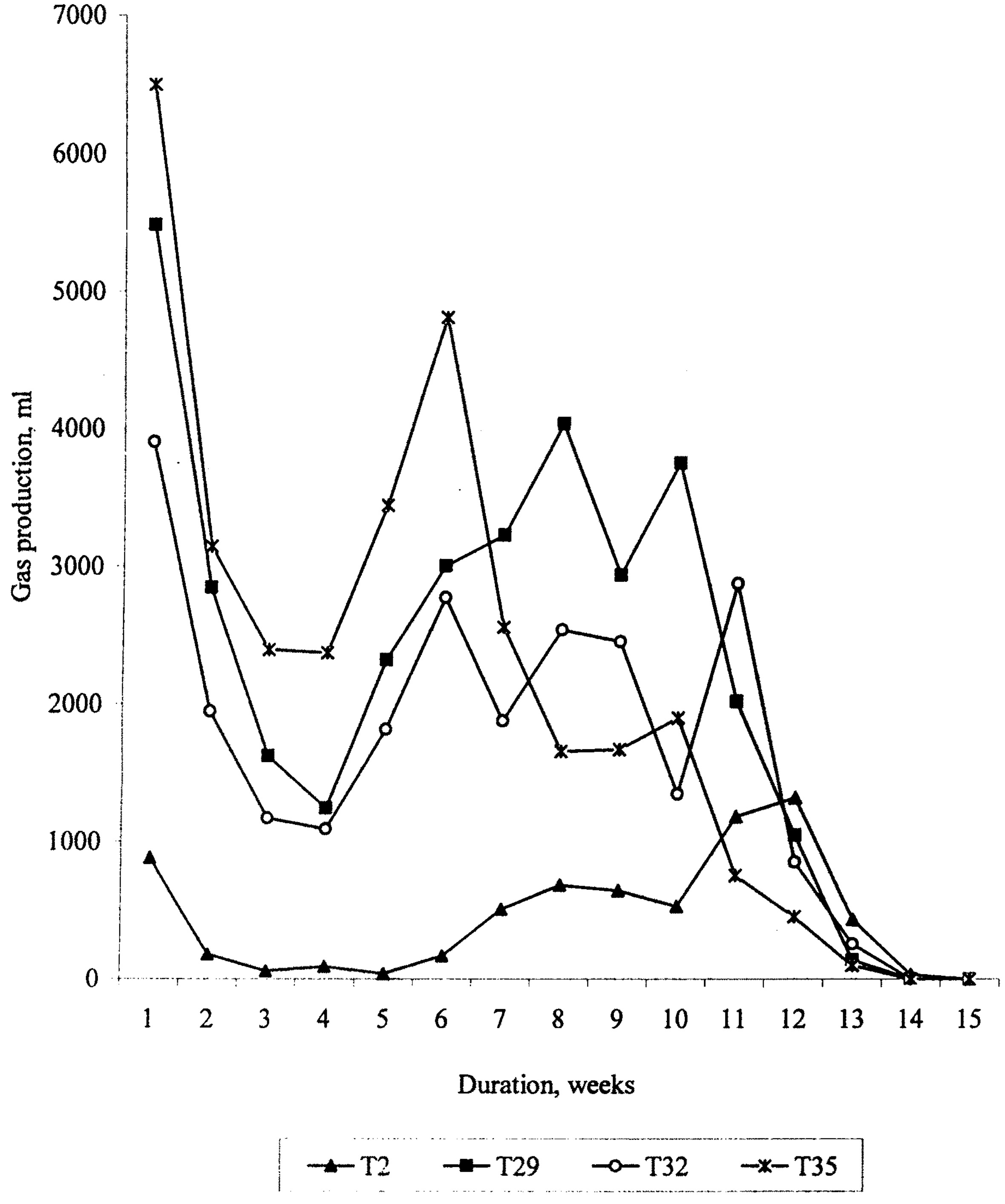



**Fig 4.19 WEEKLY BIOGAS PRODUCTION FROM POULTRY DROPPINGS BASED MATERIAL COMBINATION WITH 10 % TS**

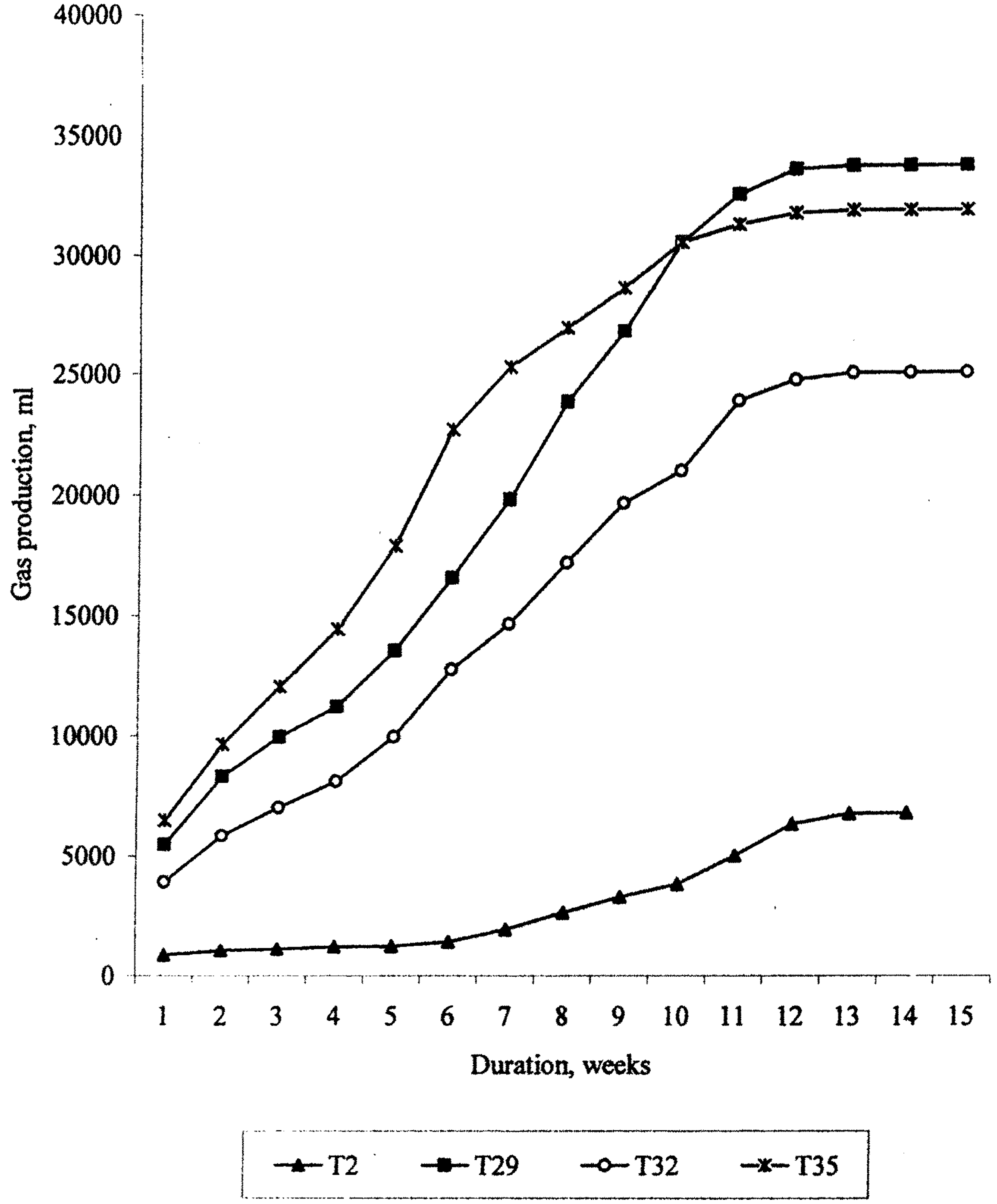



**Fig 4.20 CUMULATIVE BIOGAS PRODUCTION FROM POULTRY DROPPINGS BASED MATERIAL COMBINATION WITH 10% TS**

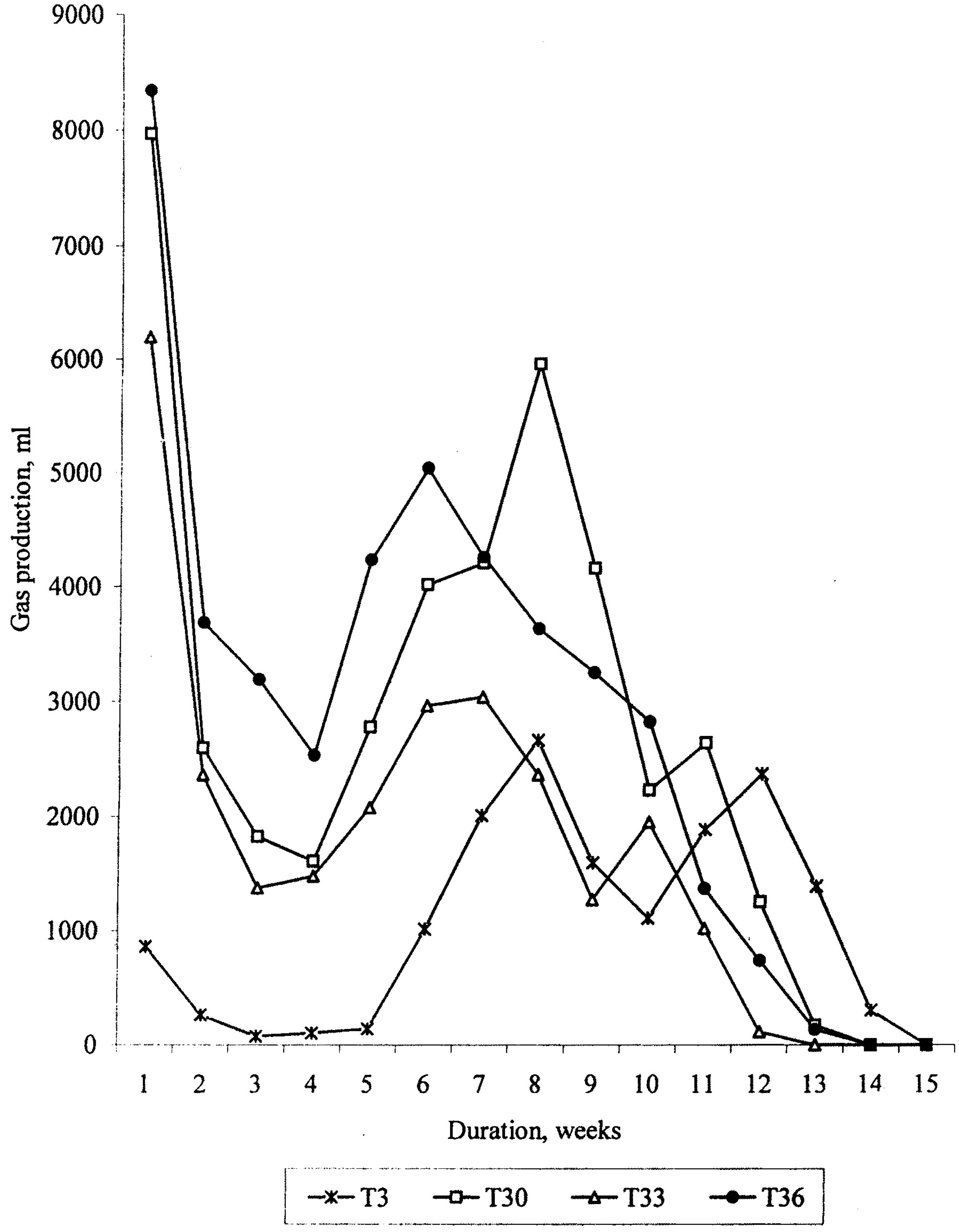



**Fig 4. 21 WEEKLY BIOGAS PRODUCTION FROM POULTRY DROPPINGS BASED MATERIAL COMBINATION WITH 15% TS**

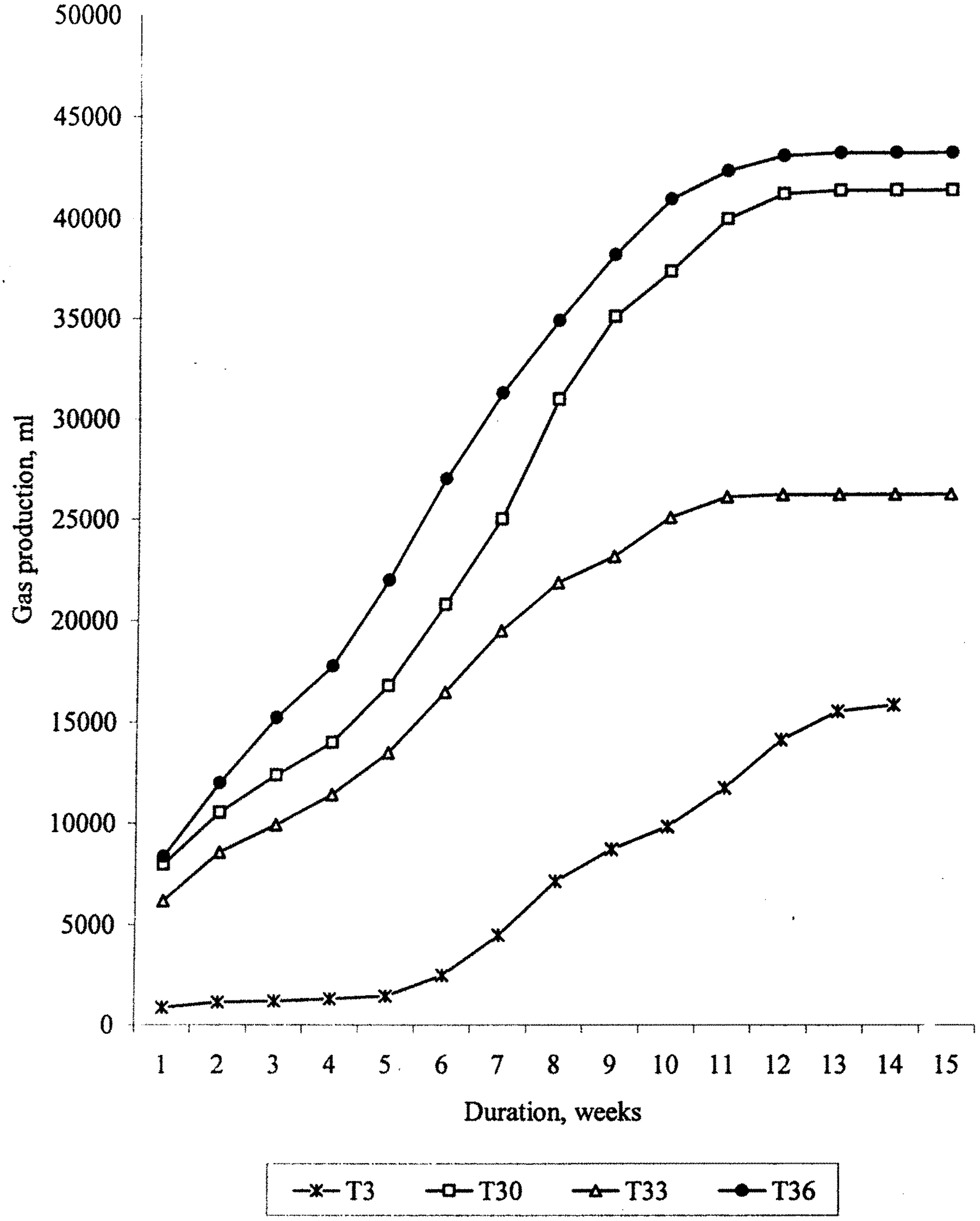



**Fig 4.22 CUMULATIVE BIOGAS PRODUCTION FROM POULTRY DROPPINGS BASED MATERIAL COMBINATION WITH 15% TS**

Among all the poultry droppings based material combinations, the maximum biogas produced in cowdung and poultry droppings in 2:1 ratio with 15 per cent TS as 47273 ml. Also the average gas yield recorded as 457 ml per day and the maximum gas production recorded as 1685 ml per day in the same treatment.

Out of different combinations, the gas production from the following treatments was analyzed without mixing any other feed stock material. Total biogas production of the poultry droppings alone as feed material with the addition of desired quantity of water to have the 5 per cent, 10 per cent and 15 per cent TS are summarized in Table 4.14

**Table 4.14. Total biogas production from Poultry Droppings as feedstock in 100 per cent with 5 per cent, 10 per cent and 15 per cent TS**

| Treatment | Combination | Gas production, ml |
|---|---|---|
| $T_{37}$ | Poultry Droppings (100 per cent ) | 7770 |
| $T_{38}$ | Poultry Droppings (100 per cent ) | 16448 |
| $T_{39}$ | Poultry Droppings (100 per cent ) | 30655 |
| $T_1$ | Cowdung (100 per cent ) | 5378 |
| $T_2$ | Cowdung (100 per cent ) | 6783 |
| $T_3$ | Cowdung (100 per cent ) | 16073 |

It is clear from the table 4.14 that the total biogas production achieved was maximum (30655 ml) from poultry droppings alone ($T_{39}$) as feed material with 15 per cent TS followed by poultry droppings alone ($T_{38}$) as feed material with 10 per cent TS and the gas production lasted during $14^{th}$ to $15^{th}$ week. As the total solid increased from 5 per cent to 10 per cent the gas production also was doubled as 7770 ml to 16448 ml. and also the total solid content tripled from 5 per cent to 15 per cent the maximum total biogas production also tripled from 7770 ml to 30655 ml.

The weekly and cumulative gas production from poultry droppings alone as feed material with 5 per cent, 10 per cent and 15 per cent TS are given in figure 4.23 and 4.24

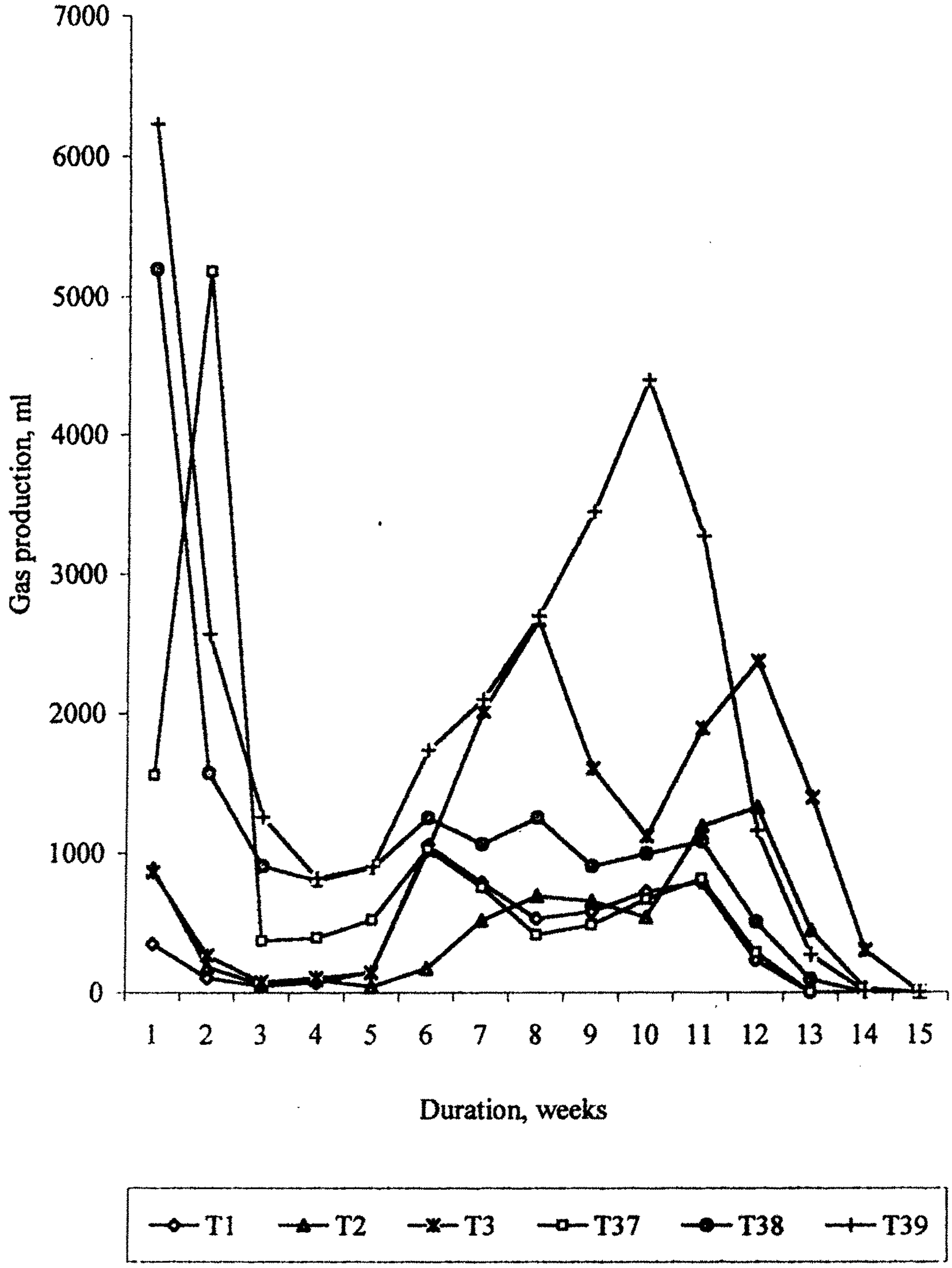



**Fig 4.23 WEEKLY BIOGAS PRODUCTION FROM POULTRY DROPPINGS ALONE WITH 5 %, 10% & 15% TS**

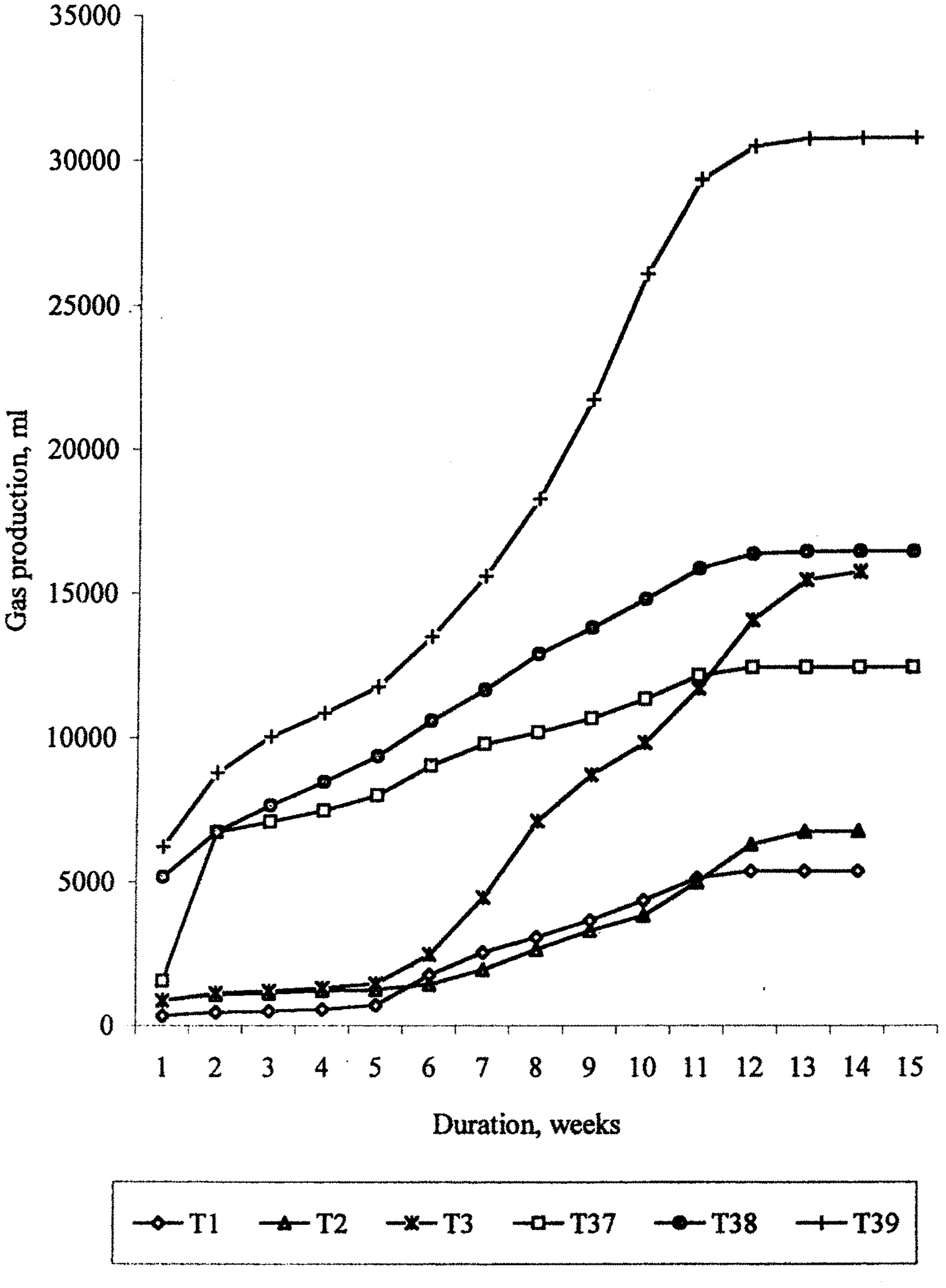



**Fig 4.24 CUMULATIVE BIOGAS PRODUCTION FROM POULTRY DROPPINGS ALONE WITH 5 %, 10% & 15% TS**

respectively. The maximum gas production per week was obtained in the case of poultry droppings alone ($T_{39}$) as feed stock with 15 per cent TS in the first week as 6230 ml followed by poultry droppings alone as feedstock ($T_{38}$) with 10 per cent TS as 5193 ml in the same week. But in the case of 5 per cent TS, the maximum biogas produced in the second week as 5175 ml.

The average gas produced per day was 303 ml in poultry droppings alone ($T_{39}$) with 15 per cent total solids followed by 172 ml in cowdung with the addition of desired quantity of waste to have the 15 per cent TS. The maximum gas production was achieved during the sixth day as 1225 ml in poultry droppings alone ($T_{39}$) with 15 per cent TS. Among all the poultry droppings as feedstock in 100 per cent with 5, 10 and 15 per cent TS, the maximum gas yield was recorded in poultry droppings as feed stock with 15 per TS ($T_{39}$) as 30655 ml.

**4.2.2. Quality of biogas from different feedstock**

The quality of biogas obtained from the feed stocks was determined using a saccharometer by measuring the methane percentage of the samples. The weekly methane content in percent of the biogas produced from 39 combinations of feed stocks is summarized in Table 4.15.

It was observed from the table 4.15 that all the combination of feedstocks, the methane content variation was in the wide range of 15 to 95 per cent. The methane content was observed very high in all the poultry manure based material combination. The range of methane content in poultry manure based material combination was 75 per cent to 95 per cent. This could be observed in the combination of cowdung mixed with poultry manure in 1:1 ratio with 5 per cent TS and cowdung mixed with poultry manure in 2:1 ratio with 20 per cent TS.

**Table 4.15. Weekly methane content in per cent for different combinations of feedstock**

| Treatments | Methane content of biogas, percent at the weeks of | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| $T_1$ | 70 | 95 | 65 | 64 | 59 | 56 | 54 | 54 | 57 | 55 | 53 | 55 | 53 | 51 | |
| $T_2$ | 47 | 45 | 49 | 37 | 54 | 57 | 70 | 59 | 61 | 65 | 63 | 56 | 48 | 48 | 45 |
| $T_3$ | 62 | 57 | 52 | 46 | 61 | 60 | 61 | 58 | 58 | 64 | 60 | 54 | 55 | 50 | 46 |
| $T_4$ | 95 | 80 | 81 | 83 | 73 | 69 | 80 | 68 | 69 | 67 | 68 | | | | |
| $T_5$ | 89 | 91 | 70 | 69 | 68 | 68 | 70 | 69 | 66 | 62 | | | | | |
| $T_6$ | 86 | 69 | 65 | 69 | 65 | 64 | 65 | 63 | 66 | 65 | 60 | 52 | 50 | | |
| $T_7$ | 78 | 51 | 50 | 58 | 66 | 64 | 70 | 67 | 68 | 74 | 74 | 67 | 58 | 50 | 48 |
| $T_8$ | 90 | 88 | 92 | 72 | 77 | 76 | 65 | 68 | 66 | 61 | 59 | | | | |
| $T_9$ | 91 | 73 | 81 | 80 | 71 | 85 | 73 | 69 | 68 | 62 | 61 | | | | |
| $T_{10}$ | 74 | 54 | 70 | 73 | 62 | 72 | 73 | 59 | 60 | 65 | 63 | 61 | 50 | 44 | 40 |
| $T_{11}$ | 88 | 71 | 64 | 72 | 68 | 68 | 62 | 66 | 65 | 67 | 67 | 65 | | | |
| $T_{12}$ | 91 | 76 | 70 | 76 | 69 | 72 | 79 | 66 | 68 | 67 | 67 | 66 | 56 | | |
| $T_{13}$ | 85 | 63 | 63 | 64 | 63 | 64 | 59 | 67 | 69 | 70 | 63 | 62 | | | |
| $T_{14}$ | 76 | 58 | 46 | 61 | 63 | 60 | 57 | 61 | 63 | 64 | 63 | 61 | 52 | 50 | |
| $T_{15}$ | 81 | 64 | 71 | 62 | 65 | 63 | 46 | 69 | 71 | 64 | 66 | 62 | 56 | 52 | 51 |
| $T_{16}$ | 35 | 52 | 40 | 23 | 29 | 56 | 63 | 56 | 56 | 54 | 50 | 46 | 40 | 40 | |
| $T_{17}$ | 16 | 41 | 22 | 27 | 27 | 54 | 46 | 45 | 47 | 42 | | | | | |
| $T_{18}$ | 19 | 25 | 31 | 28 | 47 | 55 | 50 | 46 | 40 | 47 | | | | | |
| $T_{19}$ | 20 | 17 | 37 | 25 | 35 | 56 | 43 | 38 | 41 | 38 | 27 | 20 | 20 | | |
| $T_{20}$ | 35 | 56 | 30 | 22 | 29 | 43 | 50 | 49 | 50 | 53 | 51 | 43 | 36 | 28 | |
| $T_{21}$ | 24 | 27 | 27 | 27 | 34 | 45 | 65 | 51 | 45 | 45 | | | | | |
| $T_{22}$ | 21 | 16 | 23 | 26 | 38 | 56 | 46 | 45 | 45 | 40 | | | | | |
| $T_{23}$ | 23 | 23 | 37 | 28 | 75 | 41 | 52 | 57 | 56 | 53 | 50 | | | | |
| $T_{24}$ | 45 | 22 | 24 | 29 | 36 | 40 | 35 | 41 | 44 | 43 | 40 | 36 | 30 | 26 | 25 |
| $T_{25}$ | 15 | 16 | 54 | 40 | 43 | 56 | 49 | 54 | 55 | 55 | 52 | 46 | 30 | 18 | |
| $T_{26}$ | 14 | 14 | 26 | 29 | 61 | 55 | 57 | 57 | 59 | 55 | 54 | | | | |
| $T_{27}$ | 20 | 33 | 28 | 27 | 31 | 33 | 40 | 44 | 45 | 44 | 38 | 34 | 32 | | |
| $T_{28}$ | 75 | 67 | 65 | 64 | 78 | 56 | 72 | 68 | 68 | 65 | 66 | 64 | | | |
| $T_{29}$ | 56 | 68 | 66 | 71 | 70 | 73 | 75 | 66 | 66 | 62 | 62 | 60 | 50 | 47 | 41 |
| $T_{30}$ | 63 | 61 | 59 | 53 | 72 | 79 | 70 | 66 | 68 | 73 | 74 | 68 | 61 | 57 | 53 |
| $T_{31}$ | 81 | 65 | 62 | 56 | 65 | 63 | 69 | 61 | 62 | 63 | 54 | 50 | 48 | | |
| $T_{32}$ | 71 | 71 | 61 | 66 | 66 | 58 | 46 | 57 | 59 | 61 | 61 | 58 | 55 | 48 | 44 |
| $T_{33}$ | 59 | 59 | 71 | 55 | 68 | 67 | 73 | 61 | 61 | 64 | 63 | 59 | 54 | 50 | 49 |
| $T_{34}$ | 69 | 58 | 63 | 63 | 66 | 62 | 68 | 61 | 63 | 66 | 63 | 58 | | | |
| $T_{35}$ | 62 | 55 | 66 | 65 | 62 | 60 | 64 | 63 | 65 | 66 | 66 | 60 | 55 | 51 | |
| $T_{36}$ | 61 | 55 | 65 | 68 | 68 | 64 | 64 | 65 | 67 | 68 | 65 | 61 | 55 | 50 | 46 |
| $T_{37}$ | 70 | 64 | 67 | 71 | 72 | 66 | 62 | 70 | 71 | 71 | 72 | 70 | 64 | 58 | |
| $T_{38}$ | 69 | 62 | 56 | 55 | 66 | 67 | 71 | 71 | 73 | 75 | 74 | 67 | 60 | 60 | 52 |
| $T_{39}$ | 74 | 57 | 60 | 65 | 69 | 68 | 64 | 69 | 67 | 68 | 64 | 60 | 57 | 57 | 49 |

The methane content observed was very less in the poultry deep litter based material combinations because of presence of non combustible material along with the bed material. In the case of poultry droppings, the methane percent was high from first week onwards and the variation of methane content was between 60 to 80 per cent.

The methane concentration was reported as 60 to 75 per cent by Wong-Chong (1975), 60 to 75 per cent by Kugelman and McCarty (1965), 55 to 60 per cent by Ganesan *et al.* (1981) and 55 to 63 per cent by Murugesan (1982) agreed well to different treatments of this experiment.

The highest average methane content in per cent was recorded in poultry manure based material combination ($T_4$) mixed with cowdung 1:1 ratio with 5 per cent TS as 76 per cent. Oba and Honda (1981) stated methane of 60 to 84 per cent from agriculture and cattle waste which confirmed in this experiment. Where as the minimum average methane content was recorded as 32 per cent in the cowdung mixed with poultry deep litter ($T_{19}$) in the ratio of 1:1 with the addition of desired quantity of waste to have the 20 per cent total solids. The table 4.16 shows the total methane content and methane per cent of all the combinations

**4.2.2.1. Methane yield from poultry based material combinations**

Weekly methane yield from poultry manure based combinations in the ratios of 1:1, 1:2 and 2:1 and 2:1 with 5 per cent, 10 per cent, 15 per cent and 20 per cent TS are shown in figure 4.25 to 4.28.

From figure 4.25, the highest methane yield has been noticed from poultry manure material combination in 2:1 ratio ($T_{12}$) with 5 per cent TS was during $6^{th}$ week as 940 ml with methane content of 72 per cent, and gas yield of 1305 ml. In all the combinations the gas production and methane content was almost nil after $13^{th}$ week.

**Table 4.16. Total Gas Production and Methane content**

| Treatments | Total biogas production, ml | Methane Per cent | Methane content (ml) |
|---|---|---|---|
| 1 | 5378 | 60 | 3062 |
| 2 | 6783 | 54 | 3897 |
| 3 | 16073 | 56 | 3062 |
| 4 | 1925 | 76 | 1475 |
| 5 | 4540 | 72 | 3219 |
| 6 | 10593 | 65 | 6393 |
| 7 | 15905 | 63 | 10394 |
| 8 | 1698 | 74 | 1150 |
| 9 | 2555 | 74 | 2103 |
| 10 | 11898 | 61 | 8888 |
| 11 | 7670 | 69 | 5532 |
| 12 | 5173 | 71 | 4512 |
| 13 | 11545 | 66 | 7417 |
| 14 | 18058 | 60 | 10891 |
| 15 | 18073 | 63 | 11610 |
| 16 | 11708 | 46 | 5916 |
| 17 | 5428 | 37 | 1282 |
| 18 | 8048 | 39 | 1933 |
| 19 | 12088 | 32 | 2738 |
| 20 | 11833 | 41 | 5562 |
| 21 | 6200 | 39 | 1617 |
| 22 | 9153 | 36 | 2045 |
| 23 | 13225 | 45 | 3687 |
| 24 | 11750 | 34 | 4208 |
| 25 | 14838 | 42 | 6238 |
| 26 | 8683 | 44 | 1910 |
| 27 | 20655 | 35 | 7078 |
| 28 | 14710 | 67 | 9968 |
| 29 | 33640 | 62 | 22051 |
| 30 | 41333 | 65 | 27889 |
| 31 | 15360 | 61 | 9882 |
| 32 | 24908 | 59 | 15368 |
| 33 | 29128 | 61 | 16605 |
| 34 | 16855 | 63 | 9960 |
| 35 | 34873 | 61 | 19746 |
| 36 | 47273 | 61 | 27567 |
| 37 | 7770 | 68 | 8319 |
| 38 | 16448 | 65 | 11135 |
| 39 | 30655 | 63 | 20545 |

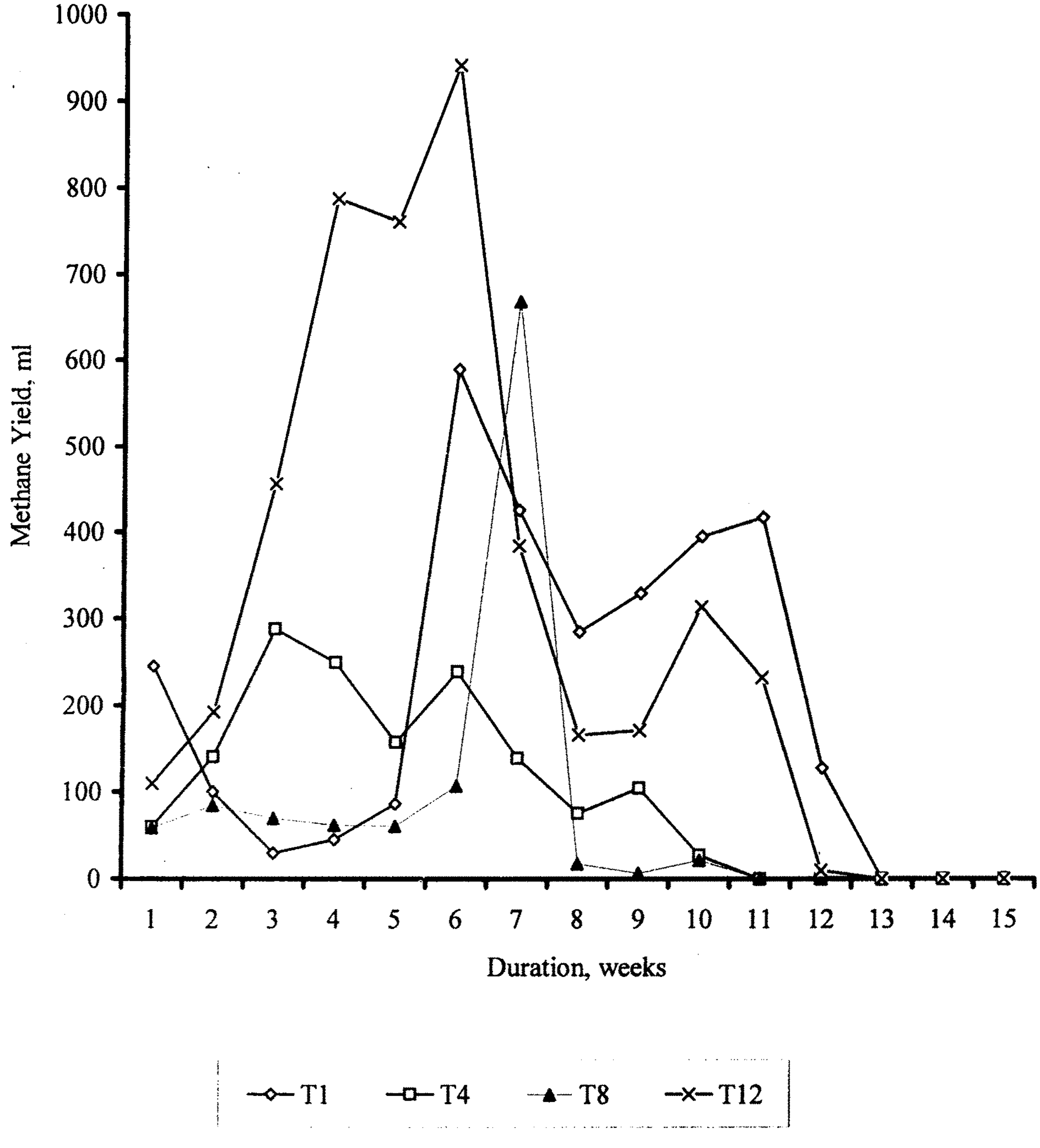



**Fig 4.25 METHANE YIELD FROM POULTRY MANURE BASED COMBINATIONS IN THE RATIOS OF 1:1, 1:2 & 2:1 WITH 5% TS**

From figure 4.26, it has been noticed that the methane production reached above 1000 ml in cowdung and poultry manure in 2:1 ratio ($T_{13}$) during 3rd week to 6th week. This was different from all other treatment in poultry manure based material combinations, where as all other treatments more or less followed the same trend.

Figure 4.27 it indicates that the methane production from poultry manure based combinations in the ratios of 1:1, 1:2 and 2:1 with 15 per cent TS. The methane yield was very good throughout the period and it was between the range of 1000 ml to 2100 ml. Among these combinations, the cowdung and poultry manure mixed with 2:1 ratio ($T_{14}$) produced maximum methane yield of 2043 ml during 6th week. Sushilkumar and Biswas (1982) reported that the methane concentration was between 56 and 58 per cent during fourth to sixth week of digestion which was confirmed in this experiment.

Figure 4.28 it reveals that the methane production from poultry manure based combinations with 20 per cent TS. The highest methane production was recorded during the 3rd to 6th week from cowdung and poultry manure in 1:1 ratio ($T_7$) as 2480 ml followed by cowdung and poultry manure in 2:1 ratio ($T_{15}$) and cowdung and poultry manure in 1:2 ratio ($T_{11}$). Initial methane production was very low and it reached peak production during 3rd to 8th week in all the combinations. This is similar to the results reported by Murugesan (1982) that the biogas produced from the poultry droppings and rumen fluid incorporated treatments contained about 55 to 63 per cent of methane during third to seventh week of digestion. The methane production was stopped during 13th to 15th week.

Among all the poultry manure based material combinations, the highest methane production has been obtained from cowdung and poultry manure in 2:1 ratio ($T_{15}$) as 11,610 ml. This combination of cowdung and poultry manure in 2:1 ratio ($T_{15}$) proved to

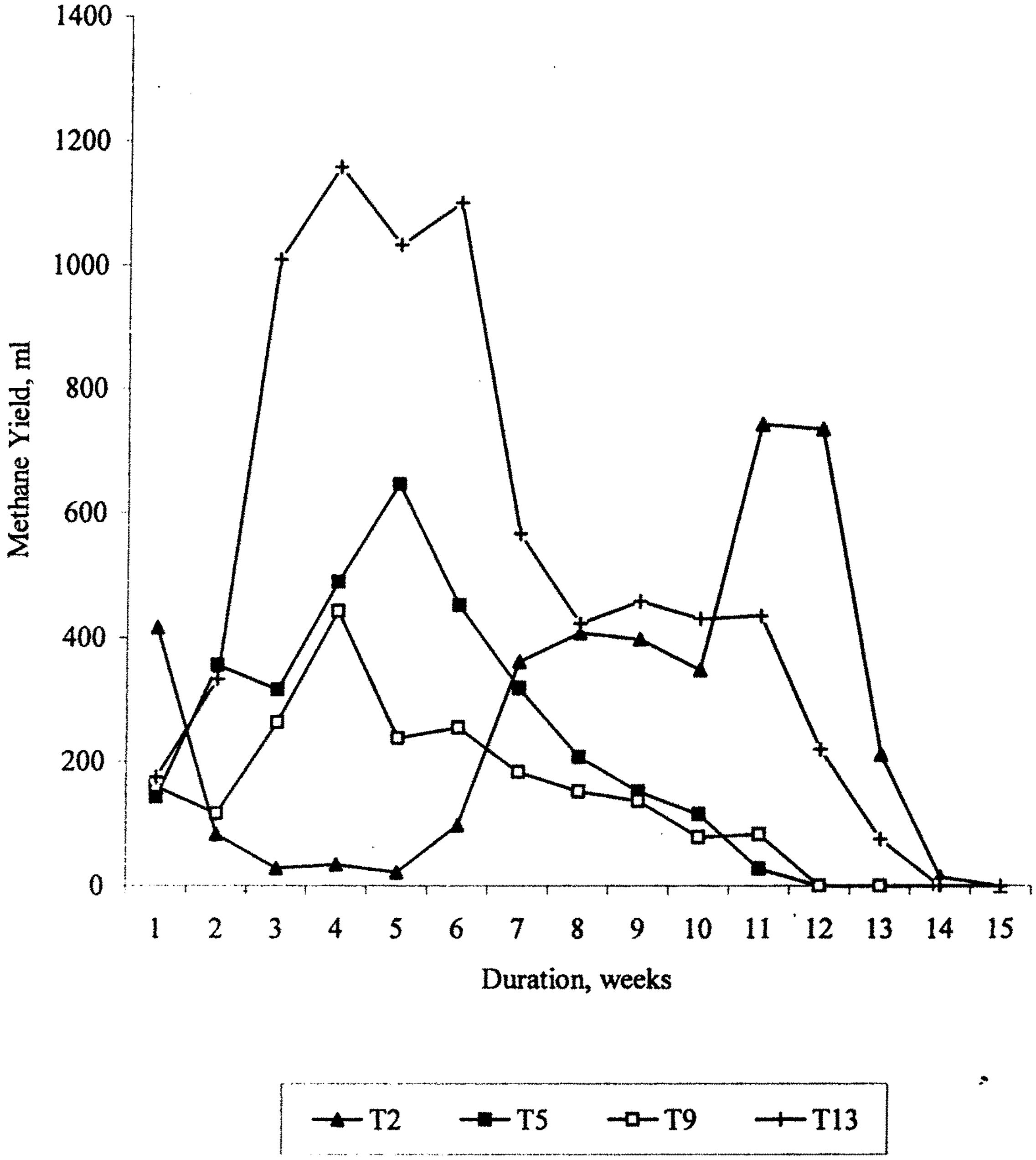



**Fig 4.26 METHANE YIELD FROM POULTRY MANURE BASED COMBINATIONS IN THE RATIOS OF 1:1, 1:2 & 2:1 WITH 10% TS**

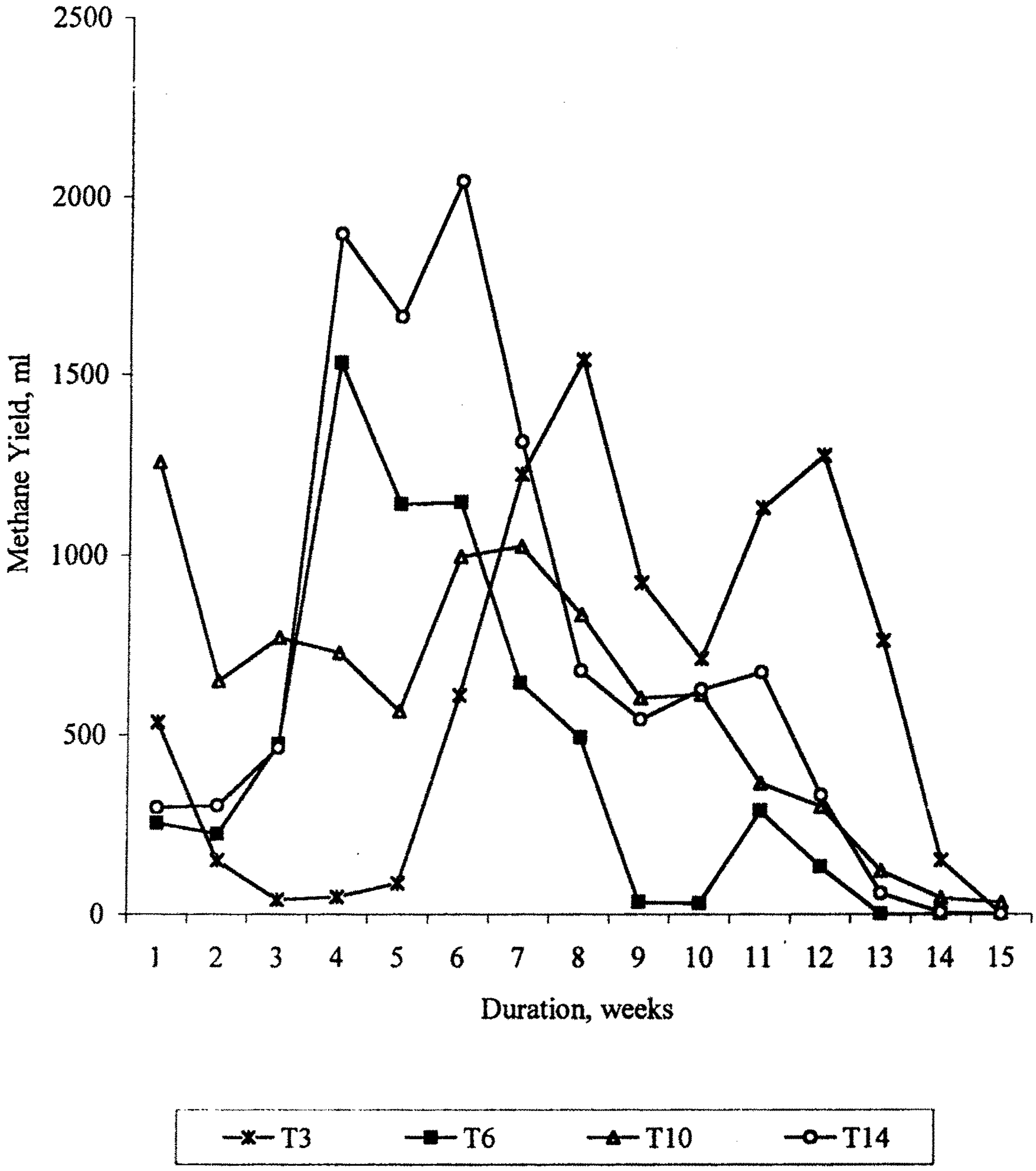



**Fig 4.27 METHANE YIELD FROM POULTRY MANURE BASED COMBINATIONS IN THE RATIOS OF 1:1, 1:2 & 2:1 WITH 15% TS**

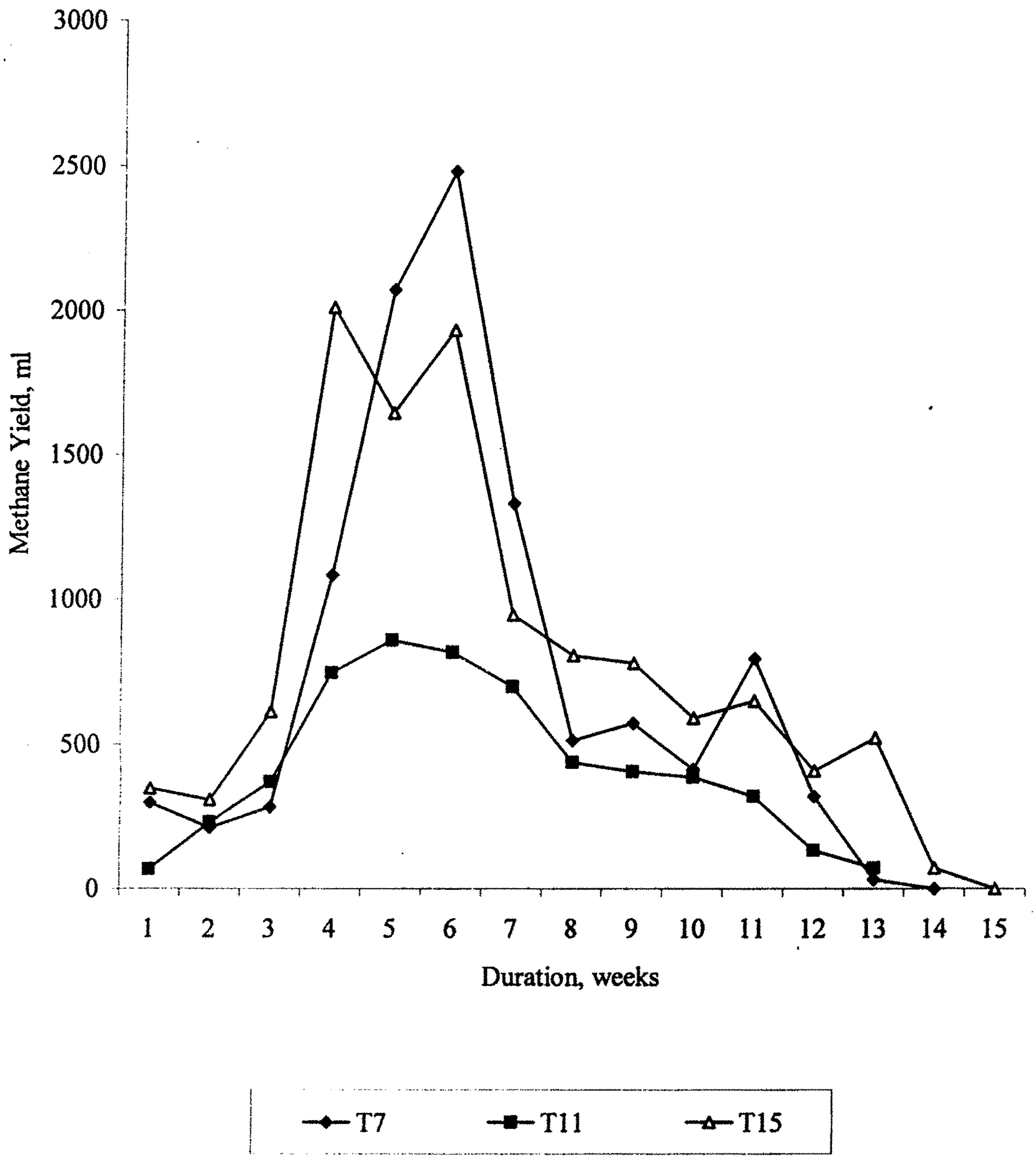



**Fig 4.28 METHANE YIELD FROM POULTRY MANURE BASED COMBINATIONS IN THE RATIOS OF 1:1, 1:2 & 2:1 WITH 20% TS**

be the best treatment in poultry manure based combination since the methane percentage also ranged between 50 to 80 percent in all the weeks.

**4.2.2.2. Methane yield from poultry deep litter based material combinations.**

Figure 4.29 it indicates that the highest methane yield from poultry deep litter material combinations with 5 per cent TS as 3070 ml during 1st week. The methane production dropped to very low level during 2nd week to 5th week after that they raised to optimum level in the entire poultry deep litter based material combination with 5 per cent TS. During 13th week all the combination produced very low methane content of less than 100 ml.

The methane yield from poultry deep litter based material combination with 10 per cent TS is shown in figure 4.30. The trend was similar to that of 5 per cent TS. Methane production was high during 1st week followed by drop in methane production upto 6th week and then increasing till 13th week and then attaining stability 15th week. The cowdung and poultry deep litter in 1:1 ratio ($T_{17}$) and cowdung and poultry deep litter in 1:2 ratio ($T_{21}$) produced less than 200 ml after 2nd week, whereas methane yield from cowdung as feedstock in 100 per cent ($T_2$) and cowdung and poultry deep litter in 2:1 ratio ($T_{25}$) were good.

The methane production from poultry deep litter based material combinations in the ratios of 1:1, 1:2 and 2:1 with 15 per cent TS are shown in figure 4.31. The methane yield from poultry deep litter based combinations with 15 per cent TS was high during 1st week and then decreased to nil condition from 9th week onwards. Whereas the methane yields from 15 per cent of TS the cowdung alone as feedstock ($T_3$) shows tremendous methane of from 5th to 15th week.

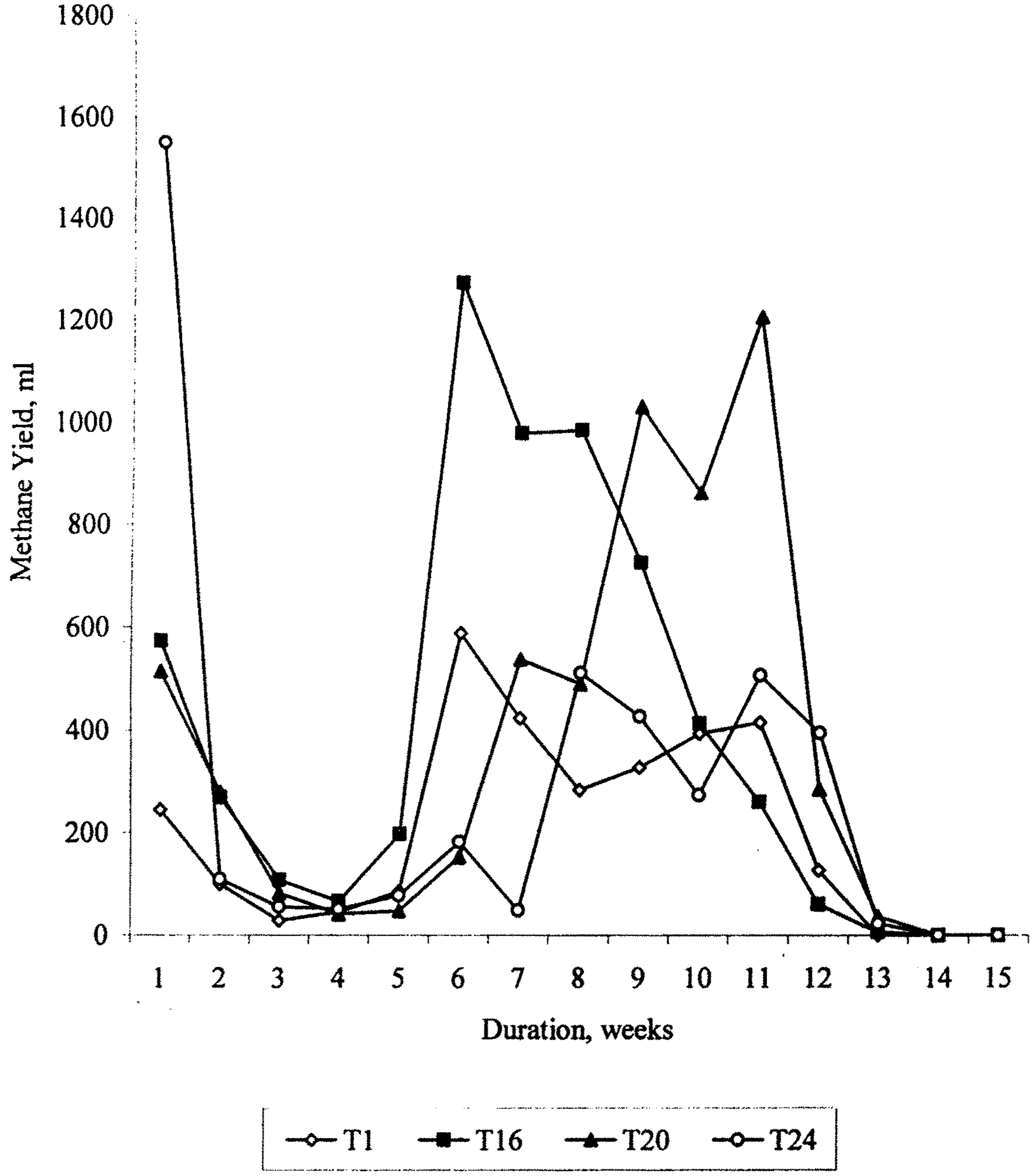



**Fig 4.29 METHANE YIELD FROM POULTRY DEEP LITTER BASED MATERIAL COMBINATIONS IN THE RATIOS OF 1:1, 1:2 & 2:1 WITH 5% TS**

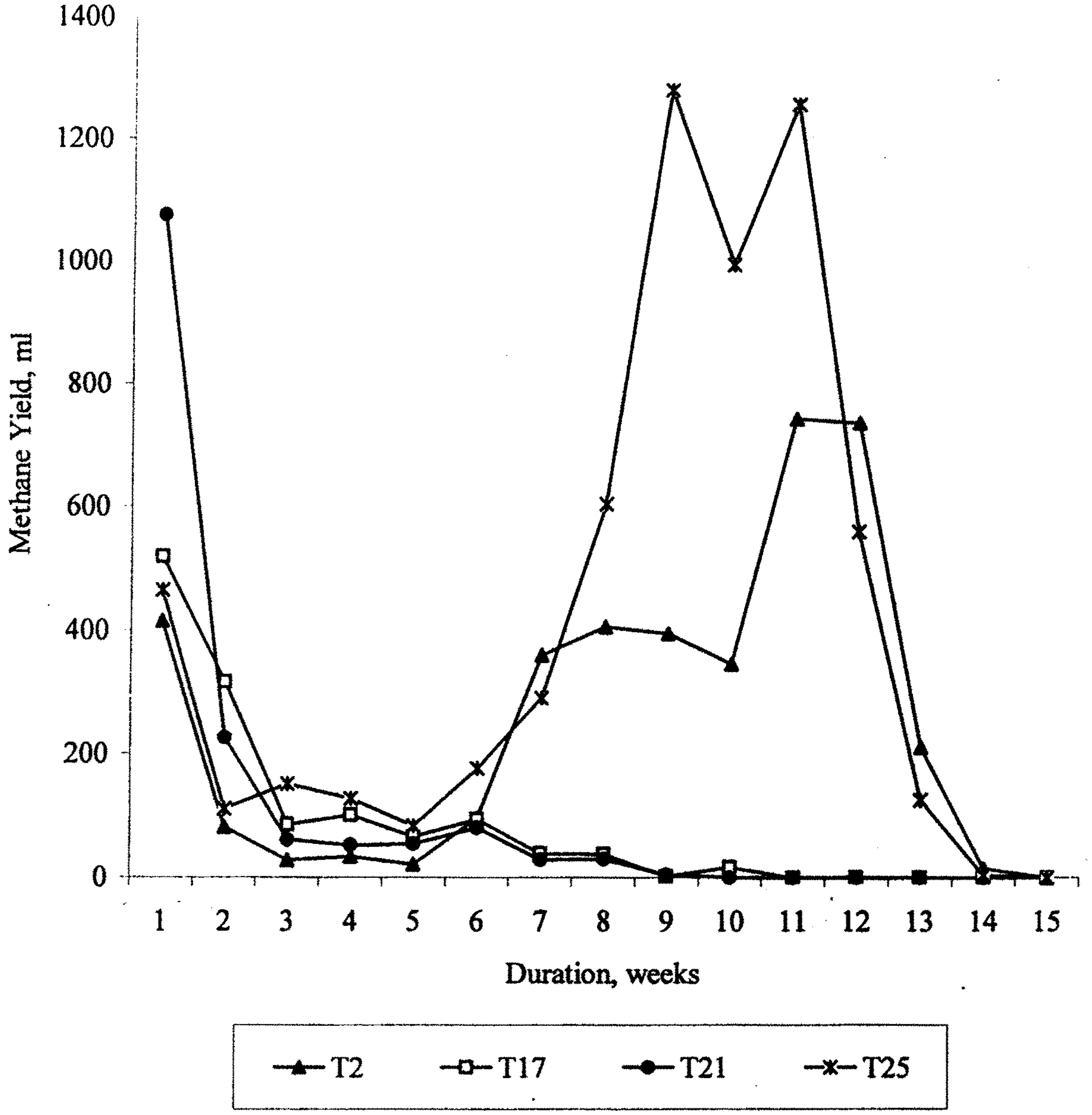



**Fig 4.30 METHANE YIELD FROM POULTRY DEEP LITTER BASED MATERIAL COMBINATIONS IN THE RATIOS OF 1:1, 1:2 & 2:1 WITH 10% TS**

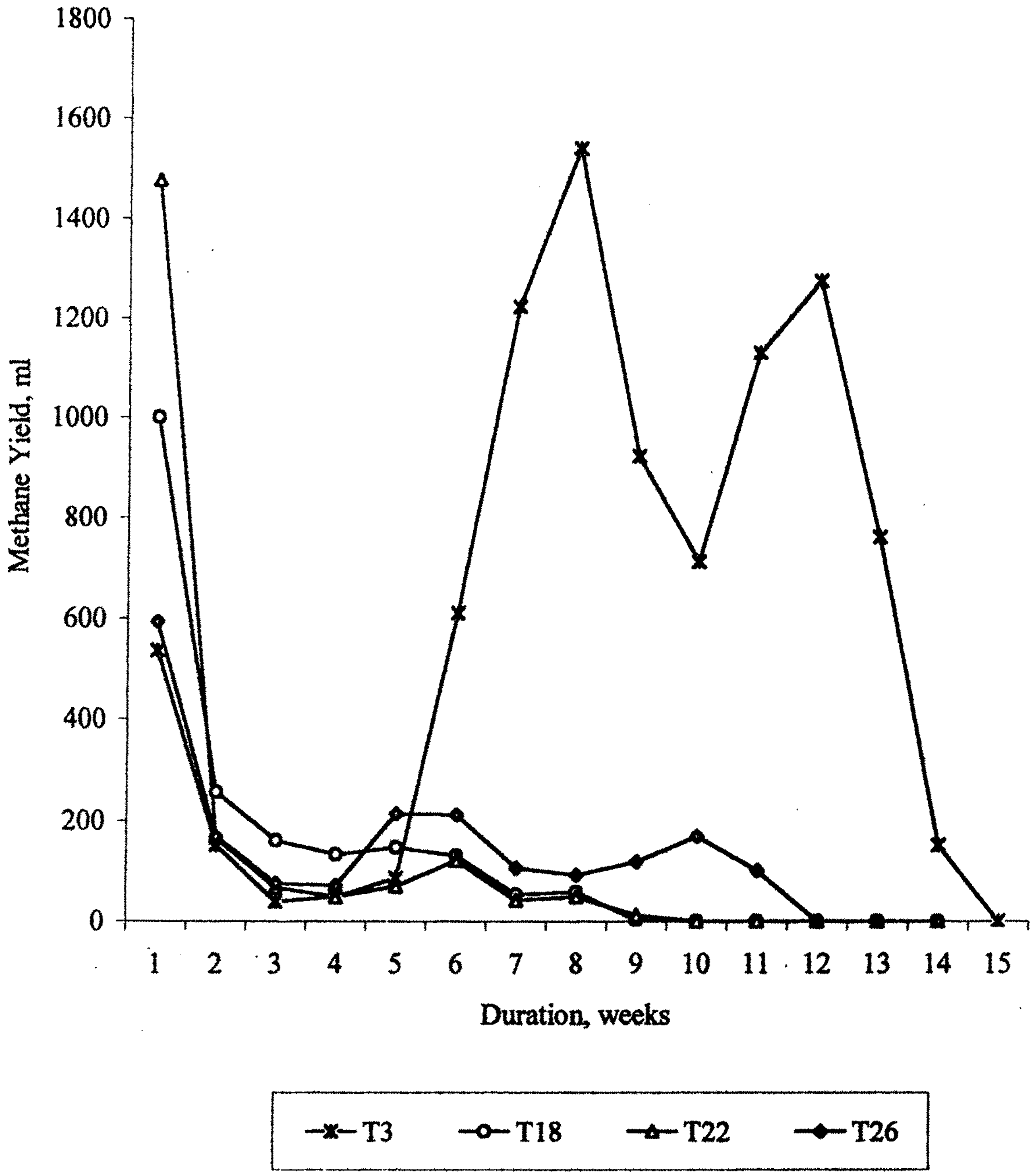



**Fig 4.31 METHANE YIELD FROM POULTRY DEEP LITTER BASED MATERIAL COMBINATIONS IN THE RATIOS OF 1:1, 1:2 & 2:1 WITH 15% TS**

From figure 4.32 the methane yield during 1st week was very high, whereas the methane yield dropped to very low level in the following weeks except cowdung mixed with poultry deep litter in 2:1 ratio ($T_{27}$) which reached to a peak value of 1647 ml during 9th week. The methane yield from all the combinations of poultry deep litter material was very low as ranged between 1282 ml to 7078 ml.

Among all these deep litter material combination methane yield recorded as 7078 ml as maximum in cowdung mixed with poultry deep litter with 2:1 ratio ($T_{27}$). But methane yield was very low compared to all other poultry waste. This lower yield was due to lower methane content of 30 to 45 per cent.

**4.2.2.3. Methane yield from poultry droppings based material combinations.**

The methane production from poultry droppings based material combination with 5 per cent TS was shown in figure 4.33. All the combinations of poultry dropping produced higher methane during 1st week as compared to cowdung alone as feed material. The methane production dropped during first three weeks and increased during 5th week then dropped upto 9th week and then it had increased during 10th week. The methane yield stopped after 13th week in all the combinations. The highest methane production per week was from cowdung and poultry droppings mixed with 2:1 ratio ($T_{34}$) during 1st week as 1749 ml. All other poultry droppings based material combination produced peak methane yield during 1st week itself.

Figure 4.34, it indicates that the methane yield from poultry droppings based combinations with 10 per cent TS were also peak production was during 1st week and followed the same trend as that of 5 per cent TS. All the combination produced more methane yield than cowdung as feed material and the highest yield per week was 4029 ml from cowdung and poultry droppings mixed with 2:1 ratio ($T_{35}$) during 1st week.

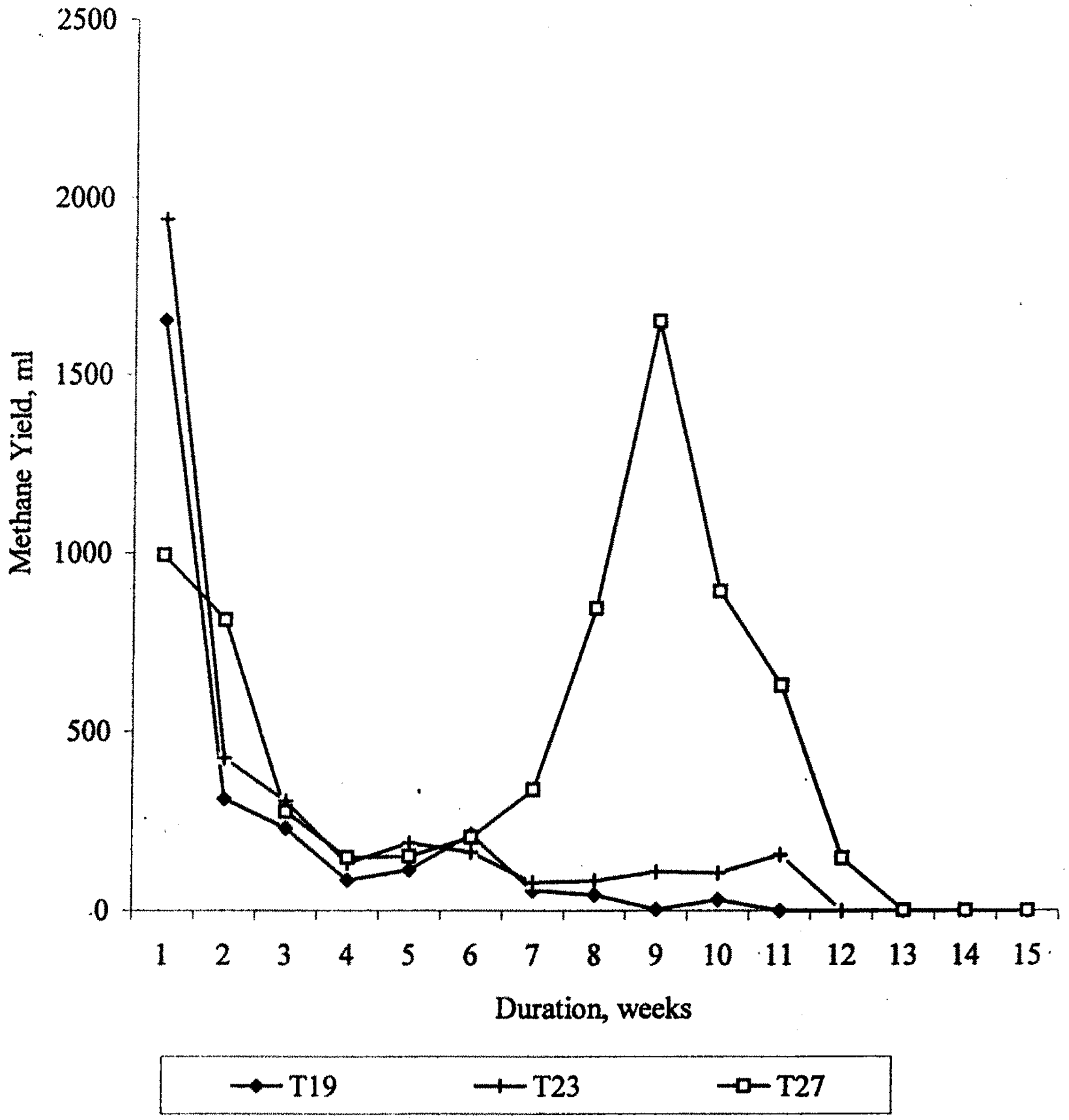



**Fig 4.32 METHANE YIELD FROM POULTRY DEEP LITTER BASED MATERIAL COMBINATIONS IN THE RATIOS OF 1:1, 1:2 & 2:1 WITH 20% TS**

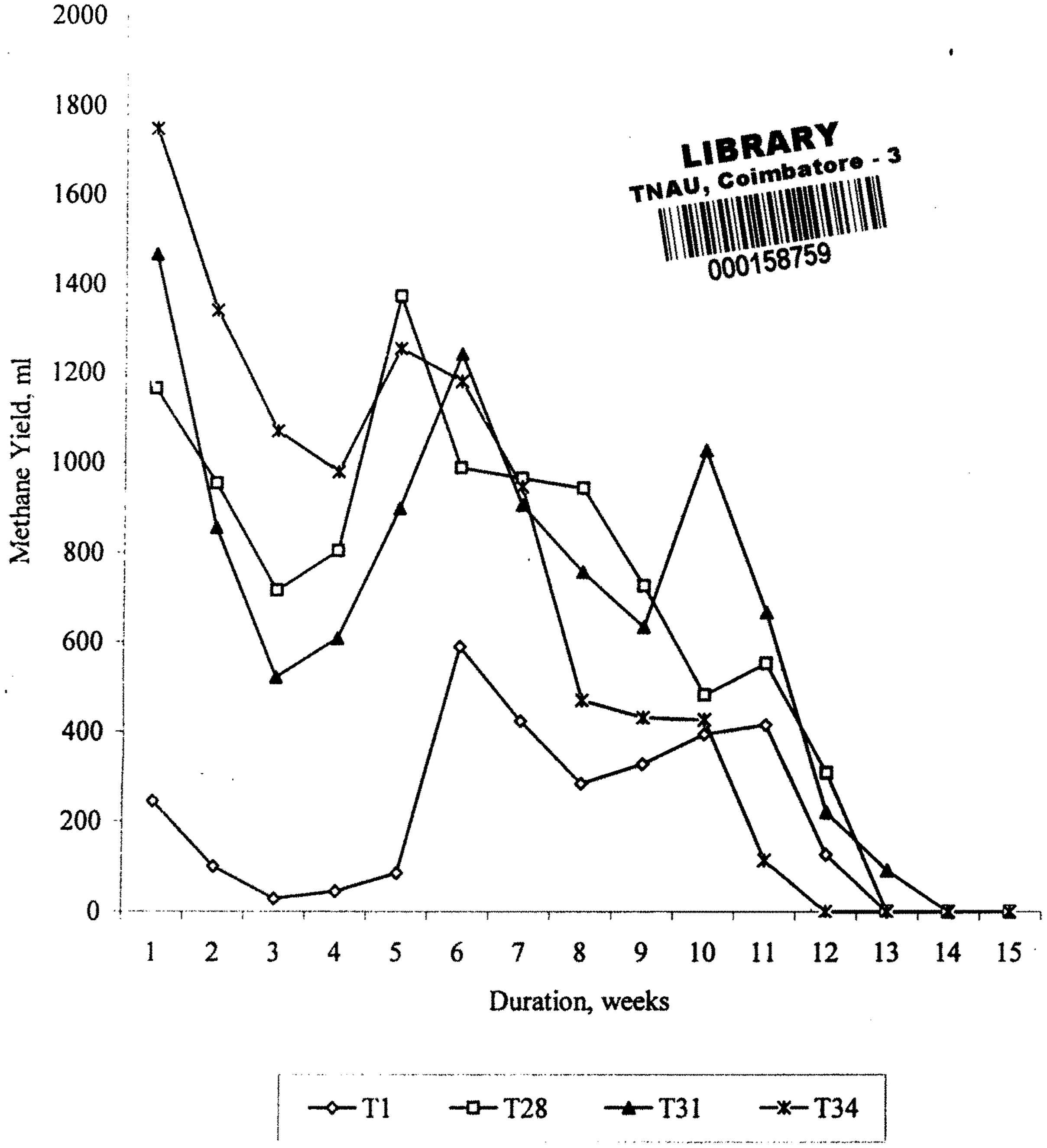





**Fig 4.33 METHANE YIELD FROM POULTRY DROPPINGS BASED MATERIAL COMBINATIONS IN THE RATIOS OF 1:1, 1:2 & 2:1 WITH 5% TS**

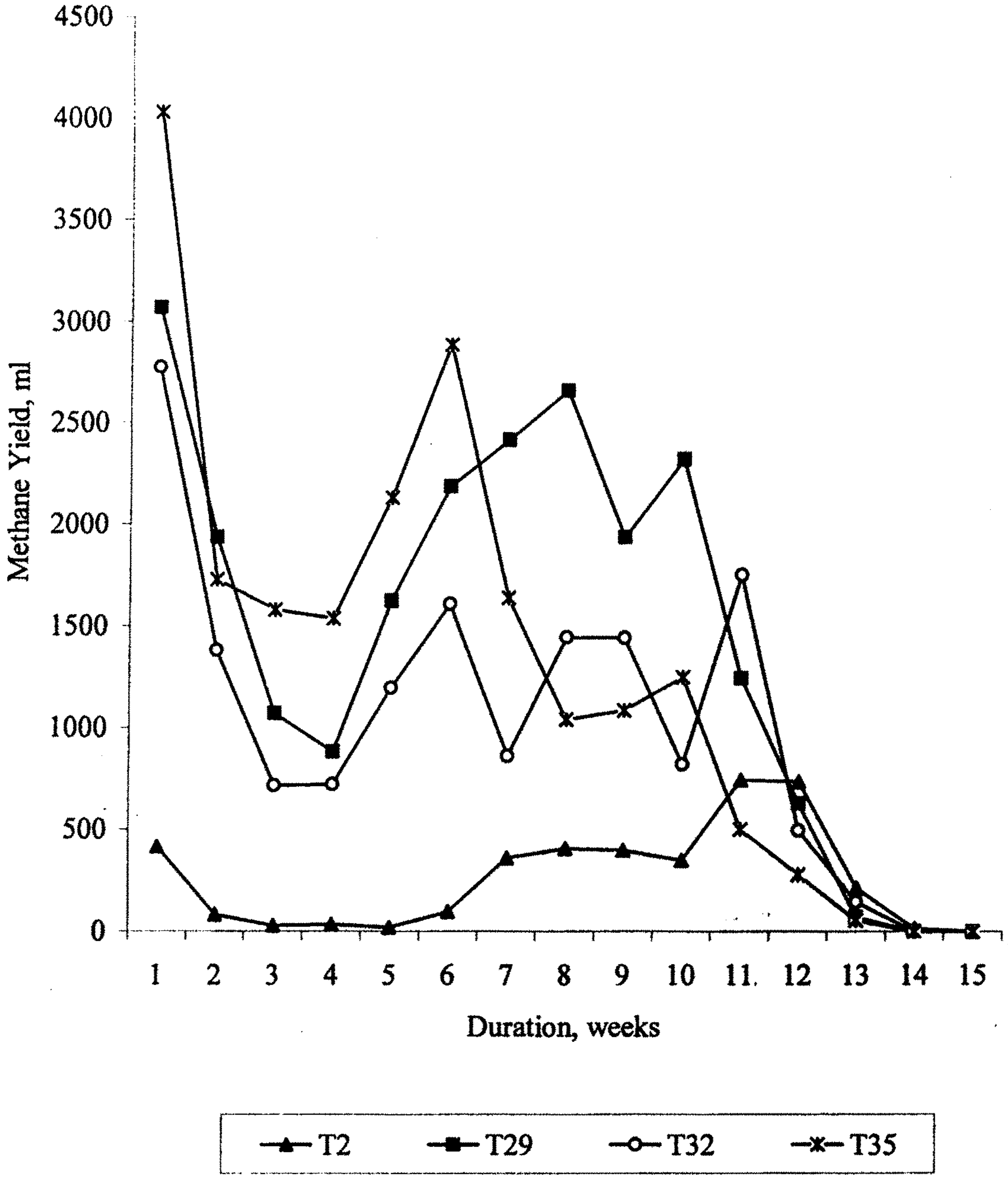



**Fig 4.34 METHANE YIELD FROM POULTRY DROPPINGS BASED MATERIAL COMBINATIONS IN THE RATIOS OF 1:1, 1:2 & 2:1 WITH 10% TS**

The methane yield from poultry droppings based material combination with 15 per cent TS are shown in figure 4.35. The trend was very similar to that of 5 per cent, 10 per cent TS. The highest methane production was more than 5000 ml per week in cowdung and poultry droppings mixed with 1:1 ratio ($T_{30}$) and cowdung and poultry droppings mixed with 2:1 ratio ($T_{36}$) as compared to the highest methane yield per week as 4029 ml in cowdung and poultry droppings mixed with 2:1 ratio ($T_{35}$) with 10 per cent TS. All the combinations produced more methane as compared to cowdung alone as feed material.

Among poultry droppings based material combinations in the ratios of 1:1, 1:2 and 2:1 with 5, 10, and 15 per cent TS, the highest methane yield from cowdung and poultry droppings combination ($T_{36}$) mixed with 2:1 ratio as 27567 ml which also produced highest total biogas. The methane yield was also high in all the poultry dropping based material combinations. This high yield of methane is due to high methane per cent. The range of methane per cent was 60 to 65 per cent as compared to 30 to 45 per cent in poultry deeplitter based material combination. Oba and Honda (1981) stated methane content of 60 to 84 per cent from agricultural and cattle waste which were confirmed in this experiment.

Figure 4.36, it shows that the methane yield from poultry droppings and cowdung alone as feed material with 5, 10 and 15 per cent TS. The highest methane yield produced per week during first week was 4610 ml in poultry droppings alone as feedstock with 15 per cent TS ($T_{39}$) and also it had another peak methane yield during $10^{th}$ week. All the treatments produced higher methane during first week followed by decreasing trend and then increased except the poultry droppings alone as feedstock with the addition of desired quantity of waste to have the 5 per cent TS ($T_{37}$) which produced highest methane yield during the second week. Among these feed stock, the poultry droppings alone as feedstock with 15 per cent TS ($T_{39}$) produced highest total methane yield of 27567 ml.

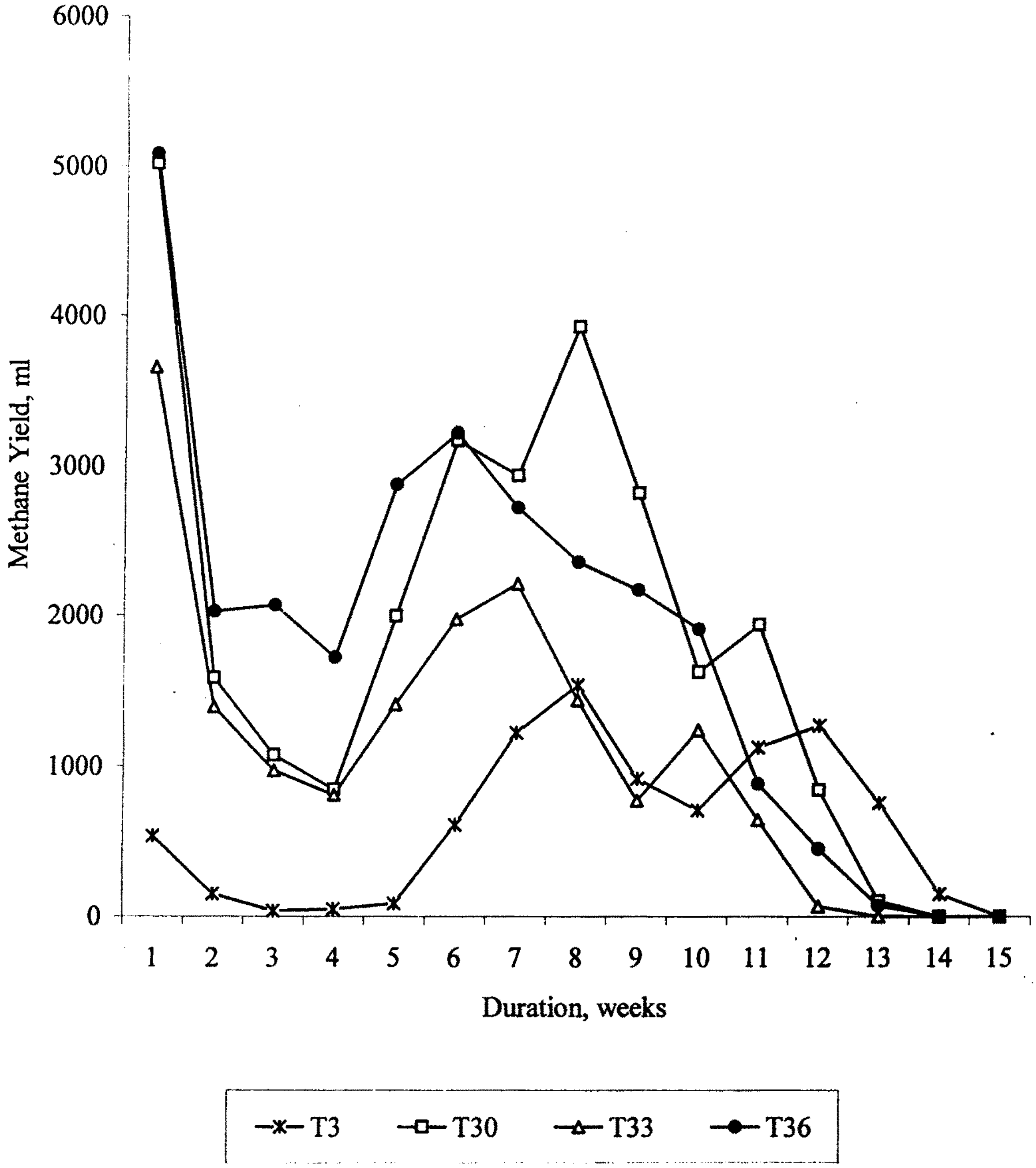



**Fig 4.35 METHANE YIELD FROM POULTRY DROPPINGS BASED MATERIAL COMBINATIONS IN THE RATIOS OF 1:1, 1:2 & 2:1 WITH 15% TS**

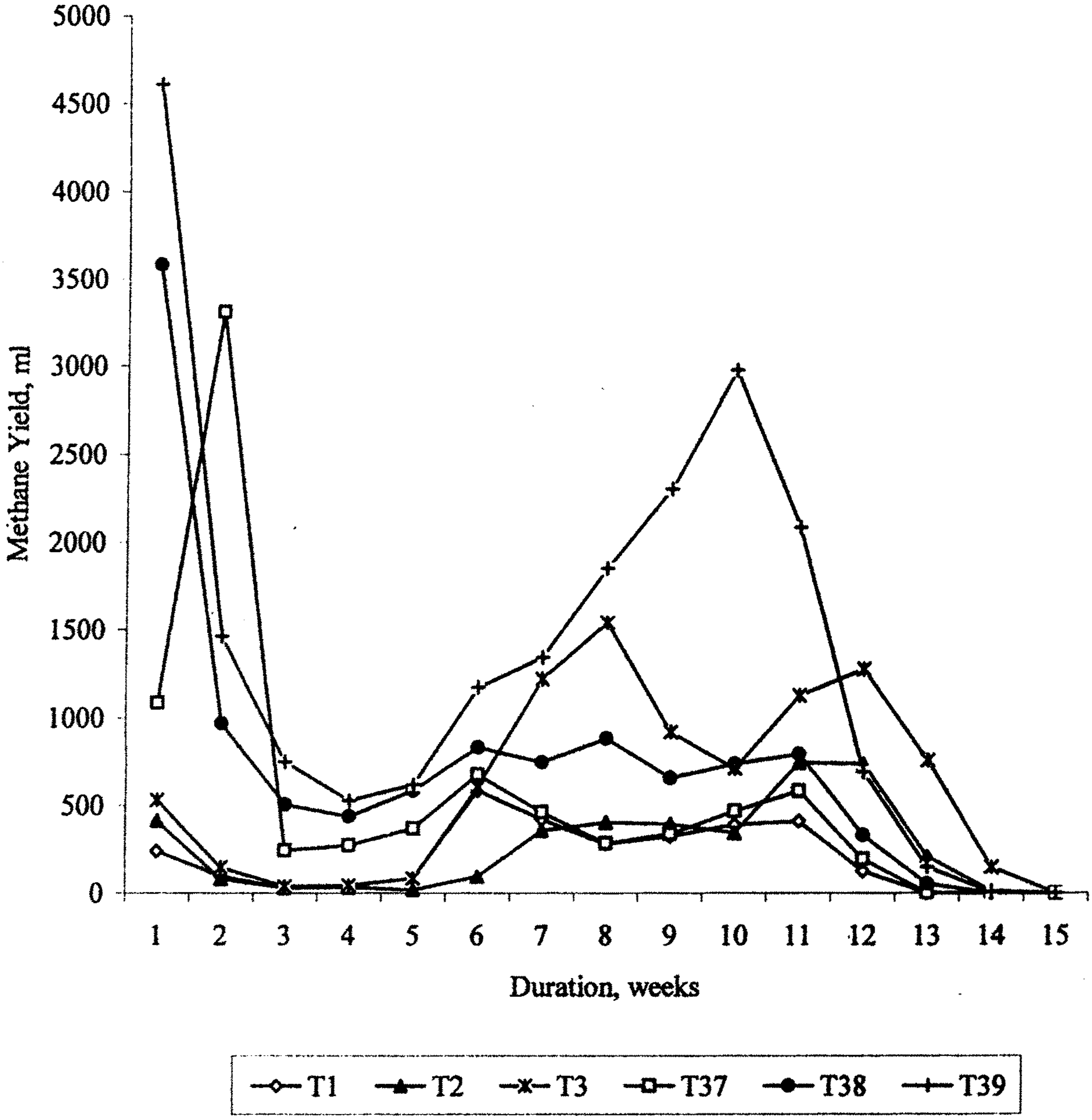



**Fig 4.36 METHANE YIELD FROM POULTRY DROPPINGS ALONE WITH 5%, 10% & 15% TS**

Statistical analysis was carried out for methane production with 39 treatments using Agres 7.1 package and the ANOVA table is given in Appendix B.

From the analysis it is inferred that the treatment with cowdung and poultry droppings ($T_{30}$) in 1:1 ratio with 15 per cent total solids gave the highest methane production of 27889 ml. The methane production ranged between 1150 ml to 27889 ml.

Statistical analysis was carried out for gas production with 39 treatments using Agres 7.1 package and the ANOVA table is given in Appendix B.

From the analysis, the treatment with cow dung mixed with poultry droppings ($T_{36}$) in 2:1 ratio with 15 per cent TS is proved to give the highest gas production and the gas production ranged between 1698 ml and 47273 ml.

**4.2.3. Methane yield per kg of Total Solids added and Volatile Solids added**

The total biogas produced from all the 39 combinations of feedstocks were observed and volume ($m^3$) of total methane produced per kg of TS added and volume ($m^3$) of total methane produced per kg of VS added were calculated and given in table 4.17.

Total methane production ($m^3$) per kg of TS and VS added for different combinations of feedstocks are shown in figures 4.37 and 4.38. It can be seen from figure 4.37, that the maximum methane production of 0.1470 $m^3$ per kg of TS added was observed in the combination of poultry droppings mixed with cowdung in 1:1 ratio ($T_{29}$). The lowest methane production of 0.0085 $m^3$ per kg of TS added was observed in the combination of poultry deep litter mixed with cowdung in 1:1 ratio ($T_{17}$). Most of the combinations from poultry droppings based material produced more methane yield ($m^3$) per kg of TS added, the treatments from poultry droppings mixed with cowdung in 1:1 ratio ($T_{28}$) to cowdung mixed with poultry droppings in 2:1 ratio ($T_{36}$).

**Table 4.17. Total methane production per kg of TS and VS added for different combinations of feedstocks**

| Treatment | Total methane yield (ml) | Methane production $m^3$ / kg | |
|---|---|---|---|
| | | TS added | VS added |
| $T_1$ | 3062 | 0.0408 | 0.0575 |
| $T_2$ | 3897 | 0.0260 | 0.0366 |
| $T_3$ | 3062 | 0.0136 | 0.0383 |
| $T_4$ | 1475 | 0.0197 | 0.0497 |
| $T_5$ | 3219 | 0.0215 | 0.0604 |
| $T_6$ | 6393 | 0.0284 | 0.0719 |
| $T_7$ | 10394 | 0.0346 | 0.0780 |
| $T_8$ | 1150 | 0.0153 | 0.0457 |
| $T_9$ | 2103 | 0.0140 | 0.0416 |
| $T_{10}$ | 8888 | 0.0395 | 0.1177 |
| $T_{11}$ | 5532 | 0.0184 | 0.0550 |
| $T_{12}$ | 4512 | 0.0602 | 0.1371 |
| $T_{13}$ | 7417 | 0.0494 | 0.0858 |
| $T_{14}$ | 10891 | 0.0484 | 0.1179 |
| $T_{15}$ | 11610 | 0.0387 | 0.1005 |
| $T_{16}$ | 5916 | 0.0789 | 0.1034 |
| $T_{17}$ | 1282 | 0.0085 | 0.0112 |
| $T_{18}$ | 1933 | 0.0086 | 0.0118 |
| $T_{19}$ | 2738 | 0.0091 | 0.0120 |
| $T_{20}$ | 5562 | 0.0742 | 0.1022 |
| $T_{21}$ | 1617 | 0.0108 | 0.0148 |
| $T_{22}$ | 2045 | 0.0091 | 0.0124 |
| $T_{23}$ | 3687 | 0.0123 | 0.0156 |
| $T_{24}$ | 4208 | 0.0561 | 0.0777 |
| $T_{25}$ | 6238 | 0.0416 | 0.0574 |
| $T_{26}$ | 1910 | 0.0085 | 0.0119 |
| $T_{27}$ | 7078 | 0.0236 | 0.0326 |
| $T_{28}$ | 9968 | 0.1329 | 0.2876 |
| $T_{29}$ | 22051 | 0.1470 | 0.3182 |
| $T_{30}$ | 27889 | 0.1240 | 0.2624 |
| $T_{31}$ | 9882 | 0.1318 | 0.3102 |
| $T_{32}$ | 15368 | 0.1025 | 0.2412 |
| $T_{33}$ | 16605 | 0.0738 | 0.1773 |
| $T_{34}$ | 9960 | 0.1328 | 0.2496 |
| $T_{35}$ | 19746 | 0.1316 | 0.2474 |
| $T_{36}$ | 27567 | 0.1225 | 0.2245 |
| $T_{37}$ | 8319 | 0.1109 | 0.3139 |
| $T_{38}$ | 11135 | 0.0742 | 0.2101 |
| $T_{39}$ | 20545 | 0.0913 | 0.2584 |

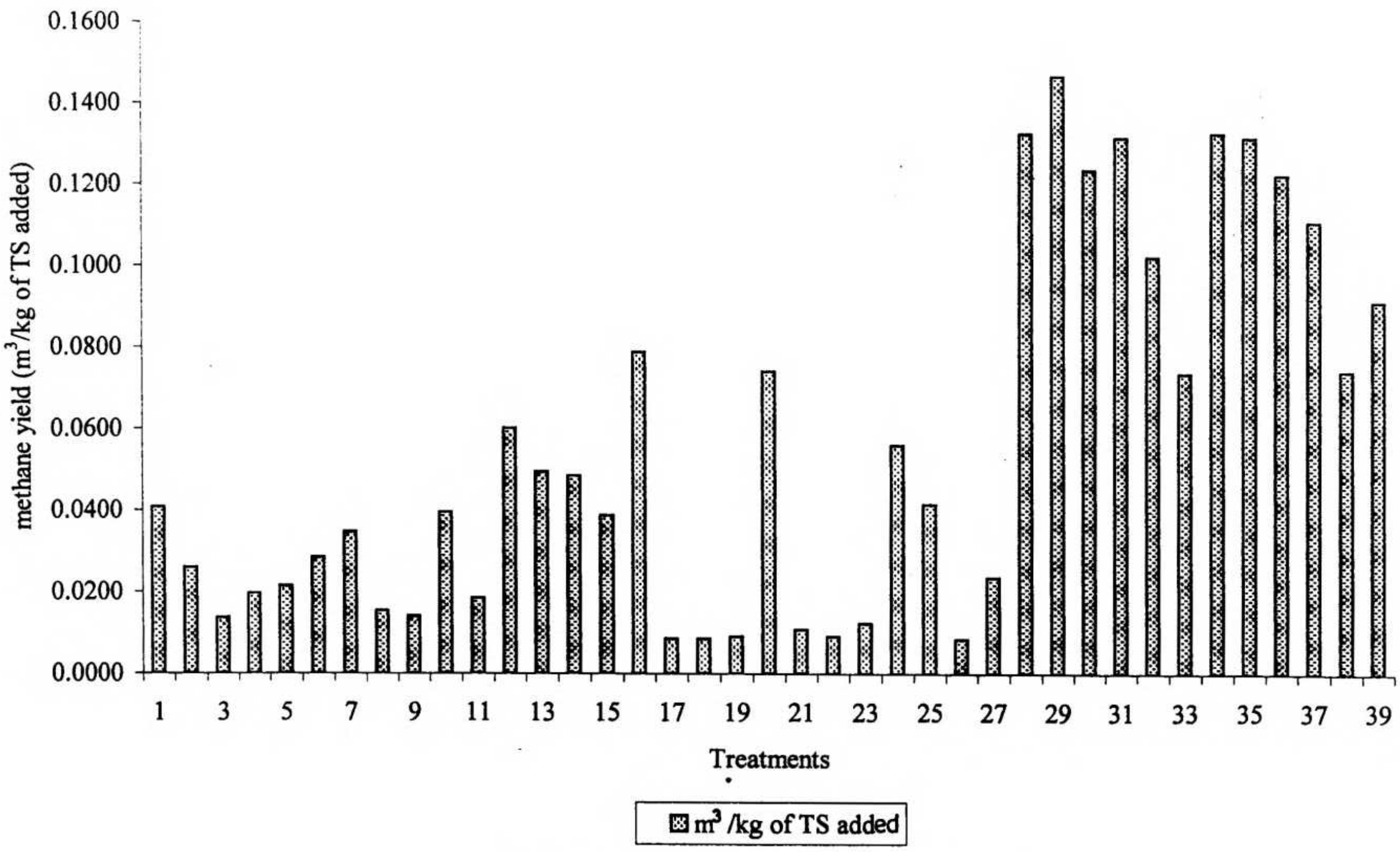



**Fig: 4.37 Methane yield ($m^3$) per kg of TS added**

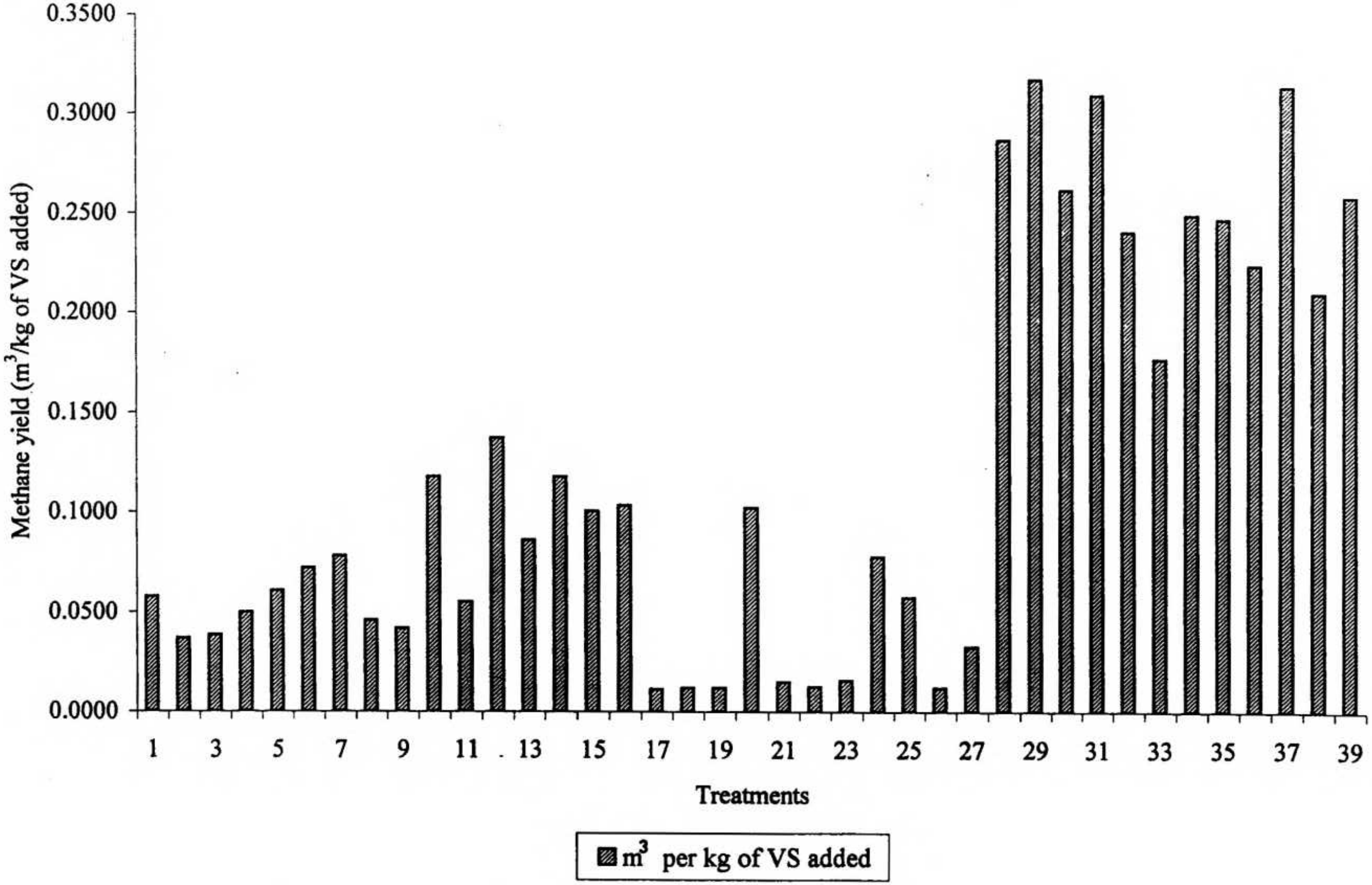



**Fig. 4.38. Methane yield ($m^3$) per kg of VS added**

Among all the combinations, the higher yield of methane per kg of VS added from cowdung and poultry droppings mixed with 1:1 ratio ($T_{29}$) as 0.3182 $m^3$ per kg of VS added are shown in figure 4.38. The lower yield of methane per kg of VS added in the combination of cowdung and poultry deep litter mixed with 1:1 ratio ($T_{17}$) as 0.0474 $m^3$ per kg of VS added. Cowdung and poultry droppings mixed with 1:1 ratio ($T_{29}$) and cowdung mixed with poultry deep litter in 1:1 ratio ($T_{17}$) shows the maximum and minimum methane produced ($m^3$) per kg of TS added and VS added respectively

**4.3. Performance evaluation of the brooders**

In this study, the biogas burner type brooder (hanging type) was fabricated and its performance was tested. The brooder was fueled by biogas as described and the floor temperature recorded under this brooder was compared with the LPG brooder. A thermocouple was used for measuring floor temperatures when brooders were operated at different heat input rate. The ambient temperature was 30$^0$C. The hanging height of the brooder during the test was 100 cm, which was kept lower than usual in order to obtain a higher floor temperature field to get an explicit comparison between these brooders. In actual application, the temperature can be moderated by raising the hanging height of the brooder or adjusting the fuel flow.

**4.3.1. Temperature distribution under brooder unit**

The temperature distribution in the brooder unit was measured at a radial distance of 0, 15, 30, 45, 60, 75, 90, 105, 120, 135 and 150 cm from biogas burner when the burner was fixed at a height of 75 and 100 cm from the ground level. For control, temperature distribution was measured from the centre of the brooder unit.

#### 4.3.1.1. Biogas brooder

Spatial temperature distribution in biogas brooder (Plate 4.1) at different heights of biogas burner from the ground level is shown in Figure 4.39. From the figure, it is clear that there was a decrease in level of temperature as the height of the biogas burner from the ground level and the distance from the biogas burner was increased.

The temperature of 39 °C recorded near the burner when the burner was fixed at a height of 75 cm from the ground level. For the same point, the temperature obtained was 36°C when the burner was fixed at a height of 100 cm from the ground level.

From the figure 4.39, the temperature was varied between 30 and 39°C when the height of the biogas burner was fixed at 75 and 100 cm from the ground level. The recommended temperature for the safe brooding of quail during the first week is 35-37.8°C (Reddy, 1991) and it was attained at 75 cm height.

For the second week of brooding, the temperature required for quail was recommended as 32.2-35°C (Reddy, 1991). This temperature was obtained when the biogas burner was fixed at a height of 100 cm from ground level. At this height, the recommended temperature was obtained in more base area than at other heights of burner position.

During the third week of brooding, the temperature required for quail is 26.6 - 32.2°C (Reddy, 1991). It was obtained when the biogas burner was fixed at a height of 100 cm from the ground level.

#### 4.3.1.2. LPG brooder

Spatial temperature distribution in LPG brooder (Plate 4.2) at different heights of heat source from the ground level is shown in Figure 4.40. From the figure, it is seen that the temperature dropped as the distance from the LPG burner was increased.

Plate No. 4.1 Temperature measurement in biogas brooder

Plate No. 4.3 Illumination measurement in biogas brooder

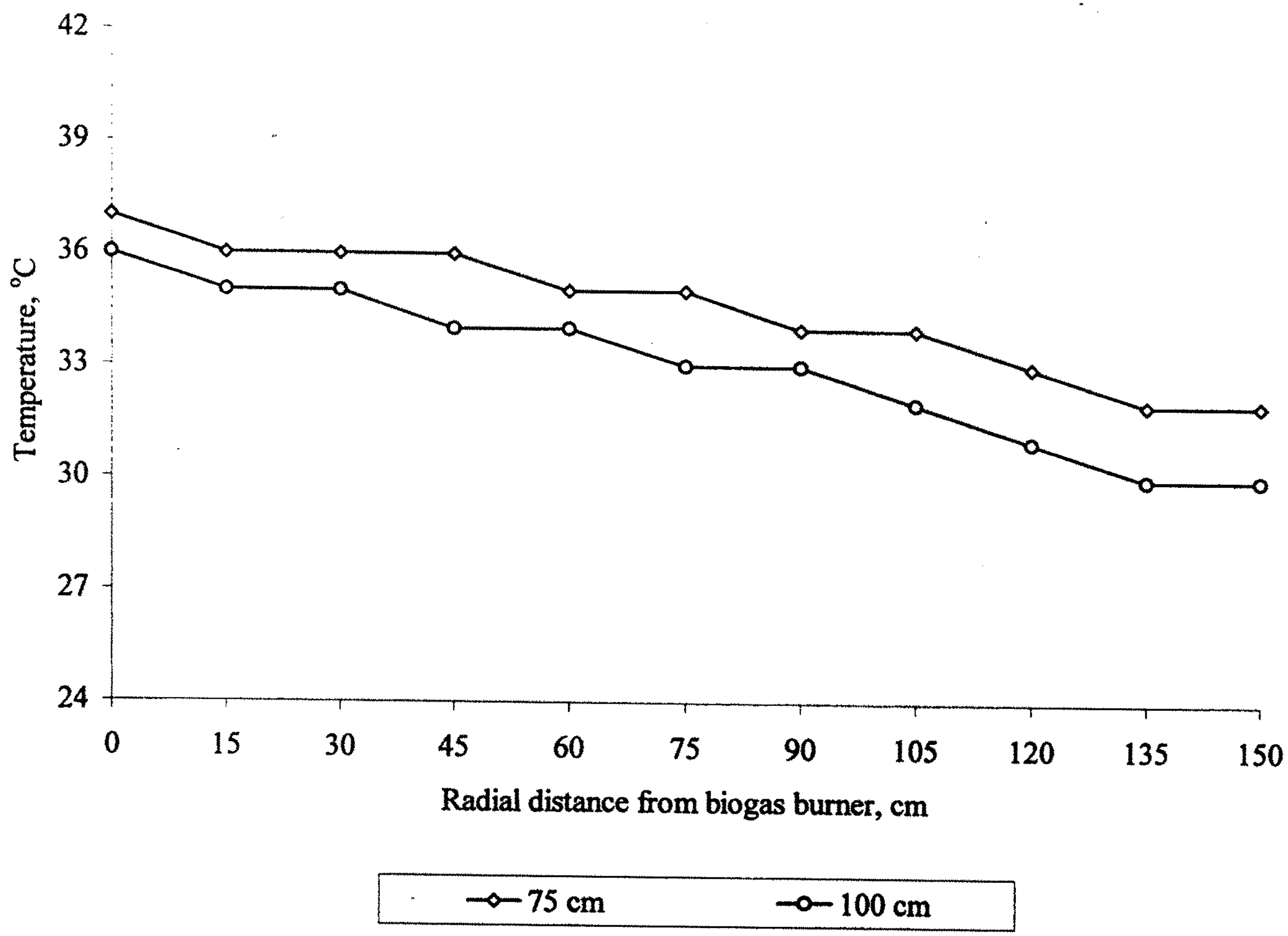



**Fig. 4.39 Spatial temperature distribution in Biogas Brooder**

**Plate No. 4.2 Temperature measurement in LPG brooder**

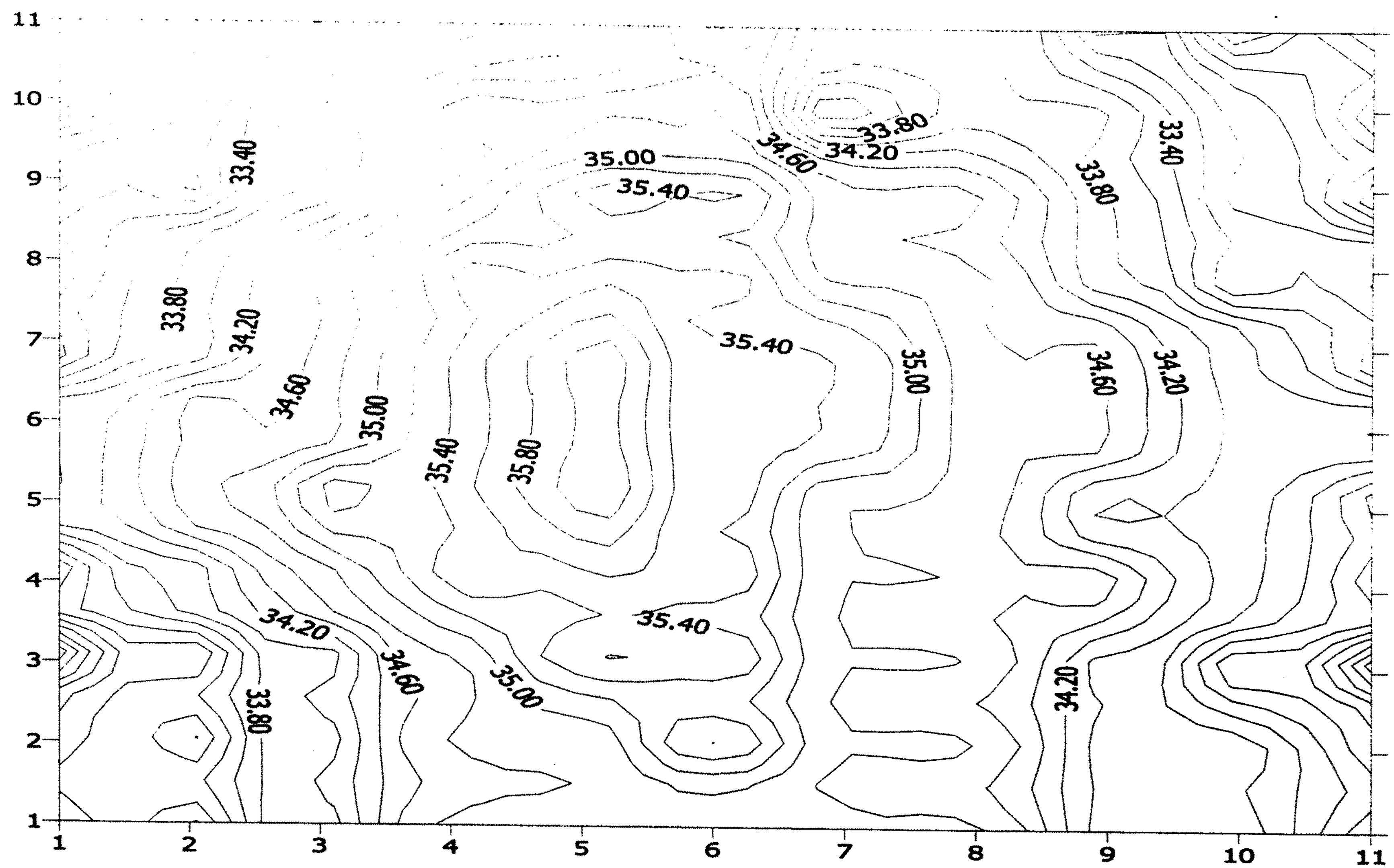



Fig. 4.43 Isothermal contour of grourd level for biogas brooder with biogas burner position at the height of 75 cm from the ground level.

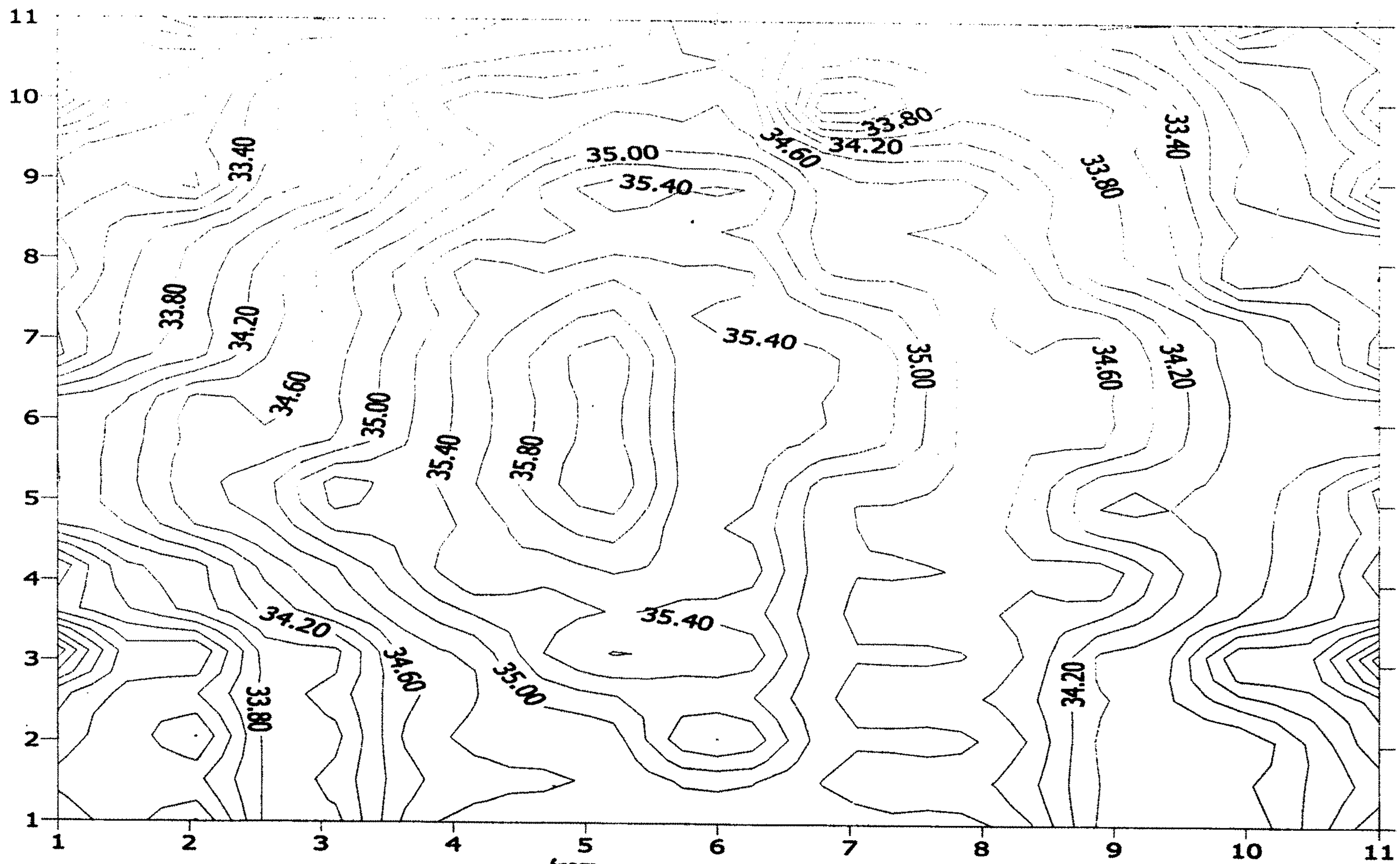



**Fig. 4.44 Isothermal contour of 5 cm from ground level for biogas brooder with biogas burner position at the height of 75 cm from the ground level**

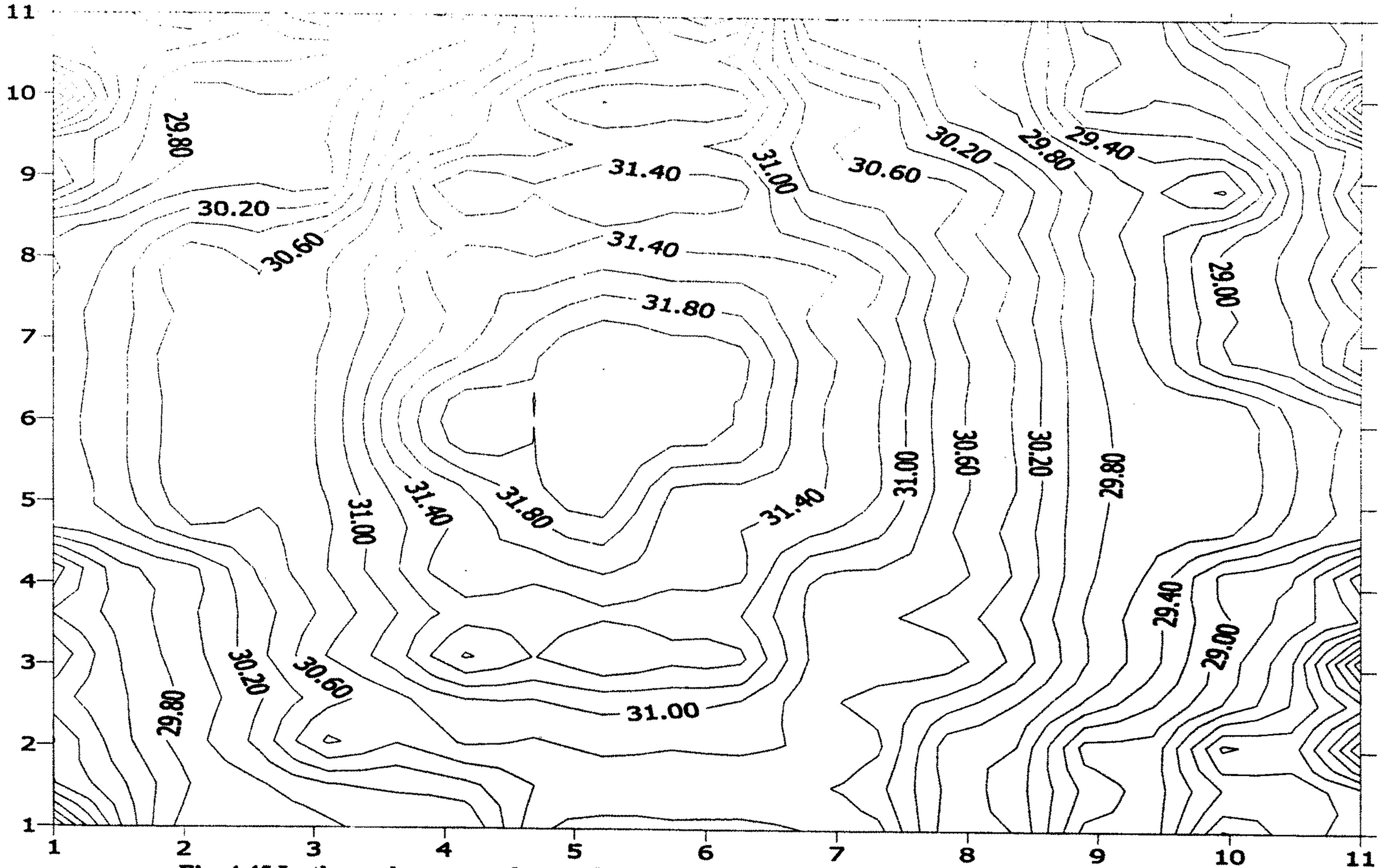



**Fig. 4.45 Isothermal contour of ground level for LPG brooder with LPG burner position at the height of 100 cm from the ground level**

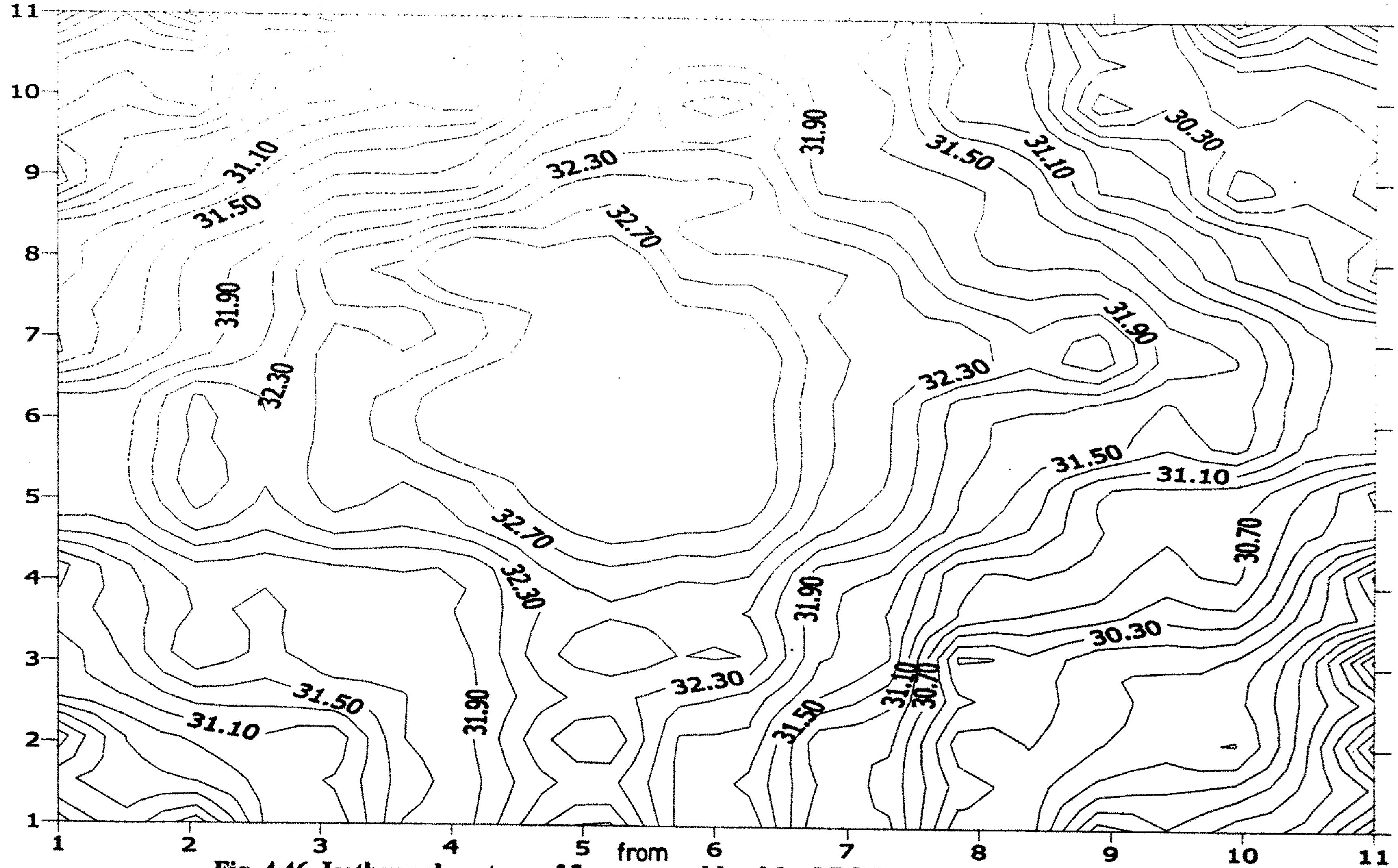



Fig. 4.46 Isothermal contour of 5 cm from ground level for LPG brooder with LPG burner position at the height of 100 cm from the ground level

#### 4.3.3.1. Biogas brooder

The illumination at different heights of biogas burner in biogas brooder (Plate 4.2) is shown in Figure 4.47. The illumination (or) light intensity released by heat source (biogas burner) was decreased with increase in the distance from the biogas burner when the burner was fixed at different height from the ground level. The light intensity requirement of chicks in the brooding period was 54 $lm/m^2$ (54 lux) followed by two weeks lower light intensity reported by Hughese and Weaver (1979). The light intensity of 58 $lm/m^2$ was obtained at 75 cm height of biogas burner at a radial distance of 30 cm from the biogas burner. This illumination was achieved just above the requirement.

For second and third weeks of brooding, the required illumination was obtained when biogas burner fixed at a height of 100 cm from the ground level. The illumination decreased when the height of heat source from the ground level was increased.

#### 4.3.3.2. LPG brooder

The illumination released from LPG burner at a height of 100 cm from the ground level for LPG brooder is shown in figure 4.48. From the figure, the illumination was decreased when the radial distance from the centre of brooder increases. Illumination was lower in outer edge of brooder because of heat source is placed in centre of the brooder.

The maximum illumination (34 lux) was obtained near to heat source and minimum was recorded as 14 lux at the edge of the brooder when heat source placed 75 cm and 100 cm from the ground level respectively. The light intensity at this height was much lower than recommended light intensity of 54 lux (Hughese and Weaver, 1979).

The light intensity released from biogas brooder was higher than LPG brooder and the adjustment in biogas burner height increased the light intensity. In the case of

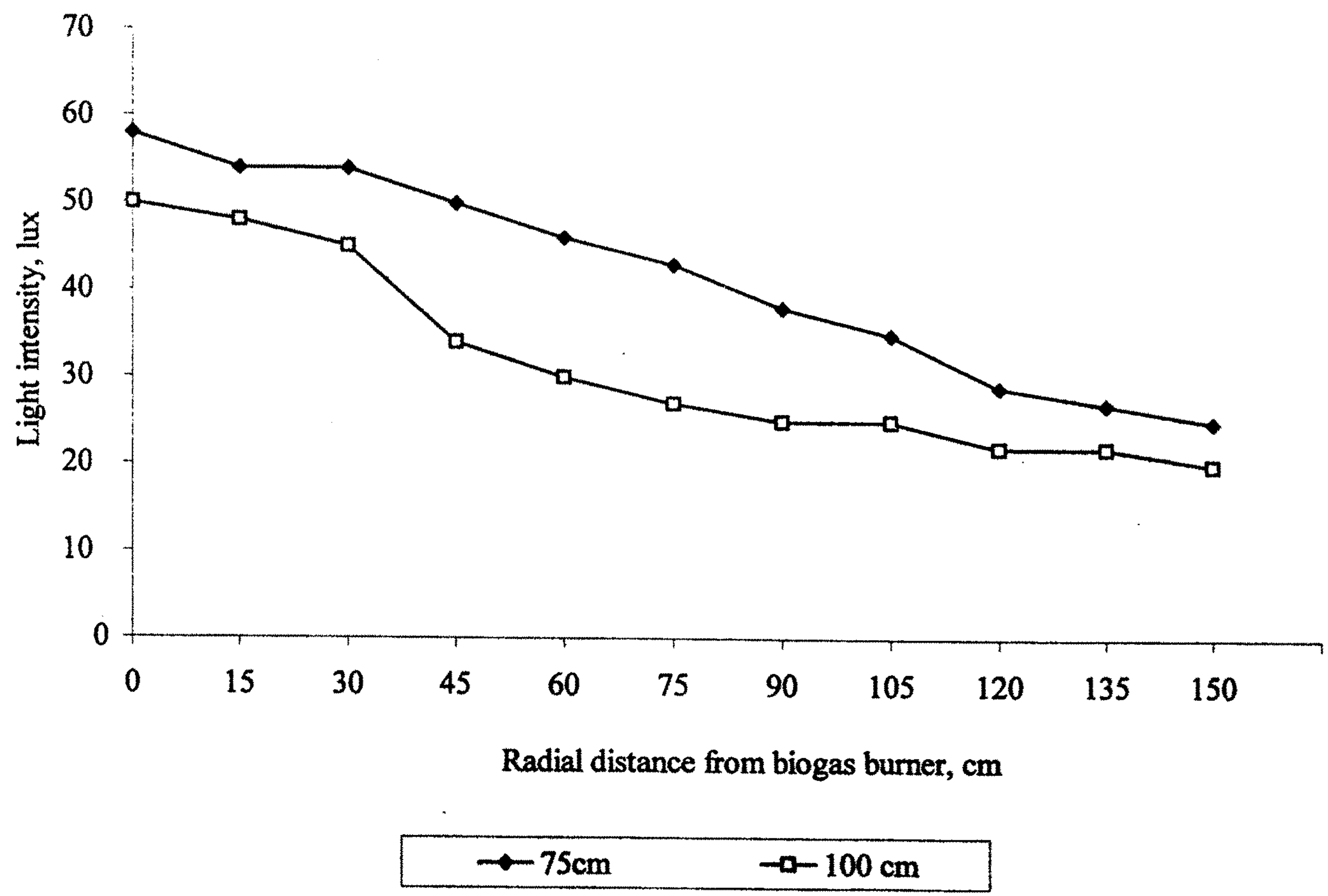



**Fig. 4.47 Illumination at different height of biogas burner**

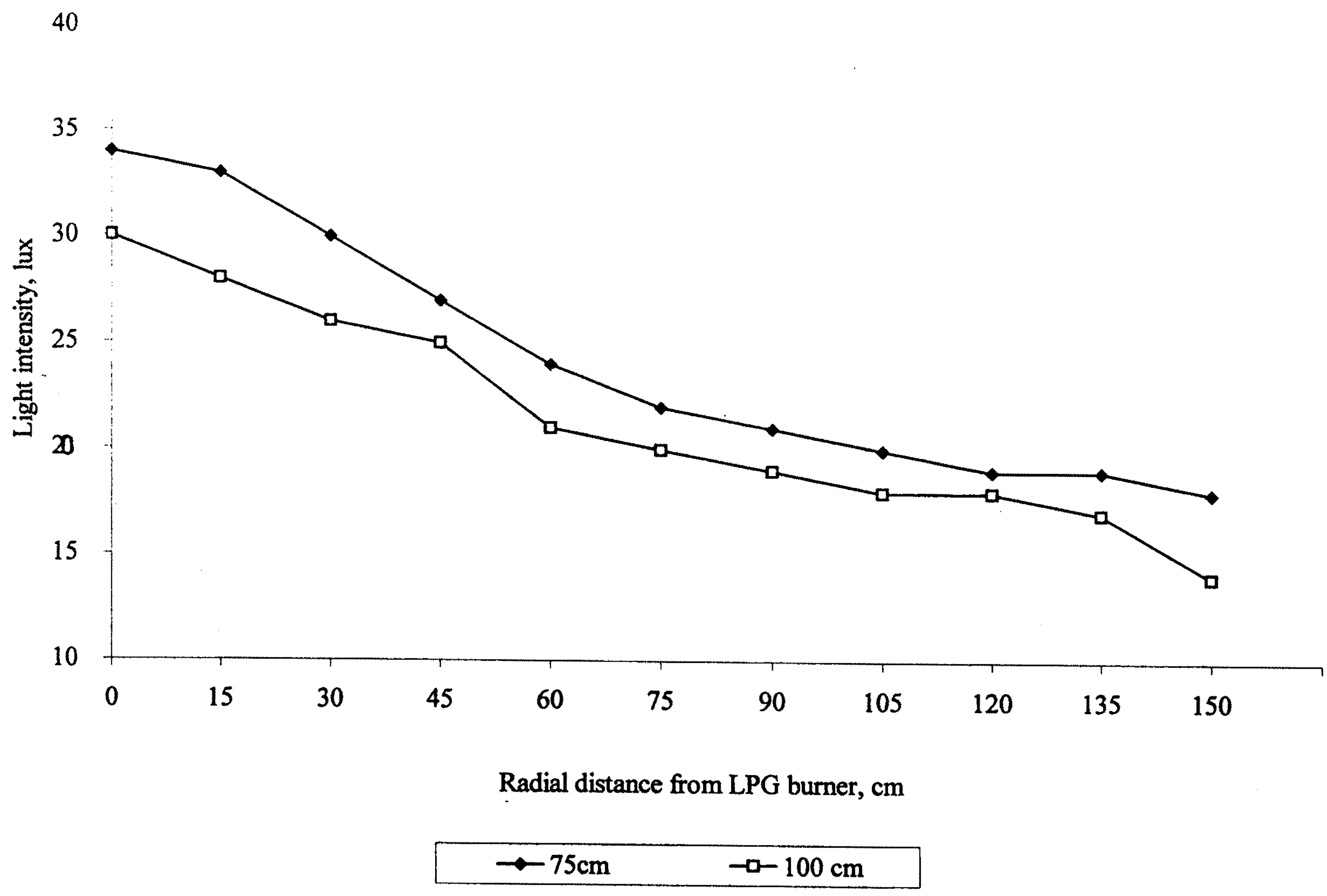



**Fig 4.48 llumination at different height of LPG burner**

LPG brooder also there is an possibility of adjusting the height of heat source. So the constant illumination released from the source for three week of brooding.

#### 4.3.5.4. Biogas and LPG consumption

The energy consumption for the brooders was given in Appendix D.

a) Total biogas consumption in three weeks of the brooding in biogas burner type brooder was 155 $m^3$

b) Total LPG energy used in the LPG brooder during the three weeks of brooding was 68.25 kg.

### 4.4. Cost economics for brooding and incubation

Based on the daily gas requirements for brooding operation, KVIC Biogas plant of 85 $m^3$ capacity was selected for the study.

Fixed Cost

| | | |
|---|---|---|
| **Cost of the biogas plant** | **=** | **Rs. 7, 25,000** |
| Salvage value | = | Rs. 72,500 |
| Life period | = | 20 years |
| Depreciation per year | = | Rs. 32,625 |
| Depreciation per day | = | Rs. 89.38 |
| Interest per year (12.5per cent ) | = | Rs. 90,625 |
| Interest per day | = | Rs. 248.29 |
| Land cost per year | = | Rs. 7,250 |
| Land cost per day | = | Rs. 19.86 |
| Total fixed cost per day | = | Rs. 109.24 |

**Variable cost**

| | | |
|---|---|---|
| Cost of feed stock per day (2250 kg) | = | Nil |
| Cost of water per year | = | Nil |
| Cost of water per day | = | Nil |
| Repair and maintenance | = | Rs.1,500/year = Rs. 4.10/day |
| Labour charge | = | 3000 per month = Rs. 100/day |
| Painting cost per year | = | Rs. 1500 |
| | = | Rs. 4.10/day |
| Total cost of operation per day | = | Fixed cost per day + Variable per day |
| | = | Rs. 465.73 |
| For 1 $m^3$ of biogas production cost | = | Rs. 465.73/85 = Rs. 5.48 |

**4.4.1. Biogas brooder**

**Fixed cost**

| | | |
|---|---|---|
| Cost of biogas brooder | = | Rs. 2000 |
| Salvage value | = | Rs. 200 |
| Life period | = | 7 year |
| Depreciation per year | = | Rs. 257 |
| Depreciation per day | = | 70 paise |
| Interest per year | = | Rs. 250 |
| Interest per day | = | 68 paise |
| Housing cost per year | = | Rs. 200 |
| Housing cost per day | = | 55 paise |
| Total fixed cost | = | Rs. 1.93/day |

**Variable cost**

| | | |
|---|---|---|
| Labour charge for 21 day of brooding | = | Rs. 400 |
| Labour charge per day | = | Rs. 19.05 |
| Cost of biogas consumption for brooding of 750 chicks in 21 days | = | 155 $m^3$ x 5.48 |
| | = | Rs. 849.40 = 40.45/day |
| Other cost | = | Rs. 50/21 days of brooding period |
| | = | Rs. 2.38/day |
| Total cost of operation per day in biogas brooder | = | Rs. 61.88 |
| Cost of brooding per chick | = | Rs. 1.73 |

**4.4.2. LPG brooder**

**Fixed Cost**

| | | |
|---|---|---|
| Cost of LPG brooder | = | Rs. 2700 |
| Salvage value | = | Rs. 270 |
| Life period | = | 7 year |
| Depreciation per year | = | Rs. 347 |
| Depreciation per day | = | 95 paise |
| Interest per year | = | Rs. 337.5 |
| Interest per day | = | 93 paise |
| Housing cost per year | = | Rs. 270 |
| Housing cost per day | = | 74 paise |
| Total fixed cost per day | = | Rs. 2.62 |

**Variable cost**

| | | |
|---|---|---|
| Labour charge per day | = | Rs. 23.81 |

| | | |
|---|---|---|
| LPG cost for 21 days of brooding | = | 68.25 kg x Rs. 26 per kg |
| | = | Rs. 1774.5 |
| LPG charge for brooding per day | = | Rs. 84.5 |
| Other cost | = | Rs. 60/21 days of brooding |
| | = | Rs. 2.86/day |
| Total variable cost | = | Rs. 111.17/day |
| Total cost of operation per day | = | Fixed cost + Variable cost |
| | = | Rs. 2.62 + Rs 111.17 |
| Total cost of operation per day | = | Rs. 113.79 |
| Cost of operation for brooding period | = | Rs. 2389 |
| Cost of brooding per chick | = | Rs. 3.20 |

### 4.5. Energy inflow and outflow of the Poultry Industry

The results of energy accounting study, the estimation of energy input in the poultry industry and the energy balancing done for the replacement of conventional energy with biogas are presented in this section.

#### 4.5.1. Energy accounting in the poultry industry

The energy input in the poultry industry could be broadly classified into the following three sections.

1. Hatchery Unit. ( 3 weeks incubation)
2. Brooding cum Growing Unit ( Till $17^{th}$ week)
3. Layering Unit( $18^{th}$ to $72^{nd}$ week)

#### 4.5.1.1. Hatchery Unit

The hatchery unit selected for the study has the capacity of hatching 5,38,128 eggs. The energy consumption for hatching is 29,952 kWh of electricity. Out of 5,38,128 eggs, the industry is having the capacity of maintaining 80,000 birds only till the layering section . The purpose of comparison study, the energy inflow and outflow was considered for 10,000 birds.

#### 4.5.1.2. Brooding cum Growing Unit

For the brooding and growing of 10,000 birds, the energy consumption is 600 kg of butane gas and 840 kWh of electricity. The total energy equivalent is 7344 kWh.

#### 4.5.1.3. Layering Unit

For layering of 10,000 birds, the energy consumption is estimated as 25,900 kWh for 55 weeks period.

### 4.5.2. Energy production potential from poultry waste

The waste available in the brooding cum growing unit and layering unit can be effectively utilized for biogas production.

#### 4.5.2.1. Brooding cum Growing unit

The quantity of waste generated from 10,000 birds during the brooding and growing period till 17$^{th}$ week has been estimated as 49 tonnes. The energy potential from this waste is estimated as 7,273 kWh. This is just sufficient to meet the energy demand for brooding and growing with the shortage of 71 kWh (7,344 – 7,273). The shortage is less than 1 per cent (0.97).

#### 4.5.2.2. Layering Unit

The quantity of waste generated from 10,000 birds during the layering period ($18^{th}$ to 72 week) has been estimated as 693 tonnes. The energy production potential from this waste is 91,160 kWh. This is more than the requirement of 25,900 kWh. The surplus energy is 65,260 kWh.

# *Summary and Conclusion*

# CHAPTER V

# SUMMARY AND CONCLUSIONS

In this chapter, the results of the experiments conducted with cowdung and poultry wastes in 39 different combinations and comparative performance evaluation of biogas brooder with the conventional liquefied petroleum gas (LPG) brooder are summarized and conclusions are drawn as follows.

- Among all the wastes, maximum total solid content was present in poultry deep litter as 89.32 per cent because of non combustible material along with bed material and the lowest total solid content was recorded in cowdung as 13.79 per cent.

- The lowest volatile solid content was present in poultry droppings as 10.60 per cent and the highest volatile solid content in poultry deep litter as 65.64 per cent among all the wastes.

- Among all the poultry waste combinations in the ratios of 1:1, 1:2 and 2:1 with 5, 10, and 15 per cent TS, the highest biogas yield from cowdung and poultry droppings ($T_{36}$) in 2:1 ratio with 15 per cent TS as 47273 ml. The biogas yield was also high in all the poultry droppings based material combinations.

- Among all the poultry waste combinations in the ratios of 1:1, 1:2 and 2:1 with 5, 10, and 15 per cent TS, the highest methane yield from cowdung and poultry droppings ($T_{30}$) in 2:1 ratio with 15 per cent TS as 27889 ml with average methane content of 65 per cent. The methane yield was also high in all the poultry droppings based material combinations.

- All the combination of feedstock had the initial methane content variation with the wide range of 15 to 94 per cent. The maximum average methane percentage was recorded as 76 per cent in the combination of poultry manure and cowdung in 1:1 ratio ($T_4$) with 5 per cent TS.

- The maximum methane produced as 0.1470 $m^3$ per kg of TS added and it was obtained in the combination of poultry droppings mixed with cowdung in 1:1 ratios ($T_{29}$) with 10 per cent TS. The lowest methane production was obtained as 0.0085 $m^3$ per kg of TS added from cowdung mixed with poultry deep litter in 1:1 ratio ($T_{17}$) with 10 per cent TS.

- Among all the combinations, the higher yield of methane observed from cowdung and poultry droppings mixed with 1:1 ratio ($T_{29}$) as 0.3182 $m^3$ per kg of VS added and lower yield of methane was observed in the combination of cowdung and poultry deep litter mixed with 1:1 ratio ($T_{17}$) as 0.0474 $m^3$ per kg of VS added.

Performance of the biogas brooder (hanging brooder type) was evaluated in terms of temperature distribution inside the brooder, light intensity from the heat source, energy consumption of biogas and LPG Brooder and cost of the brooding per chick. The performance was compared with an LPG brooder.

- Based on observations of temperature in the biogas burner type brooder for first week of brooding, the burner height of 75 cm from the ground level was found for safe brooding whereas for the second and third week of brooding, the burner height was found to be optimum at 100 cm from the ground level by adjusting the gas flow rate.

- Based on the observation of illumination measurements, the required light intensity of 58 lux was obtained (against requirement of 54 lux) on biogas brooder whereas insufficient illumination of 31 lux had only obtained in the case of LPG brooder.

- The energy consumption in biogas brooder was 155 $m^3$ for three weeks of brooding period, whereas the butane consumption was 68.25 kg in the case of LPG brooder.

- The energy demand of brooding and incubation for 10,000 birds was 600 kg of LPG and 560 kWh of electricity respectively and these can be fully eliminated by the biogas brooder which required 1,385 $m^3$ for brooding and 2,129 $m^3$ for incubation.

- In total, the energy production potential from poultry waste was 20952 $m^3$ of biogas against the requirement of 7,076 $m^3$ of biogas.

- The cost of operation per chick in the biogas (burner type) brooder was Rs. 1.73, whereas it was Rs. 3.20 in LPG brooder.

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# Appendix

## APPENDIX - A

Daily biogas production of 39 combinations of feedstock are given in the tables

**Treatment 1**
**Daily biogas production of cowdung as feedstock in 100 per cent with 5 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 230 | 100 | 165 | 46 | 190 | 30 | 110 |
| 2 | 100 | 50 | 75 | 47 | 100 | 10 | 55 |
| 3 | 25 | 25 | 25 | 48 | 120 | 30 | 75 |
| 4 | 30 | 20 | 25 | 49 | 120 | 20 | 70 |
| 5 | 0 | 0 | 0 | 50 | 180 | 20 | 100 |
| 6 | 20 | 50 | 35 | 51 | 120 | 20 | 70 |
| 7 | 50 | 0 | 25 | 52 | 100 | 10 | 55 |
| 8 | 40 | 10 | 25 | 53 | 10 | 160 | 85 |
| 9 | 70 | 20 | 45 | 54 | 80 | 20 | 50 |
| 10 | 0 | 0 | 0 | 55 | 120 | 40 | 80 |
| 11 | 40 | 10 | 25 | 56 | 160 | 10 | 85 |
| 12 | 0 | 20 | 10 | 57 | 130 | 30 | 80 |
| 13 | 0 | 0 | 0 | 58 | 200 | 20 | 110 |
| 14 | 0 | 0 | 0 | 59 | 230 | 40 | 135 |
| 15 | 0 | 0 | 0 | 60 | 60 | 10 | 35 |
| 16 | 0 | 0 | 0 | 61 | 80 | 60 | 70 |
| 17 | 20 | 10 | 15 | 62 | 20 | 10 | 15 |
| 18 | 10 | 20 | 15 | 63 | 220 | 40 | 130 |
| 19 | 0 | 10 | 5 | 64 | 100 | 0 | 50 |
| 20 | 0 | 0 | 0 | 65 | 180 | 0 | 90 |
| 21 | 10 | 10 | 10 | 66 | 400 | 60 | 230 |
| 22 | 10 | 10 | 10 | 67 | 380 | 70 | 225 |
| 23 | 0 | 0 | 0 | 68 | 90 | 0 | 45 |
| 24 | 20 | 10 | 15 | 69 | 70 | 0 | 35 |
| 25 | 20 | 10 | 15 | 70 | 80 | 0 | 40 |
| 26 | 20 | 10 | 15 | 71 | 290 | 10 | 150 |
| 27 | 0 | 10 | 5 | 72 | 270 | 10 | 140 |
| 28 | 10 | 10 | 10 | 73 | 400 | 25 | 212.5 |
| 29 | 20 | 20 | 20 | 74 | 300 | 20 | 160 |
| 30 | 10 | 20 | 15 | 75 | 40 | 40 | 40 |
| 31 | 10 | 10 | 10 | 76 | 20 | 20 | 20 |
| 32 | 30 | 30 | 30 | 77 | 100 | 20 | 60 |
| 33 | 30 | 30 | 30 | 78 | 100 | 30 | 65 |
| 34 | 30 | 30 | 30 | 79 | 100 | 20 | 60 |
| 35 | 10 | 10 | 10 | 80 | 30 | 20 | 25 |
| 36 | 120 | 30 | 75 | 81 | 60 | 20 | 40 |
| 37 | 310 | 20 | 165 | 82 | 40 | 30 | 35 |
| 38 | 360 | 70 | 215 | 83 | 10 | 0 | 5 |
| 39 | 130 | 30 | 80 | 84 | 0 | 0 | 0 |
| 40 | 340 | 80 | 210 | 85 | 0 | 0 | 0 |
| 41 | 350 | 40 | 195 | 86 | 30 | 20 | 25 |
| 42 | 200 | 20 | 110 | 87 | 20 | 20 | 20 |
| 43 | 280 | 120 | 200 | 88 | 30 | 40 | 35 |
| 44 | 300 | 60 | 180 | 89 | 50 | 60 | 55 |
| 45 | 170 | 20 | 95 | 90 | 10 | 20 | 15 |

**Treatment 2**
**Daily biogas production of cowdung as feedstock in 100 per cent with 10 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 310 | 650 | 480 | 46 | 10 | 100 | 55 |
| 2 | 130 | 100 | 115 | 47 | 10 | 200 | 105 |
| 3 | 110 | 40 | 75 | 48 | 10 | 170 | 90 |
| 4 | 110 | 70 | 90 | 49 | 0 | 210 | 105 |
| 5 | 0 | 0 | 0 | 50 | 0 | 280 | 140 |
| 6 | 0 | 10 | 5 | 51 | 10 | 300 | 155 |
| 7 | 90 | 150 | 120 | 52 | 20 | 150 | 85 |
| 8 | 90 | 80 | 85 | 53 | 0 | 200 | 100 |
| 9 | 65 | 50 | 57.5 | 54 | 0 | 120 | 60 |
| 10 | 0 | 0 | 0 | 55 | 0 | 120 | 60 |
| 11 | 50 | 30 | 40 | 56 | 10 | 170 | 90 |
| 12 | 0 | 0 | 0 | 57 | 0 | 80 | 40 |
| 13 | 0 | 0 | 0 | 58 | 60 | 220 | 140 |
| 14 | 0 | 0 | 0 | 59 | 40 | 300 | 170 |
| 15 | 0 | 0 | 0 | 60 | 0 | 130 | 65 |
| 16 | 0 | 0 | 0 | 61 | 0 | 200 | 100 |
| 17 | 10 | 10 | 10 | 62 | 0 | 150 | 75 |
| 18 | 35 | 10 | 22.5 | 63 | 20 | 100 | 60 |
| 19 | 10 | 10 | 10 | 64 | 0 | 60 | 30 |
| 20 | 0 | 0 | 0 | 65 | 10 | 80 | 45 |
| 21 | 10 | 20 | 15 | 66 | 70 | 260 | 165 |
| 22 | 20 | 10 | 15 | 67 | 80 | 290 | 185 |
| 23 | 0 | 5 | 2.5 | 68 | 0 | 80 | 40 |
| 24 | 30 | 20 | 25 | 69 | 0 | 80 | 40 |
| 25 | 20 | 20 | 20 | 70 | 0 | 60 | 30 |
| 26 | 20 | 20 | 20 | 71 | 10 | 70 | 40 |
| 27 | 10 | 0 | 5 | 72 | 20 | 280 | 150 |
| 28 | 10 | 0 | 5 | 73 | 30 | 250 | 140 |
| 29 | 10 | 20 | 15 | 74 | 20 | 340 | 180 |
| 30 | 0 | 0 | 0 | 75 | 0 | 480 | 240 |
| 31 | 0 | 10 | 5 | 76 | 0 | 360 | 180 |
| 32 | 10 | 10 | 10 | 77 | 20 | 480 | 250 |
| 33 | 0 | 0 | 0 | 78 | 0 | 460 | 230 |
| 34 | 10 | 10 | 10 | 79 | 30 | 430 | 230 |
| 35 | 0 | 0 | 0 | 80 | 0 | 440 | 220 |
| 36 | 20 | 30 | 25 | 81 | 0 | 530 | 265 |
| 37 | 40 | 70 | 55 | 82 | 0 | 300 | 150 |
| 38 | 40 | 60 | 50 | 83 | 20 | 200 | 110 |
| 39 | 0 | 0 | 0 | 84 | 40 | 180 | 110 |
| 40 | 10 | 30 | 20 | 85 | 10 | 100 | 55 |
| 41 | 0 | 30 | 15 | 86 | 20 | 400 | 210 |
| 42 | 0 | 10 | 5 | 87 | 10 | 360 | 185 |
| 43 | 30 | 10 | 20 | 88 | 20 | 400 | 210 |
| 44 | 20 | 120 | 70 | 89 | 30 | 420 | 225 |
| 45 | 20 | 120 | 70 | 90 | 20 | 120 | 70 |

**Treatment 3**
**Daily biogas production of cowdung as feedstock in 100 per cent with 15 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 270 | 300 | 285 | 46 | 230 | 330 | 280 |
| 2 | 140 | 160 | 150 | 47 | 210 | 200 | 205 |
| 3 | 90 | 70 | 80 | 48 | 300 | 110 | 205 |
| 4 | 100 | 75 | 87.5 | 49 | 320 | 260 | 290 |
| 5 | 0 | 0 | 0 | 50 | 330 | 220 | 275 |
| 6 | 150 | 70 | 110 | 51 | 450 | 60 | 255 |
| 7 | 100 | 200 | 150 | 52 | 340 | 300 | 320 |
| 8 | 80 | 160 | 120 | 53 | 630 | 300 | 465 |
| 9 | 90 | 110 | 100 | 54 | 650 | 350 | 500 |
| 10 | 0 | 0 | 0 | 55 | 600 | 420 | 510 |
| 11 | 30 | 50 | 40 | 56 | 500 | 220 | 360 |
| 12 | 0 | 0 | 0 | 57 | 290 | 360 | 325 |
| 13 | 0 | 0 | 0 | 58 | 430 | 250 | 340 |
| 14 | 0 | 10 | 5 | 59 | 240 | 430 | 335 |
| 15 | 0 | 0 | 0 | 60 | 90 | 90 | 90 |
| 16 | 0 | 20 | 10 | 61 | 200 | 180 | 190 |
| 17 | 10 | 20 | 15 | 62 | 120 | 100 | 110 |
| 18 | 30 | 30 | 30 | 63 | 200 | 200 | 200 |
| 19 | 0 | 20 | 10 | 64 | 0 | 0 | 0 |
| 20 | 0 | 0 | 0 | 65 | 30 | 20 | 25 |
| 21 | 10 | 10 | 10 | 66 | 380 | 480 | 430 |
| 22 | 20 | 20 | 20 | 67 | 350 | 470 | 410 |
| 23 | 0 | 10 | 5 | 68 | 120 | 80 | 100 |
| 24 | 20 | 30 | 25 | 69 | 80 | 70 | 75 |
| 25 | 30 | 20 | 25 | 70 | 70 | 70 | 70 |
| 26 | 10 | 30 | 20 | 71 | 350 | 0 | 175 |
| 27 | 0 | 0 | 0 | 72 | 320 | 0 | 160 |
| 28 | 10 | 10 | 10 | 73 | 510 | 0 | 255 |
| 29 | 30 | 30 | 30 | 74 | 310 | 10 | 160 |
| 30 | 0 | 10 | 5 | 75 | 600 | 400 | 500 |
| 31 | 0 | 0 | 0 | 76 | 60 | 450 | 255 |
| 32 | 30 | 30 | 30 | 77 | 150 | 540 | 345 |
| 33 | 0 | 10 | 5 | 78 | 140 | 600 | 370 |
| 34 | 40 | 40 | 40 | 79 | 120 | 560 | 340 |
| 35 | 40 | 20 | 30 | 80 | 120 | 520 | 320 |
| 36 | 90 | 100 | 95 | 81 | 200 | 670 | 435 |
| 37 | 110 | 60 | 85 | 82 | 250 | 520 | 385 |
| 38 | 110 | 250 | 180 | 83 | 190 | 350 | 270 |
| 39 | 30 | 40 | 35 | 84 | 200 | 380 | 290 |
| 40 | 200 | 240 | 220 | 85 | 100 | 200 | 150 |
| 41 | 270 | 270 | 270 | 86 | 350 | 250 | 300 |
| 42 | 130 | 130 | 130 | 87 | 360 | 270 | 315 |
| 43 | 150 | 130 | 140 | 88 | 390 | 340 | 365 |
| 44 | 520 | 640 | 580 | 89 | 370 | 350 | 360 |
| 45 | 270 | 340 | 305 | 90 | 150 | 300 | 225 |

**Treatment 4**
**Daily biogas production of cowdung and poultry manure as feedstock in 1:1 ratio with 5 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 25 | 10 | 17.5 | 46 | 10 | 25 | 17.5 |
| 2 | 0 | 0 | 0 | 47 | 0 | 20 | 10 |
| 3 | 0 | 0 | 0 | 48 | 20 | 50 | 35 |
| 4 | 30 | 30 | 30 | 49 | 0 | 10 | 5 |
| 5 | 0 | 10 | 5 | 50 | 10 | 20 | 15 |
| 6 | 0 | 0 | 0 | 51 | 30 | 70 | 50 |
| 7 | 10 | 10 | 10 | 52 | 20 | 20 | 20 |
| 8 | 50 | 30 | 40 | 53 | 10 | 0 | 5 |
| 9 | 65 | 55 | 60 | 54 | 0 | 10 | 5 |
| 10 | 0 | 0 | 0 | 55 | 0 | 20 | 10 |
| 11 | 10 | 10 | 10 | 56 | 0 | 10 | 5 |
| 12 | 0 | 60 | 30 | 57 | 0 | 0 | 0 |
| 13 | 30 | 10 | 20 | 58 | 0 | 0 | 0 |
| 14 | 20 | 10 | 15 | 59 | 10 | 10 | 10 |
| 15 | 20 | 30 | 25 | 60 | 0 | 0 | 0 |
| 16 | 35 | 15 | 25 | 61 | 0 | 0 | 0 |
| 17 | 30 | 30 | 30 | 62 | 0 | 0 | 0 |
| 18 | 60 | 150 | 105 | 63 | 260 | 20 | 140 |
| 19 | 50 | 120 | 85 | 64 | 0 | 0 | 0 |
| 20 | 40 | 60 | 50 | 65 | 0 | 0 | 0 |
| 21 | 40 | 30 | 35 | 66 | 10 | 20 | 15 |
| 22 | 40 | 50 | 45 | 67 | 0 | 20 | 10 |
| 23 | 30 | 40 | 35 | 68 | 0 | 0 | 0 |
| 24 | 50 | 80 | 65 | 69 | 0 | 0 | 0 |
| 25 | 40 | 70 | 55 | 70 | 20 | 10 | 15 |
| 26 | 40 | 60 | 50 | 71 | 0 | 0 | 0 |
| 27 | 10 | 20 | 15 | 72 | 0 | 0 | 0 |
| 28 | 30 | 40 | 35 | 73 | 0 | 0 | 0 |
| 29 | 50 | 40 | 45 | 74 | 0 | 0 | 0 |
| 30 | 10 | 10 | 10 | 75 | 0 | 0 | 0 |
| 31 | 20 | 0 | 10 | | | | |
| 32 | 30 | 40 | 35 | | | | |
| 33 | 50 | 20 | 35 | | | | |
| 34 | 40 | 50 | 45 | | | | |
| 35 | 20 | 50 | 35 | | | | |
| 36 | 50 | 100 | 75 | | | | |
| 37 | 90 | 70 | 80 | | | | |
| 38 | 100 | 80 | 90 | | | | |
| 39 | 40 | 20 | 30 | | | | |
| 40 | 60 | 50 | 55 | | | | |
| 41 | 10 | 20 | 15 | | | | |
| 42 | 0 | 0 | 0 | | | | |
| 43 | 60 | 40 | 50 | | | | |
| 44 | 40 | 40 | 40 | | | | |
| 45 | 10 | 20 | 15 | | | | |

**Treatment 5**

**Daily biogas production of cowdung and poultry manure as feedstock in 1:1 ratio with 10 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 20 | 30 | 25 | 46 | 40 | 30 | 35 |
| 2 | 0 | 0 | 0 | 47 | 30 | 30 | 30 |
| 3 | 0 | 0 | 0 | 48 | 40 | 60 | 50 |
| 4 | 10 | 20 | 15 | 49 | 20 | 40 | 30 |
| 5 | 0 | 0 | 0 | 50 | 40 | 50 | 45 |
| 6 | 40 | 20 | 30 | 51 | 60 | 120 | 90 |
| 7 | 100 | 80 | 90 | 52 | 20 | 50 | 35 |
| 8 | 40 | 70 | 55 | 53 | 50 | 50 | 50 |
| 9 | 70 | 80 | 75 | 54 | 30 | 10 | 20 |
| 10 | 0 | 0 | 0 | 55 | 30 | 30 | 30 |
| 11 | 50 | 50 | 50 | 56 | 30 | 30 | 30 |
| 12 | 50 | 100 | 75 | 57 | 20 | 30 | 25 |
| 13 | 60 | 60 | 60 | 58 | 70 | 50 | 60 |
| 14 | 100 | 50 | 75 | 59 | 100 | 100 | 100 |
| 15 | 20 | 30 | 25 | 60 | 0 | 0 | 0 |
| 16 | 40 | 50 | 45 | 61 | 30 | 40 | 35 |
| 17 | 30 | 40 | 35 | 62 | 10 | 10 | 10 |
| 18 | 40 | 90 | 65 | 63 | 0 | 0 | 0 |
| 19 | 50 | 100 | 75 | 64 | 50 | 40 | 45 |
| 20 | 60 | 40 | 50 | 65 | 0 | 0 | 0 |
| 21 | 160 | 150 | 155 | 66 | 60 | 80 | 70 |
| 22 | 90 | 120 | 105 | 67 | 50 | 90 | 70 |
| 23 | 130 | 40 | 85 | 68 | 0 | 0 | 0 |
| 24 | 120 | 110 | 115 | 69 | 0 | 0 | 0 |
| 25 | 90 | 100 | 95 | 70 | 0 | 0 | 0 |
| 26 | 60 | 110 | 85 | 71 | 10 | 20 | 15 |
| 27 | 100 | 90 | 95 | 72 | 10 | 20 | 15 |
| 28 | 140 | 120 | 130 | 73 | 0 | 0 | 0 |
| 29 | 180 | 180 | 180 | 74 | 0 | 0 | 0 |
| 30 | 140 | 130 | 135 | 75 | 0 | 0 | 0 |
| 31 | 100 | 110 | 105 | 76 | 10 | 10 | 10 |
| 32 | 100 | 210 | 155 | 77 | 5 | 5 | 5 |
| 33 | 110 | 120 | 115 | 78 | 0 | 0 | 0 |
| 34 | 160 | 160 | 160 | 79 | 0 | 0 | 0 |
| 35 | 100 | 100 | 100 | 80 | 0 | 0 | 0 |
| 36 | 150 | 250 | 200 | | | | |
| 37 | 70 | 200 | 135 | | | | |
| 38 | 110 | 100 | 105 | | | | |
| 39 | 20 | 10 | 15 | | | | |
| 40 | 150 | 140 | 145 | | | | |
| 41 | 40 | 60 | 50 | | | | |
| 42 | 10 | 20 | 15 | | | | |
| 43 | 30 | 250 | 140 | | | | |
| 44 | 140 | 130 | 135 | | | | |
| 45 | 20 | 50 | 35 | | | | |

**Treatment 6**

**Daily biogas production of cowdung and poultry manure as feedstock in 1:1 ratio with 15 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 50 | 30 | 40 | 46 | 140 | 180 | 160 |
| 2 | 50 | 10 | 30 | 47 | 160 | 100 | 130 |
| 3 | 0 | 0 | 0 | 48 | 70 | 120 | 95 |
| 4 | 40 | 40 | 40 | 49 | 130 | 120 | 125 |
| 5 | 0 | 0 | 0 | 50 | 160 | 80 | 120 |
| 6 | 60 | 100 | 80 | 51 | 140 | 280 | 210 |
| 7 | 90 | 125 | 107.5 | 52 | 120 | 200 | 160 |
| 8 | 30 | 30 | 30 | 53 | 80 | 80 | 80 |
| 9 | 70 | 80 | 75 | 54 | 70 | 40 | 55 |
| 10 | 0 | 0 | 0 | 55 | 80 | 60 | 70 |
| 11 | 60 | 80 | 70 | 56 | 90 | 80 | 85 |
| 12 | 30 | 120 | 75 | 57 | 60 | 60 | 60 |
| 13 | 20 | 20 | 20 | 58 | 110 | 140 | 125 |
| 14 | 60 | 50 | 55 | 59 | 150 | 150 | 150 |
| 15 | 45 | 40 | 42.5 | 60 | 0 | 0 | 0 |
| 16 | 30 | 10 | 20 | 61 | 80 | 50 | 65 |
| 17 | 50 | 60 | 55 | 62 | 10 | 10 | 10 |
| 18 | 70 | 170 | 120 | 63 | 110 | 60 | 85 |
| 19 | 110 | 180 | 145 | 64 | 50 | 40 | 45 |
| 20 | 130 | 230 | 180 | 65 | 30 | 30 | 30 |
| 21 | 160 | 170 | 165 | 66 | 150 | 130 | 140 |
| 22 | 240 | 420 | 330 | 67 | 170 | 140 | 155 |
| 23 | 250 | 420 | 335 | 68 | 20 | 60 | 40 |
| 24 | 360 | 440 | 400 | 69 | 10 | 40 | 25 |
| 25 | 380 | 400 | 390 | 70 | 20 | 40 | 30 |
| 26 | 380 | 400 | 390 | 71 | 50 | 100 | 75 |
| 27 | 130 | 110 | 120 | 72 | 40 | 90 | 65 |
| 28 | 300 | 210 | 255 | 73 | 85 | 180 | 132.5 |
| 29 | 370 | 270 | 320 | 74 | 40 | 100 | 70 |
| 30 | 290 | 250 | 270 | 75 | 50 | 50 | 50 |
| 31 | 200 | 190 | 195 | 76 | 40 | 40 | 40 |
| 32 | 200 | 270 | 235 | 77 | 50 | 50 | 50 |
| 33 | 200 | 230 | 215 | 78 | 40 | 60 | 50 |
| 34 | 260 | 310 | 285 | 79 | 50 | 50 | 50 |
| 35 | 200 | 270 | 235 | 80 | 40 | 50 | 45 |
| 36 | 550 | 200 | 375 | 81 | 60 | 80 | 70 |
| 37 | 500 | 330 | 415 | 82 | 20 | 30 | 25 |
| 38 | 380 | 260 | 320 | 83 | 0 | 0 | 0 |
| 39 | 100 | 50 | 75 | 84 | 0 | 0 | 0 |
| 40 | 380 | 220 | 300 | 85 | 0 | 0 | 15 |
| 41 | 260 | 140 | 200 | 86 | 30 | 30 | 0 |
| 42 | 160 | 50 | 105 | 87 | 30 | 40 | 0 |
| 43 | 180 | 150 | 165 | 88 | 50 | 50 | 0 |
| 44 | 180 | 210 | 195 | 89 | 60 | 50 | 0 |
| 45 | 160 | 80 | 120 | 90 | 40 | 30 | 0 |

**Treatment 7**
**Daily biogas production of cowdung and poultry manure as feedstock in 1:1 ratio with 20 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 60 | 85 | 72.5 | 46 | 320 | 320 | 320 |
| 2 | 30 | 50 | 40 | 47 | 0 | 320 | 160 |
| 3 | 0 | 15 | 7.5 | 48 | 200 | 180 | 190 |
| 4 | 60 | 80 | 70 | 49 | 160 | 260 | 210 |
| 5 | 0 | 0 | 0 | 50 | 140 | 140 | 140 |
| 6 | 0 | 10 | 5 | 51 | 110 | 150 | 130 |
| 7 | 200 | 170 | 185 | 52 | 130 | 100 | 115 |
| 8 | 0 | 110 | 55 | 53 | 130 | 120 | 125 |
| 9 | 100 | 120 | 110 | 54 | 60 | 80 | 70 |
| 10 | 10 | 0 | 5 | 55 | 60 | 90 | 75 |
| 11 | 110 | 120 | 115 | 56 | 120 | 100 | 110 |
| 12 | 110 | 40 | 75 | 57 | 60 | 110 | 85 |
| 13 | 10 | 10 | 10 | 58 | 170 | 170 | 170 |
| 14 | 50 | 40 | 45 | 59 | 300 | 280 | 290 |
| 15 | 40 | 30 | 35 | 60 | 0 | 0 | 0 |
| 16 | 20 | 40 | 30 | 61 | 110 | 120 | 115 |
| 17 | 70 | 80 | 75 | 62 | 50 | 30 | 40 |
| 18 | 100 | 40 | 70 | 63 | 130 | 150 | 140 |
| 19 | 140 | 50 | 95 | 64 | 10 | 40 | 25 |
| 20 | 140 | 60 | 100 | 65 | 40 | 30 | 35 |
| 21 | 190 | 130 | 160 | 66 | 250 | 130 | 190 |
| 22 | 260 | 140 | 200 | 67 | 240 | 140 | 190 |
| 23 | 350 | 100 | 225 | 68 | 30 | 80 | 55 |
| 24 | 400 | 120 | 260 | 69 | 10 | 60 | 35 |
| 25 | 410 | 170 | 290 | 70 | 10 | 40 | 25 |
| 26 | 500 | 50 | 275 | 71 | 170 | 180 | 175 |
| 27 | 540 | 10 | 275 | 72 | 150 | 160 | 155 |
| 28 | 370 | 320 | 345 | 73 | 280 | 310 | 295 |
| 29 | 680 | 450 | 565 | 74 | 140 | 160 | 150 |
| 30 | 450 | 420 | 435 | 75 | 80 | 160 | 120 |
| 31 | 300 | 280 | 290 | 76 | 40 | 110 | 75 |
| 32 | 410 | 490 | 450 | 77 | 90 | 110 | 100 |
| 33 | 400 | 460 | 430 | 78 | 80 | 100 | 90 |
| 34 | 550 | 580 | 565 | 79 | 70 | 110 | 90 |
| 35 | 380 | 430 | 405 | 80 | 50 | 80 | 65 |
| 36 | 950 | 770 | 860 | 81 | 100 | 100 | 100 |
| 37 | 740 | 700 | 720 | 82 | 60 | 80 | 70 |
| 38 | 570 | 540 | 555 | 83 | 20 | 20 | 20 |
| 39 | 280 | 220 | 250 | 84 | 10 | 10 | 20 |
| 40 | 580 | 740 | 660 | 85 | 0 | 0 | 10 |
| 41 | 440 | 440 | 440 | 86 | 100 | 100 | 0 |
| 42 | 450 | 330 | 390 | 87 | 100 | 110 | 100 |
| 43 | 420 | 390 | 405 | 88 | 100 | 120 | 105 |
| 44 | 300 | 160 | 230 | 89 | 120 | 140 | 110 |
| 45 | 410 | 360 | 385 | 90 | 100 | 110 | 130 |

**Treatment 8**
**Daily biogas production of cowdung and poultry manure as feedstock in 1:2 ratio with 5 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 65 | 35 | 50 | 46 | 210 | 240 | 225 |
| 2 | 0 | 0 | 0 | 47 | 10 | 0 | 5 |
| 3 | 0 | 0 | 0 | 48 | 0 | 0 | 0 |
| 4 | 10 | 10 | 10 | 49 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 50 | 0 | 10 | 5 |
| 6 | 0 | 0 | 0 | 51 | 10 | 0 | 5 |
| 7 | 5 | 5 | 5 | 52 | 0 | 10 | 5 |
| 8 | 10 | 10 | 10 | 53 | 0 | 0 | 0 |
| 9 | 70 | 60 | 65 | 54 | 0 | 10 | 5 |
| 10 | 0 | 0 | 0 | 55 | 0 | 0 | 0 |
| 11 | 20 | 20 | 20 | 56 | 0 | 10 | 5 |
| 12 | 0 | 0 | 0 | 57 | 0 | 0 | 0 |
| 13 | 0 | 0 | 0 | 58 | 0 | 0 | 0 |
| 14 | 0 | 0 | 0 | 59 | 10 | 10 | 10 |
| 15 | 10 | 0 | 5 | 60 | 0 | 0 | 0 |
| 16 | 0 | 0 | 0 | 61 | 0 | 0 | 0 |
| 17 | 10 | 20 | 15 | 62 | 0 | 0 | 0 |
| 18 | 20 | 30 | 25 | 63 | 0 | 0 | 0 |
| 19 | 0 | 10 | 5 | 64 | 0 | 0 | 0 |
| 20 | 0 | 0 | 0 | 65 | 50 | 20 | 35 |
| 21 | 20 | 30 | 25 | 66 | 0 | 0 | 0 |
| 22 | 10 | 20 | 15 | 67 | 0 | 0 | 0 |
| 23 | 10 | 10 | 10 | 68 | 0 | 0 | 0 |
| 24 | 10 | 20 | 15 | 69 | 0 | 0 | 0 |
| 25 | 10 | 20 | 15 | 70 | 0 | 0 | 0 |
| 26 | 20 | 30 | 25 | 71 | 0 | 0 | 0 |
| 27 | 0 | 0 | 0 | 72 | 0 | 0 | 0 |
| 28 | 10 | 0 | 5 | | | | |
| 29 | 30 | 30 | 30 | | | | |
| 30 | 0 | 10 | 5 | | | | |
| 31 | 10 | 5 | 7.5 | | | | |
| 32 | 20 | 20 | 20 | | | | |
| 33 | 0 | 0 | 0 | | | | |
| 34 | 10 | 20 | 15 | | | | |
| 35 | 0 | 0 | 0 | | | | |
| 36 | 30 | 30 | 30 | | | | |
| 37 | 50 | 60 | 55 | | | | |
| 38 | 40 | 20 | 30 | | | | |
| 39 | 10 | 10 | 10 | | | | |
| 40 | 10 | 20 | 15 | | | | |
| 41 | 0 | 0 | 0 | | | | |
| 42 | 0 | 0 | 0 | | | | |
| 43 | 10 | 20 | 15 | | | | |
| 44 | 520 | 540 | 530 | | | | |
| 45 | 320 | 310 | 315 | | | | |

**Treatment 9**

**Daily biogas production of cowdung and poultry manure as feedstock in 1:2 ratio with 10 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 40 | 30 | 35 | 46 | 30 | 20 | 25 |
| 2 | 0 | 0 | 0 | 47 | 10 | 10 | 10 |
| 3 | 0 | 0 | 0 | 48 | 20 | 40 | 30 |
| 4 | 10 | 10 | 10 | 49 | 10 | 10 | 10 |
| 5 | 0 | 0 | 0 | 50 | 10 | 20 | 15 |
| 6 | 140 | 60 | 100 | 51 | 20 | 30 | 25 |
| 7 | 30 | 30 | 30 | 52 | 10 | 0 | 5 |
| 8 | 10 | 10 | 10 | 53 | 10 | 30 | 20 |
| 9 | 60 | 50 | 55 | 54 | 10 | 10 | 10 |
| 10 | 0 | 0 | 0 | 55 | 10 | 20 | 15 |
| 11 | 60 | 60 | 60 | 56 | 10 | 10 | 10 |
| 12 | 0 | 0 | 0 | 57 | 10 | 10 | 10 |
| 13 | 0 | 5 | 2.5 | 58 | 60 | 40 | 50 |
| 14 | 20 | 40 | 30 | 59 | 100 | 70 | 85 |
| 15 | 40 | 20 | 30 | 60 | 20 | 20 | 20 |
| 16 | 0 | 10 | 5 | 61 | 10 | 20 | 15 |
| 17 | 50 | 30 | 40 | 62 | 0 | 0 | 0 |
| 18 | 60 | 60 | 60 | 63 | 20 | 20 | 20 |
| 19 | 60 | 50 | 55 | 64 | 0 | 0 | 0 |
| 20 | 50 | 10 | 30 | 65 | 0 | 0 | 0 |
| 21 | 90 | 120 | 105 | 66 | 60 | 60 | 60 |
| 22 | 95 | 100 | 97.5 | 67 | 60 | 70 | 65 |
| 23 | 60 | 50 | 55 | 68 | 0 | 0 | 0 |
| 24 | 100 | 100 | 100 | 69 | 0 | 0 | 0 |
| 25 | 100 | 120 | 110 | 70 | 0 | 0 | 0 |
| 26 | 90 | 80 | 85 | 71 | 30 | 10 | 20 |
| 27 | 40 | 30 | 35 | 72 | 40 | 20 | 30 |
| 28 | 70 | 70 | 70 | 73 | 50 | 20 | 35 |
| 29 | 90 | 100 | 95 | 74 | 40 | 30 | 35 |
| 30 | 40 | 40 | 40 | 75 | 0 | 20 | 10 |
| 31 | 50 | 20 | 35 | 76 | 0 | 0 | 0 |
| 32 | 50 | 40 | 45 | 77 | 0 | 10 | 5 |
| 33 | 20 | 40 | 30 | 78 | 0 | 0 | 0 |
| 34 | 50 | 60 | 55 | 79 | 0 | 0 | 0 |
| 35 | 30 | 40 | 35 | 80 | 0 | 0 | 0 |
| 36 | 120 | 40 | 80 | | | | |
| 37 | 80 | 140 | 110 | | | | |
| 38 | 30 | 100 | 65 | | | | |
| 39 | 0 | 0 | 0 | | | | |
| 40 | 40 | 40 | 40 | | | | |
| 41 | 0 | 10 | 5 | | | | |
| 42 | 0 | 0 | 0 | | | | |
| 43 | 40 | 30 | 35 | | | | |
| 44 | 30 | 20 | 25 | | | | |
| 45 | 10 | 20 | 15 | | | | |

**Treatment 10**
**Daily biogas production of cowdung and poultry manure as feedstock in 1:2 ratio with 15 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 50 | 80 | 65 | 46 | 80 | 120 | 100 |
| 2 | 10 | 1130 | 570 | 47 | 100 | 130 | 115 |
| 3 | 0 | 610 | 305 | 48 | 10 | 440 | 225 |
| 4 | 120 | 130 | 125 | 49 | 10 | 440 | 225 |
| 5 | 130 | 570 | 350 | 50 | 40 | 230 | 135 |
| 6 | 0 | 20 | 10 | 51 | 40 | 520 | 280 |
| 7 | 0 | 550 | 275 | 52 | 40 | 400 | 220 |
| 8 | 0 | 350 | 175 | 53 | 20 | 350 | 185 |
| 9 | 100 | 140 | 120 | 54 | 30 | 370 | 200 |
| 10 | 30 | 160 | 95 | 55 | 30 | 360 | 195 |
| 11 | 100 | 240 | 170 | 56 | 10 | 380 | 195 |
| 12 | 40 | 310 | 175 | 57 | 20 | 310 | 165 |
| 13 | 100 | 80 | 90 | 58 | 60 | 360 | 210 |
| 14 | 150 | 70 | 110 | 59 | 110 | 460 | 285 |
| 15 | 20 | 60 | 40 | 60 | 0 | 0 | 0 |
| 16 | 60 | 70 | 65 | 61 | 20 | 250 | 135 |
| 17 | 80 | 100 | 90 | 62 | 10 | 80 | 45 |
| 18 | 100 | 90 | 95 | 63 | 70 | 250 | 160 |
| 19 | 90 | 110 | 100 | 64 | 0 | 150 | 75 |
| 20 | 75 | 75 | 75 | 65 | 10 | 100 | 55 |
| 21 | 120 | 110 | 115 | 66 | 20 | 80 | 50 |
| 22 | 140 | 120 | 130 | 67 | 10 | 70 | 40 |
| 23 | 120 | 70 | 95 | 68 | 10 | 180 | 95 |
| 24 | 200 | 220 | 210 | 69 | 10 | 110 | 60 |
| 25 | 210 | 230 | 220 | 70 | 20 | 100 | 60 |
| 26 | 210 | 10 | 110 | 71 | 40 | 250 | 145 |
| 27 | 110 | 80 | 95 | 72 | 60 | 260 | 160 |
| 28 | 160 | 110 | 135 | 73 | 65 | 460 | 262.5 |
| 29 | 230 | 200 | 215 | 74 | 60 | 220 | 140 |
| 30 | 170 | 140 | 155 | 75 | 20 | 140 | 80 |
| 31 | 180 | 80 | 130 | 76 | 10 | 220 | 115 |
| 32 | 130 | 130 | 130 | 77 | 20 | 200 | 110 |
| 33 | 50 | 30 | 40 | 78 | 20 | 180 | 100 |
| 34 | 100 | 90 | 95 | 79 | 10 | 140 | 75 |
| 35 | 120 | 170 | 145 | 80 | 0 | 140 | 70 |
| 36 | 280 | 410 | 345 | 81 | 20 | 140 | 80 |
| 37 | 230 | 330 | 280 | 82 | 160 | 100 | 130 |
| 38 | 190 | 310 | 250 | 83 | 20 | 20 | 20 |
| 39 | 0 | 80 | 40 | 84 | 20 | 10 | 15 |
| 40 | 130 | 290 | 210 | 85 | 10 | 0 | 5 |
| 41 | 60 | 250 | 155 | 86 | 30 | 90 | 60 |
| 42 | 20 | 190 | 105 | 87 | 20 | 100 | 60 |
| 43 | 80 | 360 | 220 | 88 | 40 | 120 | 80 |
| 44 | 70 | 40 | 55 | 89 | 50 | 100 | 75 |
| 45 | 40 | 120 | 80 | 90 | 60 | 80 | 70 |

Treatment 11

**Daily biogas production of cowdung and poultry manure as feedstock in 1:2 ratio with 20 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 30 | 10 | 20 | 46 | 70 | 70 | 70 |
| 2 | 0 | 0 | 0 | 47 | 90 | 100 | 95 |
| 3 | 0 | 0 | 0 | 48 | 100 | 100 | 100 |
| 4 | 0 | 0 | 0 | 49 | 20 | 60 | 40 |
| 5 | 0 | 15 | 7.5 | 50 | 70 | 90 | 80 |
| 6 | 10 | 0 | 5 | 51 | 30 | 110 | 70 |
| 7 | 65 | 25 | 45 | 52 | 50 | 60 | 55 |
| 8 | 50 | 60 | 55 | 53 | 60 | 70 | 65 |
| 9 | 70 | 20 | 45 | 54 | 30 | 50 | 40 |
| 10 | 20 | 20 | 20 | 55 | 30 | 30 | 30 |
| 11 | 70 | 130 | 100 | 56 | 0 | 40 | 20 |
| 12 | 50 | 40 | 45 | 57 | 50 | 60 | 55 |
| 13 | 10 | 20 | 15 | 58 | 120 | 100 | 110 |
| 14 | 40 | 50 | 45 | 59 | 110 | 150 | 130 |
| 15 | 30 | 15 | 22.5 | 60 | 0 | 0 | 0 |
| 16 | 30 | 10 | 20 | 61 | 40 | 20 | 30 |
| 17 | 90 | 60 | 75 | 62 | 20 | 30 | 25 |
| 18 | 100 | 100 | 100 | 63 | 20 | 70 | 45 |
| 19 | 130 | 60 | 95 | 64 | 10 | 20 | 15 |
| 20 | 105 | 65 | 85 | 65 | 20 | 20 | 20 |
| 21 | 160 | 200 | 180 | 66 | 140 | 120 | 130 |
| 22 | 180 | 200 | 190 | 67 | 140 | 100 | 120 |
| 23 | 180 | 170 | 175 | 68 | 120 | 110 | 115 |
| 24 | 220 | 220 | 220 | 69 | 90 | 80 | 85 |
| 25 | 220 | 210 | 215 | 70 | 90 | 90 | 90 |
| 26 | 280 | 140 | 210 | 71 | 50 | 90 | 70 |
| 27 | 170 | 130 | 150 | 72 | 60 | 90 | 75 |
| 28 | 210 | 180 | 195 | 73 | 80 | 160 | 120 |
| 29 | 270 | 220 | 245 | 74 | 80 | 80 | 80 |
| 30 | 200 | 150 | 175 | 75 | 30 | 70 | 50 |
| 31 | 180 | 170 | 175 | 76 | 20 | 40 | 30 |
| 32 | 190 | 290 | 240 | 77 | 40 | 60 | 50 |
| 33 | 140 | 90 | 115 | 78 | 60 | 60 | 60 |
| 34 | 200 | 170 | 185 | 79 | 0 | 0 | 0 |
| 35 | 120 | 130 | 125 | 80 | 70 | 40 | 55 |
| 36 | 290 | 360 | 325 | 81 | 50 | 70 | 60 |
| 37 | 330 | 290 | 310 | 82 | 20 | 20 | 20 |
| 38 | 220 | 210 | 215 | 83 | 0 | 0 | 0 |
| 39 | 30 | 30 | 30 | 84 | 0 | 0 | 0 |
| 40 | 240 | 200 | 220 | 85 | 0 | 0 | 0 |
| 41 | 130 | 120 | 125 | 86 | 0 | 0 | 0 |
| 42 | 90 | 70 | 80 | 87 | 30 | 70 | 50 |
| 43 | 120 | 140 | 130 | 88 | 20 | 20 | 20 |
| 44 | 40 | 400 | 220 | 89 | 20 | 10 | 15 |
| 45 | 90 | 80 | 85 | 90 | 0 | 0 | 0 |

**Treatment 12**

**Daily biogas production of cowdung and poultry manure as feedstock in 2:1 ratio with 5 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 30 | 10 | 20 | 46 | 70 | 70 | 70 |
| 2 | 0 | 0 | 0 | 47 | 90 | 100 | 95 |
| 3 | 0 | 0 | 0 | 48 | 100 | 100 | 100 |
| 4 | 0 | 0 | 0 | 49 | 20 | 60 | 40 |
| 5 | 0 | 15 | 7.5 | 50 | 70 | 90 | 80 |
| 6 | 10 | 0 | 5 | 51 | 30 | 110 | 70 |
| 7 | 65 | 25 | 45 | 52 | 50 | 60 | 55 |
| 8 | 50 | 60 | 55 | 53 | 60 | 70 | 65 |
| 9 | 70 | 20 | 45 | 54 | 30 | 50 | 40 |
| 10 | 20 | 20 | 20 | 55 | 30 | 30 | 30 |
| 11 | 70 | 130 | 100 | 56 | 0 | 40 | 20 |
| 12 | 50 | 40 | 45 | 57 | 50 | 60 | 55 |
| 13 | 10 | 20 | 15 | 58 | 120 | 100 | 110 |
| 14 | 40 | 50 | 45 | 59 | 110 | 150 | 130 |
| 15 | 30 | 15 | 22.5 | 60 | 0 | 0 | 0 |
| 16 | 30 | 10 | 20 | 61 | 40 | 20 | 30 |
| 17 | 90 | 60 | 75 | 62 | 20 | 30 | 25 |
| 18 | 100 | 100 | 100 | 63 | 20 | 70 | 45 |
| 19 | 130 | 60 | 95 | 64 | 10 | 20 | 15 |
| 20 | 105 | 65 | 85 | 65 | 20 | 20 | 20 |
| 21 | 160 | 200 | 180 | 66 | 140 | 120 | 130 |
| 22 | 180 | 200 | 190 | 67 | 140 | 100 | 120 |
| 23 | 180 | 170 | 175 | 68 | 120 | 110 | 115 |
| 24 | 220 | 220 | 220 | 69 | 90 | 80 | 85 |
| 25 | 220 | 210 | 215 | 70 | 90 | 90 | 90 |
| 26 | 280 | 140 | 210 | 71 | 50 | 90 | 70 |
| 27 | 170 | 130 | 150 | 72 | 60 | 90 | 75 |
| 28 | 210 | 180 | 195 | 73 | 80 | 160 | 120 |
| 29 | 270 | 220 | 245 | 74 | 80 | 80 | 80 |
| 30 | 200 | 150 | 175 | 75 | 30 | 70 | 50 |
| 31 | 180 | 170 | 175 | 76 | 20 | 40 | 30 |
| 32 | 190 | 290 | 240 | 77 | 40 | 60 | 50 |
| 33 | 140 | 90 | 115 | 78 | 60 | 60 | 60 |
| 34 | 200 | 170 | 185 | 79 | 0 | 0 | 0 |
| 35 | 120 | 130 | 125 | 80 | 70 | 40 | 55 |
| 36 | 290 | 360 | 325 | 81 | 50 | 70 | 60 |
| 37 | 330 | 290 | 310 | 82 | 20 | 20 | 20 |
| 38 | 220 | 210 | 215 | 83 | 0 | 0 | 0 |
| 39 | 30 | 30 | 30 | 84 | 0 | 0 | 0 |
| 40 | 240 | 200 | 220 | 85 | 0 | 0 | 0 |
| 41 | 130 | 120 | 125 | 86 | 0 | 0 | 0 |
| 42 | 90 | 70 | 80 | 87 | 30 | 70 | 50 |
| 43 | 120 | 140 | 130 | 88 | 20 | 20 | 20 |
| 44 | 40 | 400 | 220 | 89 | 20 | 10 | 15 |
| 45 | 90 | 80 | 85 | 90 | 0 | 0 | 0 |

Treatment 13

Daily biogas production of cowdung and poultry manure as feedstock in 2:1 ratio with 10 per cent TS

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 45 | 45 | 45 | 46 | 180 | 160 | 170 |
| 2 | 0 | 0 | 0 | 47 | 160 | 100 | 130 |
| 3 | 5 | 0 | 2.5 | 48 | 130 | 110 | 120 |
| 4 | 60 | 50 | 55 | 49 | 180 | 100 | 140 |
| 5 | 0 | 0 | 0 | 50 | 130 | 120 | 125 |
| 6 | 60 | 0 | 30 | 51 | 110 | 90 | 100 |
| 7 | 0 | 145 | 72.5 | 52 | 150 | 100 | 125 |
| 8 | 0 | 140 | 70 | 53 | 100 | 100 | 100 |
| 9 | 80 | 50 | 65 | 54 | 70 | 50 | 60 |
| 10 | 30 | 30 | 30 | 55 | 80 | 60 | 70 |
| 11 | 90 | 140 | 115 | 56 | 20 | 80 | 50 |
| 12 | 120 | 130 | 125 | 57 | 70 | 60 | 65 |
| 13 | 30 | 15 | 22.5 | 58 | 140 | 120 | 130 |
| 14 | 80 | 120 | 100 | 59 | 180 | 130 | 155 |
| 15 | 50 | 60 | 55 | 60 | 10 | 10 | 10 |
| 16 | 130 | 100 | 115 | 61 | 60 | 60 | 60 |
| 17 | 160 | 140 | 150 | 62 | 60 | 50 | 55 |
| 18 | 400 | 180 | 290 | 63 | 80 | 300 | 190 |
| 19 | 630 | 260 | 445 | 64 | 60 | 60 | 60 |
| 20 | 285 | 350 | 317.5 | 65 | 10 | 10 | 10 |
| 21 | 220 | 240 | 230 | 66 | 180 | 260 | 220 |
| 22 | 390 | 250 | 320 | 67 | 190 | 210 | 200 |
| 23 | 350 | 180 | 265 | 68 | 40 | 50 | 45 |
| 24 | 390 | 240 | 315 | 69 | 30 | 50 | 40 |
| 25 | 380 | 250 | 315 | 70 | 20 | 60 | 40 |
| 26 | 260 | 180 | 220 | 71 | 100 | 100 | 100 |
| 27 | 150 | 140 | 145 | 72 | 100 | 100 | 100 |
| 28 | 230 | 230 | 230 | 73 | 180 | 170 | 175 |
| 29 | 250 | 300 | 275 | 74 | 100 | 100 | 100 |
| 30 | 270 | 200 | 235 | 75 | 80 | 60 | 70 |
| 31 | 250 | 190 | 220 | 76 | 70 | 90 | 80 |
| 32 | 300 | 310 | 305 | 77 | 60 | 70 | 65 |
| 33 | 50 | 190 | 120 | 78 | 60 | 60 | 60 |
| 34 | 200 | 300 | 250 | 79 | 60 | 40 | 50 |
| 35 | 210 | 260 | 235 | 80 | 50 | 30 | 40 |
| 36 | 570 | 470 | 520 | 81 | 60 | 50 | 55 |
| 37 | 400 | 400 | 400 | 82 | 70 | 70 | 70 |
| 38 | 50 | 350 | 200 | 83 | 20 | 40 | 30 |
| 39 | 80 | 100 | 90 | 84 | 10 | 10 | 10 |
| 40 | 270 | 110 | 190 | 85 | 0 | 0 | 0 |
| 41 | 190 | 170 | 180 | 86 | 40 | 40 | 40 |
| 42 | 140 | 140 | 140 | 87 | 0 | 0 | 0 |
| 43 | 130 | 150 | 140 | 88 | 10 | 10 | 10 |
| 44 | 190 | 130 | 160 | 89 | 10 | 10 | 10 |
| 45 | 110 | 90 | 100 | 90 | 40 | 50 | 45 |

## Treatment 14
## Daily biogas production of cowdung and poultry manure as feedstock in 2:1 ratio with 1 5 per cent TS

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 35 | 65 | 50 | 46 | 330 | 310 | 320 |
| 2 | 10 | 20 | 15 | 47 | 330 | 330 | 330 |
| 3 | 20 | 70 | 45 | 48 | 300 | 270 | 285 |
| 4 | 100 | 150 | 125 | 49 | 200 | 210 | 205 |
| 5 | 0 | 0 | 0 | 50 | 120 | 200 | 160 |
| 6 | 0 | 20 | 10 | 51 | 350 | 160 | 255 |
| 7 | 120 | 180 | 150 | 52 | 120 | 180 | 150 |
| 8 | 100 | 110 | 105 | 53 | 170 | 180 | 175 |
| 9 | 90 | 110 | 100 | 54 | 100 | 120 | 110 |
| 10 | 30 | 30 | 30 | 55 | 110 | 130 | 120 |
| 11 | 110 | 120 | 115 | 56 | 130 | 150 | 140 |
| 12 | 70 | 90 | 80 | 57 | 120 | 120 | 120 |
| 13 | 20 | 20 | 20 | 58 | 160 | 190 | 175 |
| 14 | 100 | 50 | 75 | 59 | 220 | 200 | 210 |
| 15 | 20 | 25 | 22.5 | 60 | 50 | 60 | 55 |
| 16 | 40 | 20 | 30 | 61 | 100 | 110 | 105 |
| 17 | 150 | 170 | 160 | 62 | 60 | 50 | 55 |
| 18 | 160 | 190 | 175 | 63 | 150 | 130 | 140 |
| 19 | 220 | 260 | 240 | 64 | 150 | 100 | 125 |
| 20 | 190 | 200 | 195 | 65 | 40 | 30 | 35 |
| 21 | 190 | 180 | 185 | 66 | 300 | 340 | 320 |
| 22 | 320 | 420 | 370 | 67 | 300 | 340 | 320 |
| 23 | 320 | 410 | 365 | 68 | 50 | 70 | 60 |
| 24 | 370 | 650 | 510 | 69 | 50 | 60 | 55 |
| 25 | 370 | 570 | 470 | 70 | 60 | 60 | 60 |
| 26 | 310 | 620 | 465 | 71 | 100 | 170 | 135 |
| 27 | 460 | 420 | 440 | 72 | 100 | 170 | 135 |
| 28 | 570 | 400 | 485 | 73 | 190 | 210 | 200 |
| 29 | 500 | 450 | 475 | 74 | 120 | 160 | 140 |
| 30 | 410 | 380 | 395 | 75 | 200 | 160 | 180 |
| 31 | 350 | 260 | 305 | 76 | 150 | 130 | 140 |
| 32 | 310 | 310 | 310 | 77 | 130 | 140 | 135 |
| 33 | 280 | 530 | 405 | 78 | 120 | 120 | 120 |
| 34 | 350 | 420 | 385 | 79 | 100 | 120 | 110 |
| 35 | 300 | 430 | 365 | 80 | 70 | 100 | 85 |
| 36 | 690 | 890 | 790 | 81 | 100 | 100 | 100 |
| 37 | 540 | 630 | 585 | 82 | 70 | 70 | 70 |
| 38 | 450 | 540 | 495 | 83 | 20 | 40 | 30 |
| 39 | 200 | 300 | 250 | 84 | 20 | 20 | 30 |
| 40 | 550 | 550 | 550 | 85 | 10 | 0 | 5 |
| 41 | 350 | 450 | 400 | 86 | 40 | 40 | 40 |
| 42 | 340 | 330 | 335 | 87 | 30 | 20 | 25 |
| 43 | 360 | 320 | 340 | 88 | 20 | 20 | 20 |
| 44 | 470 | 450 | 460 | 89 | 20 | 10 | 10 |
| 45 | 380 | 350 | 365 | 90 | 0 | 0 | 0 |

**Treatment 15**

**Daily biogas production of cowdung and poultry manure as feedstock in 2:1 ratio with 20 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 230 | 200 | 215 | 46 | 200 | 180 | 190 |
| 2 | 10 | 65 | 37.5 | 47 | 310 | 200 | 255 |
| 3 | 5 | 20 | 12.5 | 48 | 320 | 200 | 260 |
| 4 | 80 | 125 | 102.5 | 49 | 300 | 300 | 300 |
| 5 | 0 | 0 | 0 | 50 | 260 | 140 | 200 |
| 6 | 0 | 20 | 10 | 51 | 280 | 150 | 215 |
| 7 | 120 | 180 | 150 | 52 | 270 | 160 | 215 |
| 8 | 150 | 100 | 125 | 53 | 250 | 170 | 210 |
| 9 | 80 | 90 | 85 | 54 | 120 | 80 | 100 |
| 10 | 20 | 20 | 20 | 55 | 170 | 80 | 125 |
| 11 | 90 | 80 | 85 | 56 | 110 | 90 | 100 |
| 12 | 80 | 40 | 60 | 57 | 190 | 170 | 180 |
| 13 | 20 | 30 | 25 | 58 | 300 | 100 | 200 |
| 14 | 60 | 100 | 80 | 59 | 300 | 200 | 250 |
| 15 | 30 | 40 | 35 | 60 | 80 | 60 | 70 |
| 16 | 30 | 20 | 25 | 61 | 160 | 80 | 120 |
| 17 | 160 | 80 | 120 | 62 | 160 | 70 | 115 |
| 18 | 200 | 150 | 175 | 63 | 170 | 150 | 160 |
| 19 | 200 | 200 | 200 | 64 | 140 | 120 | 130 |
| 20 | 150 | 140 | 145 | 65 | 30 | 20 | 25 |
| 21 | 140 | 180 | 160 | 66 | 150 | 170 | 160 |
| 22 | 350 | 370 | 360 | 67 | 160 | 170 | 165 |
| 23 | 360 | 450 | 405 | 68 | 260 | 110 | 185 |
| 24 | 490 | 500 | 495 | 69 | 210 | 60 | 135 |
| 25 | 480 | 490 | 485 | 70 | 190 | 50 | 120 |
| 26 | 600 | 300 | 450 | 71 | 190 | 100 | 145 |
| 27 | 600 | 450 | 525 | 72 | 190 | 100 | 145 |
| 28 | 540 | 510 | 525 | 73 | 310 | 180 | 245 |
| 29 | 550 | 600 | 575 | 74 | 200 | 120 | 160 |
| 30 | 390 | 360 | 375 | 75 | 120 | 60 | 90 |
| 31 | 410 | 350 | 380 | 76 | 120 | 40 | 80 |
| 32 | 320 | 250 | 285 | 77 | 130 | 100 | 115 |
| 33 | 250 | 200 | 225 | 78 | 80 | 100 | 90 |
| 34 | 370 | 280 | 325 | 79 | 120 | 100 | 110 |
| 35 | 390 | 330 | 360 | 80 | 90 | 120 | 105 |
| 36 | 720 | 220 | 470 | 81 | 170 | 110 | 140 |
| 37 | 700 | 440 | 570 | 82 | 100 | 100 | 100 |
| 38 | 570 | 400 | 485 | 83 | 50 | 50 | 50 |
| 39 | 250 | 260 | 255 | 84 | 50 | 50 | 50 |
| 40 | 560 | 300 | 430 | 85 | 40 | 80 | 60 |
| 41 | 430 | 280 | 355 | 86 | 40 | 60 | 50 |
| 42 | 660 | 340 | 500 | 87 | 20 | 60 | 40 |
| 43 | 510 | 410 | 460 | 88 | 30 | 40 | 35 |
| 44 | 500 | 300 | 400 | 89 | 80 | 100 | 90 |
| 45 | 250 | 130 | 190 | 90 | 90 | 110 | 100 |

**Treatment 16**

**Daily biogas production of cowdung and poultry deep litter as feedstock in 1:1 ratio with 5 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 320 | 490 | 405 | 46 | 200 | 100 | 150 |
| 2 | 425 | 415 | 420 | 47 | 310 | 290 | 300 |
| 3 | 205 | 230 | 217.5 | 48 | 320 | 300 | 310 |
| 4 | 260 | 300 | 280 | 49 | 300 | 250 | 275 |
| 5 | 50 | 70 | 60 | 50 | 280 | 410 | 345 |
| 6 | 40 | 90 | 65 | 51 | 270 | 270 | 270 |
| 7 | 200 | 180 | 190 | 52 | 250 | 380 | 315 |
| 8 | 100 | 100 | 100 | 53 | 240 | 240 | 240 |
| 9 | 130 | 120 | 125 | 54 | 170 | 180 | 175 |
| 10 | 40 | 30 | 35 | 55 | 220 | 200 | 210 |
| 11 | 140 | 110 | 125 | 56 | 230 | 180 | 205 |
| 12 | 80 | 40 | 60 | 57 | 220 | 170 | 195 |
| 13 | 30 | 20 | 25 | 58 | 300 | 200 | 250 |
| 14 | 30 | 60 | 45 | 59 | 270 | 250 | 260 |
| 15 | 20 | 60 | 40 | 60 | 0 | 120 | 60 |
| 16 | 10 | 30 | 20 | 61 | 160 | 200 | 180 |
| 17 | 40 | 30 | 35 | 62 | 170 | 180 | 175 |
| 18 | 50 | 70 | 60 | 63 | 200 | 150 | 175 |
| 19 | 50 | 70 | 60 | 64 | 70 | 100 | 85 |
| 20 | 0 | 30 | 15 | 65 | 60 | 50 | 55 |
| 21 | 40 | 40 | 40 | 66 | 220 | 280 | 250 |
| 22 | 40 | 40 | 40 | 67 | 210 | 270 | 240 |
| 23 | 20 | 30 | 25 | 68 | 80 | 10 | 45 |
| 24 | 40 | 40 | 40 | 69 | 70 | 10 | 40 |
| 25 | 40 | 50 | 45 | 70 | 80 | 20 | 50 |
| 26 | 50 | 60 | 55 | 71 | 100 | 50 | 75 |
| 27 | 30 | 30 | 30 | 72 | 100 | 50 | 75 |
| 28 | 70 | 40 | 55 | 73 | 170 | 60 | 115 |
| 29 | 130 | 70 | 100 | 74 | 100 | 60 | 80 |
| 30 | 120 | 40 | 80 | 75 | 30 | 50 | 40 |
| 31 | 80 | 60 | 70 | 76 | 70 | 90 | 80 |
| 32 | 70 | 50 | 60 | 77 | 50 | 60 | 55 |
| 33 | 210 | 40 | 125 | 78 | 20 | 20 | 20 |
| 34 | 160 | 80 | 120 | 79 | 10 | 30 | 20 |
| 35 | 150 | 100 | 125 | 80 | 20 | 20 | 20 |
| 36 | 820 | 310 | 565 | 81 | 40 | 30 | 35 |
| 37 | 800 | 340 | 570 | 82 | 30 | 30 | 30 |
| 38 | 50 | 310 | 180 | 83 | 0 | 0 | 0 |
| 39 | 250 | 310 | 280 | 84 | 0 | 10 | 5 |
| 40 | 360 | 280 | 320 | 85 | 0 | 0 | 0 |
| 41 | 300 | 250 | 275 | 86 | 0 | 0 | 0 |
| 42 | 90 | 80 | 85 | 87 | 10 | 10 | 10 |
| 43 | 90 | 110 | 100 | 88 | 0 | 0 | 0 |
| 44 | 250 | 250 | 250 | 89 | 40 | 40 | 40 |
| 45 | 210 | 130 | 170 | 90 | 20 | 30 | 25 |

**Treatment 17**
**Daily biogas production of cowdung and poultry deep litter as feedstock in 1:1 ratio with 10 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 500 | 1800 | 1150 | 46 | 0 | 0 | 0 |
| 2 | 570 | 1255 | 912.5 | 47 | 0 | 0 | 0 |
| 3 | 230 | 630 | 430 | 48 | 20 | 20 | 20 |
| 4 | 290 | 310 | 300 | 49 | 30 | 0 | 15 |
| 5 | 110 | 120 | 115 | 50 | 10 | 20 | 15 |
| 6 | 120 | 100 | 110 | 51 | 20 | 20 | 20 |
| 7 | 180 | 290 | 235 | 52 | 10 | 10 | 10 |
| 8 | 150 | 250 | 200 | 53 | 30 | 10 | 20 |
| 9 | 150 | 160 | 155 | 54 | 10 | 10 | 10 |
| 10 | 80 | 80 | 80 | 55 | 10 | 0 | 5 |
| 11 | 110 | 110 | 110 | 56 | 0 | 10 | 5 |
| 12 | 110 | 140 | 125 | 57 | 0 | 10 | 5 |
| 13 | 50 | 70 | 60 | 58 | 0 | 0 | 0 |
| 14 | 50 | 40 | 45 | 59 | 0 | 0 | 0 |
| 15 | 50 | 40 | 45 | 60 | 0 | 0 | 0 |
| 16 | 40 | 60 | 50 | 61 | 0 | 0 | 0 |
| 17 | 100 | 100 | 100 | 62 | 0 | 0 | 0 |
| 18 | 30 | 80 | 55 | 63 | 0 | 0 | 0 |
| 19 | 50 | 50 | 50 | 64 | 0 | 0 | 0 |
| 20 | 20 | 30 | 25 | 65 | 0 | 0 | 0 |
| 21 | 60 | 70 | 65 | 66 | 20 | 20 | 20 |
| 22 | 60 | 70 | 65 | 67 | 20 | 20 | 20 |
| 23 | 30 | 40 | 35 | 68 | 0 | 0 | 0 |
| 24 | 60 | 60 | 60 | 69 | 0 | 0 | 0 |
| 25 | 80 | 60 | 70 | 70 | 0 | 0 | 0 |
| 26 | 40 | 70 | 55 | 71 | 0 | 0 | 0 |
| 27 | 40 | 50 | 45 | 72 | 0 | 0 | 0 |
| 28 | 40 | 50 | 45 | 73 | 0 | 0 | 0 |
| 29 | 50 | 70 | 60 | 74 | 0 | 0 | 0 |
| 30 | 10 | 30 | 20 | | | | |
| 31 | 20 | 20 | 20 | | | | |
| 32 | 40 | 70 | 55 | | | | |
| 33 | 10 | 30 | 20 | | | | |
| 34 | 40 | 50 | 45 | | | | |
| 35 | 20 | 30 | 25 | | | | |
| 36 | 50 | 80 | 65 | | | | |
| 37 | 40 | 40 | 40 | | | | |
| 38 | 50 | 30 | 40 | | | | |
| 39 | 0 | 0 | 0 | | | | |
| 40 | 10 | 10 | 10 | | | | |
| 41 | 20 | 20 | 20 | | | | |
| 42 | 0 | 0 | 0 | | | | |
| 43 | 10 | 20 | 15 | | | | |
| 44 | 30 | 20 | 25 | | | | |
| 45 | 10 | 10 | 10 | | | | |

**Treatment 18**

**Daily biogas production of cowdung and poultry deep litter as feedstock in 1:1 ratio with 15 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 1340 | 1630 | 1485 | 46 | 10 | 10 | 10 |
| 2 | 1310 | 1290 | 1300 | 47 | 10 | 0 | 5 |
| 3 | 810 | 840 | 825 | 48 | 40 | 10 | 25 |
| 4 | 850 | 850 | 850 | 49 | 0 | 0 | 0 |
| 5 | 270 | 230 | 250 | 50 | 30 | 30 | 30 |
| 6 | 120 | 160 | 140 | 51 | 40 | 20 | 30 |
| 7 | 350 | 470 | 410 | 52 | 20 | 10 | 15 |
| 8 | 250 | 270 | 260 | 53 | 10 | 20 | 15 |
| 9 | 240 | 270 | 255 | 54 | 20 | 5 | 12.5 |
| 10 | 150 | 140 | 145 | 55 | 10 | 0 | 5 |
| 11 | 150 | 130 | 140 | 56 | 20 | 10 | 15 |
| 12 | 110 | 90 | 100 | 57 | 0 | 10 | 5 |
| 13 | 60 | 50 | 55 | 58 | 0 | 0 | 0 |
| 14 | 60 | 80 | 70 | 59 | 0 | 0 | 0 |
| 15 | 30 | 50 | 40 | 60 | 0 | 0 | 0 |
| 16 | 50 | 50 | 50 | 61 | 0 | 0 | 0 |
| 17 | 80 | 130 | 105 | 62 | 0 | 0 | 0 |
| 18 | 100 | 150 | 125 | 63 | 0 | 0 | 0 |
| 19 | 50 | 50 | 50 | 64 | 0 | 0 | 0 |
| 20 | 30 | 60 | 45 | 65 | 0 | 0 | 0 |
| 21 | 90 | 110 | 100 | | | | |
| 22 | 90 | 80 | 85 | | | | |
| 23 | 60 | 60 | 60 | | | | |
| 24 | 100 | 80 | 90 | | | | |
| 25 | 100 | 90 | 95 | | | | |
| 26 | 30 | 60 | 45 | | | | |
| 27 | 60 | 40 | 50 | | | | |
| 28 | 60 | 30 | 45 | | | | |
| 29 | 100 | 70 | 85 | | | | |
| 30 | 40 | 10 | 25 | | | | |
| 31 | 50 | 20 | 35 | | | | |
| 32 | 80 | 50 | 65 | | | | |
| 33 | 30 | 10 | 20 | | | | |
| 34 | 70 | 40 | 55 | | | | |
| 35 | 30 | 20 | 25 | | | | |
| 36 | 120 | 40 | 80 | | | | |
| 37 | 90 | 40 | 65 | | | | |
| 38 | 80 | 40 | 60 | | | | |
| 39 | 10 | 10 | 10 | | | | |
| 40 | 20 | 10 | 15 | | | | |
| 41 | 0 | 0 | 0 | | | | |
| 42 | 10 | 0 | 5 | | | | |
| 43 | 10 | 10 | 10 | | | | |
| 44 | 50 | 30 | 40 | | | | |
| 45 | 20 | 10 | 15 | | | | |

**Treatment 19**
**Daily biogas production of cowdung and poultry deep litter as feedstock in 1:1 ratio with 20 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 1750 | 1850 | 1800 | 46 | 0 | 0 | 0 |
| 2 | 1650 | 1230 | 1440 | 47 | 5 | 15 | 10 |
| 3 | 1760 | 1700 | 1730 | 48 | 40 | 30 | 35 |
| 4 | 1800 | 1850 | 1825 | 49 | 0 | 0 | 0 |
| 5 | 30 | 20 | 25 | 50 | 30 | 40 | 35 |
| 6 | 320 | 210 | 265 | 51 | 20 | 40 | 30 |
| 7 | 1230 | 1100 | 1165 | 52 | 10 | 20 | 15 |
| 8 | 530 | 410 | 470 | 53 | 30 | 10 | 20 |
| 9 | 430 | 250 | 340 | 54 | 10 | 10 | 10 |
| 10 | 320 | 180 | 250 | 55 | 0 | 0 | 0 |
| 11 | 350 | 320 | 335 | 56 | 10 | 0 | 5 |
| 12 | 360 | 130 | 245 | 57 | 10 | 10 | 10 |
| 13 | 150 | 70 | 110 | 58 | 0 | 0 | 0 |
| 14 | 120 | 50 | 85 | 59 | 0 | 0 | 0 |
| 15 | 75 | 30 | 52.5 | 60 | 0 | 0 | 0 |
| 16 | 120 | 100 | 110 | 61 | 0 | 0 | 0 |
| 17 | 280 | 150 | 215 | 62 | 0 | 0 | 0 |
| 18 | 110 | 100 | 105 | 63 | 0 | 0 | 0 |
| 19 | 50 | 50 | 50 | 64 | 0 | 0 | 0 |
| 20 | 20 | 20 | 20 | 65 | 0 | 0 | 0 |
| 21 | 70 | 70 | 70 | 66 | 40 | 40 | 40 |
| 22 | 70 | 80 | 75 | 67 | 30 | 30 | 30 |
| 23 | 0 | 30 | 15 | 68 | 0 | 0 | 0 |
| 24 | 60 | 70 | 65 | 69 | 10 | 10 | 10 |
| 25 | 60 | 80 | 70 | 70 | 0 | 0 | 0 |
| 26 | 60 | 70 | 65 | 71 | 0 | 0 | 0 |
| 27 | 30 | 30 | 30 | 72 | 0 | 0 | 0 |
| 28 | 10 | 30 | 20 | 73 | 0 | 0 | 0 |
| 29 | 80 | 90 | 85 | 74 | 0 | 0 | 0 |
| 30 | 10 | 10 | 10 | 75 | 0 | 0 | 0 |
| 31 | 20 | 0 | 10 | | | | |
| 32 | 130 | 80 | 105 | | | | |
| 33 | 30 | 80 | 55 | | | | |
| 34 | 50 | 40 | 45 | | | | |
| 35 | 10 | 20 | 15 | | | | |
| 36 | 80 | 120 | 100 | | | | |
| 37 | 70 | 80 | 75 | | | | |
| 38 | 70 | 70 | 70 | | | | |
| 39 | 10 | 10 | 10 | | | | |
| 40 | 10 | 40 | 25 | | | | |
| 41 | 40 | 160 | 100 | | | | |
| 42 | 0 | 0 | 0 | | | | |
| 43 | 10 | 10 | 10 | | | | |
| 44 | 60 | 70 | 65 | | | | |
| 45 | 10 | 10 | 10 | | | | |

## Treatment 20
## Daily biogas production of cowdung and poultry deep litter as feedstock in 1:2 ratio with 5 per cent TS

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 350 | 420 | 385 | 46 | 20 | 250 | 135 |
| 2 | 295 | 510 | 402.5 | 47 | 30 | 250 | 140 |
| 3 | 230 | 210 | 220 | 48 | 30 | 200 | 115 |
| 4 | 190 | 185 | 187.5 | 49 | 20 | 260 | 140 |
| 5 | 60 | 70 | 65 | 50 | 70 | 270 | 170 |
| 6 | 100 | 20 | 60 | 51 | 80 | 40 | 60 |
| 7 | 150 | 150 | 150 | 52 | 70 | 150 | 110 |
| 8 | 120 | 100 | 110 | 53 | 120 | 40 | 80 |
| 9 | 100 | 130 | 115 | 54 | 130 | 250 | 190 |
| 10 | 60 | 55 | 57.5 | 55 | 110 | 230 | 170 |
| 11 | 110 | 80 | 95 | 56 | 200 | 240 | 220 |
| 12 | 50 | 40 | 45 | 57 | 260 | 300 | 280 |
| 13 | 50 | 30 | 40 | 58 | 400 | 380 | 390 |
| 14 | 30 | 40 | 35 | 59 | 480 | 520 | 500 |
| 15 | 25 | 45 | 35 | 60 | 0 | 0 | 0 |
| 16 | 100 | 50 | 75 | 61 | 400 | 450 | 425 |
| 17 | 20 | 50 | 35 | 62 | 130 | 160 | 145 |
| 18 | 30 | 50 | 40 | 63 | 300 | 340 | 320 |
| 19 | 20 | 30 | 25 | 64 | 280 | 140 | 210 |
| 20 | 0 | 10 | 5 | 65 | 130 | 130 | 130 |
| 21 | 40 | 80 | 60 | 66 | 400 | 400 | 400 |
| 22 | 15 | 20 | 17.5 | 67 | 300 | 300 | 300 |
| 23 | 0 | 10 | 5 | 68 | 190 | 220 | 205 |
| 24 | 60 | 50 | 55 | 69 | 170 | 200 | 185 |
| 25 | 50 | 60 | 55 | 70 | 180 | 210 | 195 |
| 26 | 20 | 30 | 25 | 71 | 530 | 210 | 370 |
| 27 | 10 | 20 | 15 | 72 | 610 | 200 | 405 |
| 28 | 10 | 20 | 15 | 73 | 800 | 400 | 600 |
| 29 | 30 | 30 | 30 | 74 | 580 | 240 | 410 |
| 30 | 10 | 20 | 15 | 75 | 500 | 100 | 300 |
| 31 | 5 | 10 | 7.5 | 76 | 80 | 60 | 70 |
| 32 | 30 | 20 | 25 | 77 | 260 | 160 | 210 |
| 33 | 20 | 30 | 25 | 78 | 220 | 140 | 180 |
| 34 | 30 | 40 | 35 | 79 | 100 | 120 | 110 |
| 35 | 30 | 20 | 25 | 80 | 130 | 60 | 95 |
| 36 | 60 | 20 | 40 | 81 | 160 | 80 | 120 |
| 37 | 60 | 110 | 85 | 82 | 90 | 20 | 55 |
| 38 | 70 | 150 | 110 | 83 | 80 | 10 | 45 |
| 39 | 0 | 0 | 0 | 84 | 80 | 30 | 55 |
| 40 | 20 | 20 | 20 | 85 | 40 | 20 | 30 |
| 41 | 40 | 160 | 100 | 86 | 50 | 40 | 45 |
| 42 | 0 | 0 | 0 | 87 | 60 | 50 | 55 |
| 43 | 30 | 180 | 105 | 88 | 40 | 20 | 30 |
| 44 | 50 | 500 | 275 | 89 | 10 | 0 | 5 |
| 45 | 20 | 310 | 165 | 90 | 0 | 0 | 0 |

Treatment 21

**Daily biogas production of cowdung and poultry deep litter as feedstock in 1:2 ratio with 10 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 1970 | 2200 | 2085 | 46 | 0 | 0 | 0 |
| 2 | 1130 | 1170 | 1150 | 47 | 0 | 0 | 0 |
| 3 | 450 | 450 | 450 | 48 | 10 | 10 | 10 |
| 4 | 365 | 330 | 347.5 | 49 | 0 | 0 | 0 |
| 5 | 50 | 70 | 60 | 50 | 0 | 10 | 5 |
| 6 | 80 | 60 | 70 | 51 | 0 | 20 | 10 |
| 7 | 220 | 420 | 320 | 52 | 20 | 0 | 10 |
| 8 | 210 | 280 | 245 | 53 | 30 | 20 | 25 |
| 9 | 200 | 220 | 210 | 54 | 0 | 0 | 0 |
| 10 | 110 | 110 | 110 | 55 | 0 | 0 | 0 |
| 11 | 120 | 210 | 165 | 56 | 10 | 10 | 10 |
| 12 | 60 | 50 | 55 | 57 | 0 | 0 | 0 |
| 13 | 20 | 20 | 20 | 58 | 0 | 0 | 0 |
| 14 | 30 | 40 | 35 | 59 | 10 | 10 | 10 |
| 15 | 20 | 25 | 22.5 | 60 | 0 | 0 | 0 |
| 16 | 20 | 10 | 15 | 61 | 0 | 0 | 0 |
| 17 | 40 | 50 | 45 | 62 | 0 | 0 | 0 |
| 18 | 50 | 60 | 55 | 63 | 0 | 0 | 0 |
| 19 | 30 | 20 | 25 | 64 | 0 | 0 | 0 |
| 20 | 10 | 10 | 10 | 65 | 0 | 0 | 0 |
| 21 | 60 | 50 | 55 | 66 | 0 | 0 | 0 |
| 22 | 50 | 40 | 45 | 67 | 0 | 0 | 0 |
| 23 | 10 | 10 | 10 | 68 | 0 | 0 | 0 |
| 24 | 30 | 30 | 30 | | | | |
| 25 | 20 | 30 | 25 | | | | |
| 26 | 40 | 40 | 40 | | | | |
| 27 | 20 | 30 | 25 | | | | |
| 28 | 20 | 20 | 20 | | | | |
| 29 | 50 | 50 | 50 | | | | |
| 30 | 30 | 10 | 20 | | | | |
| 31 | 10 | 10 | 10 | | | | |
| 32 | 30 | 20 | 25 | | | | |
| 33 | 20 | 10 | 15 | | | | |
| 34 | 30 | 30 | 30 | | | | |
| 35 | 10 | 10 | 10 | | | | |
| 36 | 60 | 40 | 50 | | | | |
| 37 | 30 | 80 | 55 | | | | |
| 38 | 70 | 40 | 55 | | | | |
| 39 | 0 | 0 | 0 | | | | |
| 40 | 10 | 10 | 10 | | | | |
| 41 | 0 | 20 | 10 | | | | |
| 42 | 0 | 0 | 0 | | | | |
| 43 | 0 | 10 | 5 | | | | |
| 44 | 30 | 30 | 30 | | | | |
| 45 | 0 | 0 | 0 | | | | |

## Treatment 22

**Daily biogas production of cowdung and poultry deep litter as feedstock in 1:2 ratio with 15 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 1800 | 1750 | 1775 | 46 | 0 | 0 | 0 |
| 2 | 1950 | 1600 | 1775 | 47 | 0 | 0 | 0 |
| 3 | 1120 | 1220 | 1170 | 48 | 20 | 30 | 25 |
| 4 | 1690 | 1750 | 1720 | 49 | 0 | 10 | 5 |
| 5 | 110 | 80 | 95 | 50 | 10 | 20 | 15 |
| 6 | 180 | 100 | 140 | 51 | 10 | 30 | 20 |
| 7 | 560 | 160 | 360 | 52 | 20 | 20 | 20 |
| 8 | 350 | 120 | 235 | 53 | 10 | 20 | 15 |
| 9 | 220 | 200 | 210 | 54 | 0 | 10 | 5 |
| 10 | 90 | 80 | 85 | 55 | 10 | 20 | 15 |
| 11 | 310 | 200 | 255 | 56 | 20 | 10 | 15 |
| 12 | 120 | 110 | 115 | 57 | 10 | 10 | 10 |
| 13 | 30 | 60 | 45 | 58 | 0 | 0 | 0 |
| 14 | 90 | 80 | 85 | 59 | 10 | 20 | 15 |
| 15 | 20 | 20 | 20 | 60 | 0 | 0 | 0 |
| 16 | 30 | 40 | 35 | 61 | 0 | 0 | 0 |
| 17 | 120 | 180 | 150 | 62 | 0 | 0 | 0 |
| 18 | 20 | 40 | 30 | 63 | 0 | 0 | 0 |
| 19 | 0 | 0 | 0 | 64 | 0 | 0 | 0 |
| 20 | 5 | 0 | 2.5 | 65 | 0 | 0 | 0 |
| 21 | 60 | 40 | 50 | 66 | 0 | 0 | 0 |
| 22 | 30 | 40 | 35 | 67 | 0 | 0 | 0 |
| 23 | 10 | 10 | 10 | 68 | 0 | 0 | 0 |
| 24 | 30 | 30 | 30 | | | | |
| 25 | 20 | 40 | 30 | | | | |
| 26 | 50 | 30 | 40 | | | | |
| 27 | 10 | 20 | 15 | | | | |
| 28 | 20 | 30 | 25 | | | | |
| 29 | 50 | 60 | 55 | | | | |
| 30 | 0 | 10 | 5 | | | | |
| 31 | 10 | 20 | 15 | | | | |
| 32 | 40 | 30 | 35 | | | | |
| 33 | 10 | 30 | 20 | | | | |
| 34 | 40 | 40 | 40 | | | | |
| 35 | 10 | 10 | 10 | | | | |
| 36 | 50 | 70 | 60 | | | | |
| 37 | 90 | 80 | 85 | | | | |
| 38 | 40 | 40 | 40 | | | | |
| 39 | 0 | 0 | 0 | | | | |
| 40 | 20 | 20 | 20 | | | | |
| 41 | 0 | 20 | 10 | | | | |
| 42 | 0 | 0 | 0 | | | | |
| 43 | 10 | 20 | 15 | | | | |
| 44 | 30 | 40 | 35 | | | | |
| 45 | 10 | 10 | 10 | | | | |

**Treatment 23**

**Daily biogas production of cowdung and poultry deep litter as feedstock in 1:2 ratio with 20 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 2215 | 2120 | 2167.5 | 46 | 10 | 10 | 10 |
| 2 | 970 | 1030 | 1000 | 47 | 10 | 0 | 5 |
| 3 | 1720 | 1730 | 1725 | 48 | 30 | 50 | 40 |
| 4 | 1950 | 1750 | 1850 | 49 | 0 | 0 | 0 |
| 5 | 650 | 550 | 600 | 50 | 20 | 20 | 20 |
| 6 | 600 | 510 | 555 | 51 | 20 | 40 | 30 |
| 7 | 110 | 940 | 525 | 52 | 20 | 10 | 15 |
| 8 | 410 | 690 | 550 | 53 | 20 | 30 | 25 |
| 9 | 160 | 180 | 170 | 54 | 20 | 10 | 15 |
| 10 | 100 | 80 | 90 | 55 | 20 | 20 | 20 |
| 11 | 320 | 330 | 325 | 56 | 20 | 20 | 20 |
| 12 | 240 | 420 | 330 | 57 | 20 | 10 | 15 |
| 13 | 150 | 200 | 175 | 58 | 60 | 60 | 60 |
| 14 | 220 | 200 | 210 | 59 | 30 | 120 | 75 |
| 15 | 125 | 140 | 132.5 | 60 | 10 | 20 | 15 |
| 16 | 200 | 170 | 185 | 61 | 10 | 10 | 10 |
| 17 | 180 | 160 | 170 | 62 | 0 | 0 | 0 |
| 18 | 100 | 110 | 105 | 63 | 20 | 20 | 20 |
| 19 | 80 | 50 | 65 | 64 | 0 | 0 | 0 |
| 20 | 90 | 65 | 77.5 | 65 | 10 | 10 | 10 |
| 21 | 90 | 90 | 90 | 66 | 100 | 100 | 100 |
| 22 | 100 | 80 | 90 | 67 | 90 | 90 | 90 |
| 23 | 70 | 60 | 65 | 68 | 0 | 0 | 0 |
| 24 | 90 | 80 | 85 | 69 | 0 | 0 | 0 |
| 25 | 110 | 90 | 100 | 70 | 0 | 0 | 0 |
| 26 | 80 | 70 | 75 | 71 | 70 | 50 | 60 |
| 27 | 40 | 50 | 45 | 72 | 80 | 60 | 70 |
| 28 | 0 | 30 | 15 | 73 | 100 | 100 | 100 |
| 29 | 60 | 40 | 50 | 74 | 70 | 50 | 60 |
| 30 | 5 | 10 | 7.5 | 75 | 0 | 0 | 0 |
| 31 | 10 | 30 | 20 | 76 | 20 | 20 | 20 |
| 32 | 80 | 70 | 75 | 77 | 10 | 0 | 5 |
| 33 | 20 | 30 | 25 | 78 | 0 | 0 | 0 |
| 34 | 50 | 50 | 50 | 79 | 0 | 0 | 0 |
| 35 | 20 | 30 | 25 | 80 | 0 | 0 | 0 |
| 36 | 100 | 100 | 100 | 81 | 0 | 0 | 0 |
| 37 | 140 | 120 | 130 | 82 | 0 | 0 | 0 |
| 38 | 50 | 120 | 85 | 83 | 0 | 0 | 0 |
| 39 | 10 | 10 | 10 | 84 | 0 | 0 | 0 |
| 40 | 20 | 40 | 30 | 85 | 0 | 0 | 0 |
| 41 | 30 | 30 | 30 | | | | |
| 42 | 10 | 10 | 10 | | | | |
| 43 | 30 | 20 | 25 | | | | |
| 44 | 50 | 60 | 55 | | | | |
| 45 | 10 | 20 | 15 | | | | |

**Treatment 24**

**Daily biogas production of cowdung and poultry deep litter as feedstock in 2:1 ratio with 5 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 390 | 310 | 350 | 46 | 20 | 40 | 30 |
| 2 | 2300 | 2430 | 2365 | 47 | 10 | 440 | 225 |
| 3 | 140 | 140 | 140 | 48 | 70 | 500 | 285 |
| 4 | 180 | 180 | 180 | 49 | 10 | 400 | 205 |
| 5 | 70 | 60 | 65 | 50 | 20 | 500 | 260 |
| 6 | 120 | 140 | 130 | 51 | 10 | 450 | 230 |
| 7 | 270 | 160 | 215 | 52 | 0 | 360 | 180 |
| 8 | 100 | 150 | 125 | 53 | 20 | 430 | 225 |
| 9 | 140 | 145 | 142.5 | 54 | 10 | 320 | 165 |
| 10 | 30 | 10 | 20 | 55 | 20 | 10 | 15 |
| 11 | 100 | 100 | 100 | 56 | 20 | 320 | 170 |
| 12 | 40 | 40 | 40 | 57 | 10 | 490 | 250 |
| 13 | 40 | 30 | 35 | 58 | 70 | 80 | 75 |
| 14 | 40 | 30 | 35 | 59 | 150 | 380 | 265 |
| 15 | 45 | 35 | 40 | 60 | 30 | 30 | 30 |
| 16 | 50 | 50 | 50 | 61 | 20 | 320 | 170 |
| 17 | 50 | 30 | 40 | 62 | 10 | 110 | 60 |
| 18 | 50 | 30 | 40 | 63 | 60 | 180 | 120 |
| 19 | 20 | 30 | 25 | 64 | 60 | 10 | 35 |
| 20 | 0 | 5 | 2.5 | 65 | 30 | 180 | 105 |
| 21 | 30 | 40 | 35 | 66 | 120 | 180 | 150 |
| 22 | 20 | 20 | 20 | 67 | 170 | 280 | 225 |
| 23 | 10 | 10 | 10 | 68 | 30 | 50 | 40 |
| 24 | 20 | 20 | 20 | 69 | 30 | 40 | 35 |
| 25 | 30 | 20 | 25 | 70 | 50 | 40 | 45 |
| 26 | 40 | 40 | 40 | 71 | 150 | 130 | 140 |
| 27 | 20 | 20 | 20 | 72 | 160 | 120 | 140 |
| 28 | 50 | 30 | 40 | 73 | 180 | 190 | 185 |
| 29 | 70 | 70 | 70 | 74 | 180 | 140 | 160 |
| 30 | 10 | 10 | 10 | 75 | 420 | 120 | 270 |
| 31 | 20 | 0 | 10 | 76 | 70 | 250 | 160 |
| 32 | 30 | 40 | 35 | 77 | 340 | 80 | 210 |
| 33 | 20 | 20 | 20 | 78 | 300 | 100 | 200 |
| 34 | 40 | 50 | 45 | 79 | 300 | 120 | 210 |
| 35 | 10 | 40 | 25 | 80 | 280 | 30 | 155 |
| 36 | 50 | 100 | 75 | 81 | 340 | 200 | 270 |
| 37 | 100 | 130 | 115 | 82 | 60 | 60 | 60 |
| 38 | 100 | 110 | 105 | 83 | 130 | 40 | 85 |
| 39 | 20 | 20 | 20 | 84 | 200 | 30 | 115 |
| 40 | 30 | 30 | 30 | 85 | 150 | 20 | 85 |
| 41 | 30 | 130 | 80 | 86 | 150 | 20 | 85 |
| 42 | 0 | 60 | 30 | 87 | 150 | 80 | 115 |
| 43 | 20 | 110 | 65 | 88 | 110 | 60 | 85 |
| 44 | 70 | 350 | 210 | 89 | 160 | 60 | 110 |
| 45 | 20 | 20 | 20 | 90 | 100 | 100 | 100 |

**Treatment 25**
**Daily biogas production of cowdung and poultry deep litter as feedstock in 2:1 ratio with 10 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 1150 | 1400 | 1275 | 46 | 200 | 180 | 190 |
| 2 | 970 | 960 | 965 | 47 | 0 | 40 | 20 |
| 3 | 130 | 140 | 135 | 48 | 10 | 40 | 25 |
| 4 | 420 | 270 | 345 | 49 | 0 | 60 | 30 |
| 5 | 110 | 80 | 95 | 50 | 20 | 80 | 50 |
| 6 | 40 | 120 | 80 | 51 | 40 | 110 | 75 |
| 7 | 220 | 190 | 205 | 52 | 10 | 70 | 40 |
| 8 | 150 | 200 | 175 | 53 | 20 | 280 | 150 |
| 9 | 200 | 185 | 192.5 | 54 | 20 | 250 | 135 |
| 10 | 40 | 30 | 35 | 55 | 390 | 430 | 410 |
| 11 | 200 | 170 | 185 | 56 | 20 | 500 | 260 |
| 12 | 50 | 30 | 40 | 57 | 20 | 700 | 360 |
| 13 | 40 | 20 | 30 | 58 | 170 | 900 | 535 |
| 14 | 20 | 50 | 35 | 59 | 100 | 700 | 400 |
| 15 | 20 | 45 | 32.5 | 60 | 0 | 500 | 250 |
| 16 | 40 | 30 | 35 | 61 | 40 | 900 | 470 |
| 17 | 30 | 20 | 25 | 62 | 20 | 170 | 95 |
| 18 | 70 | 60 | 65 | 63 | 80 | 360 | 220 |
| 19 | 40 | 40 | 40 | 64 | 30 | 130 | 80 |
| 20 | 30 | 35 | 32.5 | 65 | 110 | 130 | 120 |
| 21 | 60 | 40 | 50 | 66 | 320 | 360 | 340 |
| 22 | 60 | 50 | 55 | 67 | 300 | 300 | 300 |
| 23 | 30 | 60 | 45 | 68 | 280 | 290 | 285 |
| 24 | 60 | 60 | 60 | 69 | 310 | 380 | 345 |
| 25 | 50 | 40 | 45 | 70 | 320 | 360 | 340 |
| 26 | 50 | 60 | 55 | 71 | 420 | 500 | 460 |
| 27 | 20 | 20 | 20 | 72 | 400 | 520 | 460 |
| 28 | 40 | 40 | 40 | 73 | 250 | 790 | 520 |
| 29 | 40 | 50 | 45 | 74 | 420 | 480 | 450 |
| 30 | 20 | 20 | 20 | 75 | 180 | 120 | 150 |
| 31 | 30 | 10 | 20 | 76 | 110 | 350 | 230 |
| 32 | 40 | 40 | 40 | 77 | 200 | 100 | 150 |
| 33 | 20 | 10 | 15 | 78 | 180 | 80 | 130 |
| 34 | 40 | 40 | 40 | 79 | 260 | 60 | 160 |
| 35 | 20 | 10 | 15 | 80 | 300 | 30 | 165 |
| 36 | 70 | 50 | 60 | 81 | 380 | 70 | 225 |
| 37 | 50 | 100 | 75 | 82 | 430 | 40 | 235 |
| 38 | 120 | 40 | 80 | 83 | 300 | 20 | 160 |
| 39 | 15 | 15 | 15 | 84 | 260 | 30 | 145 |
| 40 | 60 | 20 | 40 | 85 | 160 | 20 | 90 |
| 41 | 20 | 30 | 25 | 86 | 160 | 40 | 100 |
| 42 | 20 | 20 | 20 | 87 | 110 | 50 | 80 |
| 43 | 40 | 30 | 35 | 88 | 110 | 50 | 85 |
| 44 | 70 | 100 | 85 | 89 | 100 | 60 | 80 |
| 45 | 220 | 200 | 210 | 90 | 80 | 50 | 65 |

**Treatment 26**
**Daily biogas production of cowdung and poultry deep litter as feedstock in 2:1 ratio with 15 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 1570 | 1970 | 1770 | 46 | 10 | 30 | 20 |
| 2 | 1330 | 1240 | 1285 | 47 | 0 | 10 | 5 |
| 3 | 800 | 780 | 790 | 48 | 10 | 40 | 25 |
| 4 | 700 | 710 | 705 | 49 | 0 | 10 | 5 |
| 5 | 120 | 170 | 145 | 50 | 0 | 30 | 15 |
| 6 | 100 | 180 | 140 | 51 | 40 | 40 | 40 |
| 7 | 360 | 430 | 395 | 52 | 20 | 20 | 20 |
| 8 | 340 | 330 | 335 | 53 | 40 | 20 | 30 |
| 9 | 290 | 290 | 290 | 54 | 20 | 10 | 15 |
| 10 | 100 | 180 | 140 | 55 | 30 | 10 | 20 |
| 11 | 240 | 230 | 235 | 56 | 20 | 20 | 20 |
| 12 | 100 | 130 | 115 | 57 | 10 | 10 | 10 |
| 13 | 20 | 30 | 25 | 58 | 50 | 30 | 40 |
| 14 | 60 | 60 | 60 | 59 | 100 | 130 | 115 |
| 15 | 40 | 40 | 40 | 60 | 0 | 0 | 0 |
| 16 | 30 | 20 | 25 | 61 | 20 | 10 | 15 |
| 17 | 100 | 80 | 90 | 62 | 0 | 0 | 0 |
| 18 | 40 | 20 | 30 | 63 | 20 | 20 | 20 |
| 19 | 40 | 30 | 35 | 64 | 0 | 0 | 0 |
| 20 | 20 | 10 | 15 | 65 | 60 | 40 | 50 |
| 21 | 50 | 50 | 50 | 66 | 110 | 150 | 130 |
| 22 | 50 | 40 | 45 | 67 | 110 | 140 | 125 |
| 23 | 30 | 20 | 25 | 68 | 0 | 0 | 0 |
| 24 | 50 | 60 | 55 | 69 | 0 | 0 | 0 |
| 25 | 60 | 40 | 50 | 70 | 0 | 0 | 0 |
| 26 | 50 | 40 | 45 | 71 | 50 | 20 | 35 |
| 27 | 10 | 10 | 10 | 72 | 40 | 20 | 30 |
| 28 | 20 | 0 | 10 | 73 | 100 | 40 | 70 |
| 29 | 140 | 150 | 145 | 74 | 40 | 40 | 40 |
| 30 | 50 | 50 | 50 | 75 | 20 | 0 | 10 |
| 31 | 40 | 30 | 35 | 76 | 0 | 0 | 0 |
| 32 | 50 | 40 | 45 | 77 | 0 | 0 | 0 |
| 33 | 0 | 20 | 10 | 78 | 0 | 0 | 0 |
| 34 | 60 | 40 | 50 | 79 | 0 | 0 | 0 |
| 35 | 10 | 20 | 15 | 80 | 0 | 0 | 0 |
| 36 | 120 | 60 | 90 | 81 | 0 | 0 | 0 |
| 37 | 130 | 90 | 110 | 82 | 0 | 0 | 0 |
| 38 | 60 | 40 | 50 | 83 | 10 | 10 | 10 |
| 39 | 20 | 20 | 20 | 84 | 0 | 0 | 0 |
| 40 | 25 | 30 | 27.5 | 85 | 0 | 0 | 0 |
| 41 | 20 | 30 | 25 | | | | |
| 42 | 10 | 10 | 10 | | | | |
| 43 | 50 | 10 | 30 | | | | |
| 44 | 70 | 90 | 80 | | | | |
| 45 | 20 | 20 | 20 | | | | |

**Treatment 27**

**Daily biogas production of cowdung and poultry deep litter as feedstock in 2:1 ratio with 20 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 1250 | 910 | 1080 | 46 | 80 | 120 | 100 |
| 2 | 1070 | 1220 | 1145 | 47 | 180 | 110 | 145 |
| 3 | 600 | 780 | 690 | 48 | 140 | 150 | 145 |
| 4 | 680 | 670 | 675 | 49 | 180 | 100 | 140 |
| 5 | 220 | 300 | 260 | 50 | 230 | 200 | 215 |
| 6 | 400 | 480 | 440 | 51 | 180 | 280 | 230 |
| 7 | 650 | 690 | 670 | 52 | 200 | 150 | 175 |
| 8 | 360 | 320 | 340 | 53 | 300 | 290 | 295 |
| 9 | 320 | 380 | 350 | 54 | 240 | 250 | 245 |
| 10 | 260 | 285 | 272.5 | 55 | 350 | 350 | 350 |
| 11 | 600 | 400 | 500 | 56 | 350 | 460 | 405 |
| 12 | 600 | 450 | 525 | 57 | 550 | 900 | 725 |
| 13 | 250 | 260 | 255 | 58 | 600 | 700 | 650 |
| 14 | 250 | 180 | 215 | 59 | 780 | 720 | 750 |
| 15 | 120 | 100 | 110 | 60 | 360 | 350 | 355 |
| 16 | 280 | 190 | 235 | 61 | 700 | 400 | 550 |
| 17 | 260 | 210 | 235 | 62 | 220 | 210 | 215 |
| 18 | 140 | 120 | 130 | 63 | 410 | 420 | 415 |
| 19 | 80 | 90 | 85 | 64 | 200 | 210 | 205 |
| 20 | 70 | 65 | 67.5 | 65 | 190 | 180 | 185 |
| 21 | 130 | 120 | 125 | 66 | 400 | 720 | 560 |
| 22 | 100 | 60 | 80 | 67 | 400 | 700 | 550 |
| 23 | 60 | 50 | 55 | 68 | 180 | 190 | 185 |
| 24 | 100 | 90 | 95 | 69 | 160 | 170 | 165 |
| 25 | 90 | 80 | 85 | 70 | 180 | 170 | 175 |
| 26 | 80 | 90 | 85 | 71 | 350 | 220 | 285 |
| 27 | 80 | 70 | 75 | 72 | 360 | 200 | 280 |
| 28 | 80 | 70 | 75 | 73 | 620 | 400 | 510 |
| 29 | 140 | 160 | 150 | 74 | 340 | 220 | 280 |
| 30 | 50 | 50 | 50 | 75 | 180 | 100 | 140 |
| 31 | 40 | 40 | 40 | 76 | 80 | 40 | 60 |
| 32 | 90 | 90 | 90 | 77 | 100 | 100 | 100 |
| 33 | 40 | 30 | 35 | 78 | 90 | 90 | 90 |
| 34 | 50 | 80 | 65 | 79 | 80 | 80 | 80 |
| 35 | 70 | 50 | 60 | 80 | 60 | 60 | 60 |
| 36 | 170 | 160 | 165 | 81 | 160 | 80 | 120 |
| 37 | 190 | 190 | 190 | 82 | 50 | 50 | 50 |
| 38 | 80 | 80 | 80 | 83 | 20 | 20 | 20 |
| 39 | 40 | 50 | 45 | 84 | 10 | 10 | 10 |
| 40 | 50 | 60 | 55 | 85 | 0 | 0 | 0 |
| 41 | 90 | 90 | 90 | 86 | 20 | 20 | 20 |
| 42 | 40 | 40 | 40 | 87 | 10 | 10 | 10 |
| 43 | 50 | 40 | 45 | 88 | 0 | 0 | 0 |
| 44 | 170 | 150 | 160 | 89 | 50 | 50 | 50 |
| 45 | 100 | 120 | 110 | 90 | 30 | 50 | 40 |

**Treatment 28**
**Daily biogas production of cowdung and poultry droppings as feedstock in 1:1 ratio with 5 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 220 | 160 | 190 | 46 | 80 | 120 | 100 |
| 2 | 290 | 305 | 297.5 | 47 | 300 | 200 | 250 |
| 3 | 280 | 310 | 295 | 48 | 220 | 190 | 205 |
| 4 | 330 | 300 | 315 | 49 | 170 | 180 | 175 |
| 5 | 40 | 80 | 60 | 50 | 240 | 220 | 230 |
| 6 | 100 | 160 | 130 | 51 | 240 | 180 | 210 |
| 7 | 530 | 0 | 265 | 52 | 250 | 200 | 225 |
| 8 | 240 | 180 | 210 | 53 | 220 | 250 | 235 |
| 9 | 160 | 150 | 155 | 54 | 170 | 140 | 155 |
| 10 | 130 | 140 | 135 | 55 | 180 | 160 | 170 |
| 11 | 200 | 310 | 255 | 56 | 190 | 130 | 160 |
| 12 | 260 | 275 | 267.5 | 57 | 170 | 150 | 160 |
| 13 | 250 | 160 | 205 | 58 | 220 | 190 | 205 |
| 14 | 150 | 240 | 195 | 59 | 240 | 240 | 240 |
| 15 | 100 | 90 | 95 | 60 | 50 | 60 | 55 |
| 16 | 200 | 120 | 160 | 61 | 160 | 190 | 175 |
| 17 | 300 | 180 | 240 | 62 | 50 | 30 | 40 |
| 18 | 200 | 150 | 175 | 63 | 180 | 200 | 190 |
| 19 | 120 | 140 | 130 | 64 | 100 | 60 | 80 |
| 20 | 130 | 140 | 135 | 65 | 140 | 110 | 125 |
| 21 | 160 | 170 | 165 | 66 | 210 | 230 | 220 |
| 22 | 160 | 160 | 160 | 67 | 200 | 230 | 215 |
| 23 | 110 | 150 | 130 | 68 | 40 | 30 | 35 |
| 24 | 230 | 220 | 225 | 69 | 30 | 20 | 25 |
| 25 | 260 | 240 | 250 | 70 | 50 | 30 | 40 |
| 26 | 200 | 180 | 190 | 71 | 140 | 80 | 110 |
| 27 | 140 | 20 | 80 | 72 | 120 | 90 | 105 |
| 28 | 230 | 210 | 220 | 73 | 180 | 140 | 160 |
| 29 | 300 | 300 | 300 | 74 | 140 | 100 | 120 |
| 30 | 230 | 210 | 220 | 75 | 140 | 120 | 130 |
| 31 | 200 | 180 | 190 | 76 | 100 | 100 | 100 |
| 32 | 270 | 220 | 245 | 77 | 120 | 100 | 110 |
| 33 | 230 | 200 | 215 | 78 | 110 | 120 | 115 |
| 34 | 340 | 310 | 325 | 79 | 100 | 80 | 90 |
| 35 | 260 | 270 | 265 | 80 | 80 | 70 | 75 |
| 36 | 620 | 230 | 425 | 81 | 120 | 150 | 135 |
| 37 | 270 | 400 | 335 | 82 | 40 | 40 | 40 |
| 38 | 360 | 250 | 305 | 83 | 20 | 10 | 15 |
| 39 | 180 | 140 | 160 | 84 | 10 | 10 | 10 |
| 40 | 190 | 160 | 175 | 85 | 0 | 0 | 0 |
| 41 | 250 | 200 | 225 | 86 | 10 | 20 | 15 |
| 42 | 160 | 120 | 140 | 87 | 10 | 10 | 10 |
| 43 | 200 | 180 | 190 | 88 | 0 | 0 | 0 |
| 44 | 250 | 180 | 215 | 89 | 10 | 10 | 10 |
| 45 | 200 | 210 | 205 | 90 | 40 | 20 | 30 |

**Treatment 29**

**Daily biogas production of cowdung and poultry droppings as feedstock in 1:1 ratio with 10 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 620 | 430 | 525 | 46 | 360 | 320 | 340 |
| 2 | 640 | 1270 | 955 | 47 | 730 | 500 | 615 |
| 3 | 670 | 635 | 652.5 | 48 | 580 | 550 | 565 |
| 4 | 1120 | 1190 | 1155 | 49 | 210 | 530 | 370 |
| 5 | 610 | 580 | 595 | 50 | 580 | 590 | 585 |
| 6 | 780 | 620 | 700 | 51 | 600 | 720 | 660 |
| 7 | 970 | 830 | 900 | 52 | 410 | 600 | 505 |
| 8 | 530 | 420 | 475 | 53 | 610 | 750 | 680 |
| 9 | 380 | 400 | 390 | 54 | 500 | 580 | 540 |
| 10 | 330 | 350 | 340 | 55 | 470 | 530 | 500 |
| 11 | 320 | 360 | 340 | 56 | 460 | 650 | 555 |
| 12 | 680 | 720 | 700 | 57 | 420 | 480 | 450 |
| 13 | 300 | 310 | 305 | 58 | 460 | 600 | 530 |
| 14 | 300 | 300 | 300 | 59 | 490 | 700 | 595 |
| 15 | 135 | 150 | 142.5 | 60 | 250 | 320 | 285 |
| 16 | 180 | 190 | 185 | 61 | 450 | 400 | 425 |
| 17 | 550 | 600 | 575 | 62 | 180 | 220 | 200 |
| 18 | 230 | 270 | 250 | 63 | 480 | 420 | 450 |
| 19 | 180 | 160 | 170 | 64 | 360 | 450 | 405 |
| 20 | 130 | 120 | 125 | 65 | 460 | 520 | 490 |
| 21 | 180 | 170 | 175 | 66 | 300 | 720 | 510 |
| 22 | 190 | 200 | 195 | 67 | 300 | 720 | 510 |
| 23 | 150 | 150 | 150 | 68 | 690 | 670 | 680 |
| 24 | 230 | 220 | 225 | 69 | 570 | 570 | 570 |
| 25 | 220 | 210 | 215 | 70 | 570 | 590 | 580 |
| 26 | 120 | 200 | 160 | 71 | 250 | 410 | 330 |
| 27 | 160 | 180 | 170 | 72 | 260 | 430 | 345 |
| 28 | 220 | 40 | 130 | 73 | 470 | 250 | 360 |
| 29 | 340 | 320 | 330 | 74 | 280 | 400 | 340 |
| 30 | 410 | 360 | 385 | 75 | 200 | 200 | 200 |
| 31 | 350 | 390 | 370 | 76 | 200 | 250 | 225 |
| 32 | 410 | 400 | 405 | 77 | 180 | 240 | 210 |
| 33 | 190 | 170 | 180 | 78 | 170 | 200 | 185 |
| 34 | 330 | 340 | 335 | 79 | 160 | 180 | 170 |
| 35 | 330 | 300 | 315 | 80 | 140 | 160 | 150 |
| 36 | 700 | 610 | 655 | 81 | 250 | 250 | 250 |
| 37 | 500 | 440 | 470 | 82 | 110 | 110 | 110 |
| 38 | 420 | 480 | 450 | 83 | 100 | 100 | 100 |
| 39 | 300 | 330 | 315 | 84 | 80 | 80 | 80 |
| 40 | 330 | 320 | 325 | 85 | 40 | 40 | 40 |
| 41 | 400 | 470 | 435 | 86 | 100 | 100 | 100 |
| 42 | 340 | 360 | 350 | 87 | 90 | 70 | 80 |
| 43 | 460 | 510 | 485 | 88 | 100 | 120 | 110 |
| 44 | 520 | 540 | 530 | 89 | 70 | 130 | 100 |
| 45 | 310 | 320 | 315 | 90 | 90 | 110 | 100 |

## Treatment 30
## Daily biogas production of cowdung and poultry droppings as feedstock in 1:1 ratio with 15 per cent TS

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 860 | 1430 | 1145 | 46 | 500 | 480 | 490 |
| 2 | 1530 | 1370 | 1450 | 47 | 650 | 720 | 685 |
| 3 | 900 | 610 | 755 | 48 | 550 | 800 | 675 |
| 4 | 1380 | 1450 | 1415 | 49 | 540 | 720 | 630 |
| 5 | 1420 | 1250 | 1335 | 50 | 760 | 900 | 830 |
| 6 | 1510 | 1340 | 1425 | 51 | 820 | 1000 | 910 |
| 7 | 450 | 430 | 440 | 52 | 720 | 810 | 765 |
| 8 | 430 | 400 | 415 | 53 | 980 | 820 | 900 |
| 9 | 500 | 640 | 570 | 54 | 800 | 600 | 700 |
| 10 | 620 | 700 | 660 | 55 | 860 | 940 | 900 |
| 11 | 80 | 280 | 180 | 56 | 930 | 950 | 940 |
| 12 | 300 | 320 | 310 | 57 | 1100 | 950 | 1025 |
| 13 | 260 | 180 | 220 | 58 | 860 | 920 | 890 |
| 14 | 220 | 260 | 240 | 59 | 700 | 900 | 800 |
| 15 | 135 | 120 | 127.5 | 60 | 350 | 380 | 365 |
| 16 | 200 | 220 | 210 | 61 | 450 | 450 | 450 |
| 17 | 380 | 240 | 310 | 62 | 260 | 120 | 190 |
| 18 | 550 | 600 | 575 | 63 | 400 | 450 | 425 |
| 19 | 150 | 270 | 210 | 64 | 320 | 320 | 320 |
| 20 | 200 | 180 | 190 | 65 | 280 | 310 | 295 |
| 21 | 180 | 220 | 200 | 66 | 400 | 450 | 425 |
| 22 | 230 | 220 | 225 | 67 | 300 | 720 | 510 |
| 23 | 200 | 200 | 200 | 68 | 240 | 270 | 255 |
| 24 | 240 | 240 | 240 | 69 | 210 | 200 | 205 |
| 25 | 240 | 270 | 255 | 70 | 230 | 200 | 215 |
| 26 | 60 | 300 | 180 | 71 | 320 | 360 | 340 |
| 27 | 140 | 190 | 165 | 72 | 310 | 370 | 340 |
| 28 | 330 | 350 | 340 | 73 | 510 | 540 | 525 |
| 29 | 360 | 440 | 400 | 74 | 300 | 390 | 345 |
| 30 | 360 | 360 | 360 | 75 | 600 | 300 | 450 |
| 31 | 250 | 310 | 280 | 76 | 320 | 320 | 320 |
| 32 | 410 | 400 | 405 | 77 | 310 | 300 | 305 |
| 33 | 430 | 380 | 405 | 78 | 280 | 280 | 280 |
| 34 | 510 | 520 | 515 | 79 | 200 | 240 | 220 |
| 35 | 370 | 450 | 410 | 80 | 130 | 230 | 180 |
| 36 | 700 | 1050 | 875 | 81 | 280 | 240 | 260 |
| 37 | 400 | 750 | 575 | 82 | 180 | 160 | 170 |
| 38 | 640 | 600 | 620 | 83 | 30 | 120 | 75 |
| 39 | 430 | 430 | 430 | 84 | 20 | 100 | 60 |
| 40 | 460 | 440 | 450 | 85 | 10 | 40 | 25 |
| 41 | 600 | 670 | 635 | 86 | 60 | 90 | 75 |
| 42 | 300 | 550 | 425 | 87 | 40 | 80 | 60 |
| 43 | 420 | 640 | 530 | 88 | 40 | 40 | 40 |
| 44 | 580 | 700 | 640 | 89 | 40 | 60 | 50 |
| 45 | 520 | 570 | 545 | 90 | 30 | 30 | 30 |

## Treatment 31

**Daily biogas production of cowdung and poultry droppings as feedstock in 1:2 ratio with 5 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 125 | 125 | 125 | 46 | 190 | 190 | 190 |
| 2 | 230 | 280 | 255 | 47 | 270 | 180 | 225 |
| 3 | 310 | 290 | 300 | 48 | 200 | 180 | 190 |
| 4 | 290 | 300 | 295 | 49 | 90 | 110 | 100 |
| 5 | 180 | 180 | 180 | 50 | 130 | 130 | 130 |
| 6 | 220 | 200 | 210 | 51 | 200 | 180 | 190 |
| 7 | 420 | 470 | 445 | 52 | 180 | 210 | 195 |
| 8 | 230 | 220 | 225 | 53 | 200 | 180 | 190 |
| 9 | 220 | 190 | 205 | 54 | 160 | 120 | 140 |
| 10 | 130 | 140 | 135 | 55 | 150 | 200 | 175 |
| 11 | 150 | 180 | 165 | 56 | 180 | 260 | 220 |
| 12 | 310 | 280 | 295 | 57 | 160 | 150 | 155 |
| 13 | 120 | 170 | 145 | 58 | 220 | 180 | 200 |
| 14 | 160 | 130 | 145 | 59 | 240 | 230 | 235 |
| 15 | 50 | 60 | 55 | 60 | 40 | 40 | 40 |
| 16 | 130 | 150 | 140 | 61 | 180 | 130 | 155 |
| 17 | 200 | 210 | 205 | 62 | 50 | 70 | 60 |
| 18 | 110 | 150 | 130 | 63 | 150 | 200 | 175 |
| 19 | 70 | 120 | 95 | 64 | 120 | 180 | 150 |
| 20 | 80 | 90 | 85 | 65 | 140 | 110 | 125 |
| 21 | 120 | 140 | 130 | 66 | 580 | 180 | 380 |
| 22 | 160 | 170 | 165 | 67 | 500 | 190 | 345 |
| 23 | 120 | 120 | 120 | 68 | 210 | 180 | 195 |
| 24 | 140 | 150 | 145 | 69 | 210 | 220 | 215 |
| 25 | 150 | 150 | 150 | 70 | 220 | 220 | 220 |
| 26 | 170 | 150 | 160 | 71 | 180 | 180 | 180 |
| 27 | 190 | 150 | 170 | 72 | 190 | 180 | 185 |
| 28 | 170 | 180 | 175 | 73 | 250 | 290 | 270 |
| 29 | 220 | 250 | 235 | 74 | 210 | 200 | 205 |
| 30 | 160 | 170 | 165 | 75 | 120 | 140 | 130 |
| 31 | 150 | 130 | 140 | 76 | 130 | 170 | 150 |
| 32 | 130 | 210 | 170 | 77 | 90 | 130 | 110 |
| 33 | 180 | 180 | 180 | 78 | 80 | 100 | 90 |
| 34 | 220 | 220 | 220 | 79 | 70 | 60 | 65 |
| 35 | 170 | 170 | 170 | 80 | 70 | 60 | 65 |
| 36 | 530 | 510 | 520 | 81 | 110 | 130 | 120 |
| 37 | 390 | 380 | 385 | 82 | 40 | 50 | 45 |
| 38 | 300 | 300 | 300 | 83 | 20 | 50 | 35 |
| 39 | 160 | 190 | 175 | 84 | 20 | 20 | 20 |
| 40 | 180 | 170 | 175 | 85 | 10 | 10 | 10 |
| 41 | 260 | 240 | 250 | 86 | 40 | 60 | 50 |
| 42 | 170 | 160 | 165 | 87 | 30 | 40 | 35 |
| 43 | 160 | 190 | 175 | 88 | 20 | 20 | 20 |
| 44 | 230 | 260 | 245 | 89 | 40 | 40 | 40 |
| 45 | 180 | 190 | 185 | 90 | 40 | 60 | 50 |

**Treatment 32**
**Daily biogas production of cowdung and poultry droppings as feedstock in 1:2 ratio with 10 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 455 | 515 | 485 | 46 | 20 | 200 | 110 |
| 2 | 600 | 800 | 700 | 47 | 520 | 20 | 270 |
| 3 | 730 | 780 | 755 | 48 | 550 | 530 | 540 |
| 4 | 690 | 600 | 645 | 49 | 80 | 80 | 80 |
| 5 | 410 | 460 | 435 | 50 | 400 | 160 | 280 |
| 6 | 510 | 590 | 550 | 51 | 590 | 150 | 370 |
| 7 | 510 | 160 | 335 | 52 | 350 | 230 | 290 |
| 8 | 420 | 400 | 410 | 53 | 500 | 410 | 455 |
| 9 | 350 | 335 | 342.5 | 54 | 420 | 400 | 410 |
| 10 | 230 | 180 | 205 | 55 | 500 | 100 | 300 |
| 11 | 250 | 160 | 205 | 56 | 500 | 370 | 435 |
| 12 | 390 | 400 | 395 | 57 | 400 | 400 | 400 |
| 13 | 200 | 210 | 205 | 58 | 460 | 490 | 475 |
| 14 | 170 | 200 | 185 | 59 | 630 | 470 | 550 |
| 15 | 120 | 100 | 110 | 60 | 90 | 80 | 85 |
| 16 | 180 | 200 | 190 | 61 | 410 | 300 | 355 |
| 17 | 270 | 250 | 260 | 62 | 180 | 190 | 185 |
| 18 | 210 | 220 | 215 | 63 | 420 | 380 | 400 |
| 19 | 120 | 120 | 120 | 64 | 330 | 300 | 315 |
| 20 | 100 | 90 | 95 | 65 | 140 | 110 | 125 |
| 21 | 180 | 190 | 185 | 66 | 250 | 350 | 300 |
| 22 | 100 | 120 | 110 | 67 | 250 | 350 | 300 |
| 23 | 140 | 150 | 145 | 68 | 120 | 100 | 110 |
| 24 | 150 | 150 | 150 | 69 | 80 | 110 | 95 |
| 25 | 160 | 150 | 155 | 70 | 90 | 110 | 100 |
| 26 | 190 | 180 | 185 | 71 | 440 | 410 | 425 |
| 27 | 150 | 150 | 150 | 72 | 410 | 410 | 410 |
| 28 | 190 | 210 | 200 | 73 | 700 | 820 | 760 |
| 29 | 260 | 270 | 265 | 74 | 420 | 420 | 420 |
| 30 | 290 | 280 | 285 | 75 | 460 | 300 | 380 |
| 31 | 210 | 220 | 215 | 76 | 250 | 250 | 250 |
| 32 | 240 | 230 | 235 | 77 | 250 | 200 | 225 |
| 33 | 200 | 210 | 205 | 78 | 180 | 180 | 180 |
| 34 | 390 | 280 | 335 | 79 | 120 | 160 | 140 |
| 35 | 250 | 300 | 275 | 80 | 100 | 130 | 115 |
| 36 | 630 | 600 | 615 | 81 | 180 | 170 | 175 |
| 37 | 440 | 550 | 495 | 82 | 110 | 90 | 100 |
| 38 | 460 | 460 | 460 | 83 | 90 | 60 | 75 |
| 39 | 280 | 140 | 210 | 84 | 80 | 60 | 70 |
| 40 | 260 | 160 | 210 | 85 | 60 | 60 | 60 |
| 41 | 440 | 420 | 430 | 86 | 80 | 100 | 90 |
| 42 | 350 | 360 | 355 | 87 | 70 | 80 | 75 |
| 43 | 430 | 380 | 405 | 88 | 70 | 70 | 70 |
| 44 | 270 | 450 | 360 | 89 | 40 | 80 | 60 |
| 45 | 20 | 200 | 110 | 90 | 80 | 100 | 90 |

## Treatment 33

## Daily biogas production of cowdung and poultry droppings as feedstock in 1:1 ratio with 15 per cent TS

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 770 | 785 | 777.5 | 46 | 400 | 240 | 320 |
| 2 | 980 | 1440 | 1210 | 47 | 500 | 300 | 400 |
| 3 | 620 | 1000 | 810 | 48 | 780 | 20 | 400 |
| 4 | 1070 | 1150 | 1110 | 49 | 820 | 300 | 560 |
| 5 | 740 | 780 | 760 | 50 | 530 | 320 | 425 |
| 6 | 680 | 710 | 695 | 51 | 720 | 280 | 500 |
| 7 | 510 | 1150 | 830 | 52 | 800 | 430 | 615 |
| 8 | 400 | 520 | 460 | 53 | 500 | 280 | 390 |
| 9 | 330 | 300 | 315 | 54 | 600 | 200 | 400 |
| 10 | 200 | 360 | 280 | 55 | 550 | 290 | 420 |
| 11 | 330 | 410 | 370 | 56 | 260 | 300 | 280 |
| 12 | 310 | 720 | 515 | 57 | 530 | 300 | 415 |
| 13 | 270 | 180 | 225 | 58 | 400 | 300 | 350 |
| 14 | 180 | 220 | 200 | 59 | 400 | 280 | 340 |
| 15 | 100 | 120 | 110 | 60 | 310 | 320 | 315 |
| 16 | 170 | 200 | 185 | 61 | 370 | 330 | 350 |
| 17 | 380 | 280 | 330 | 62 | 230 | 240 | 235 |
| 18 | 230 | 190 | 210 | 63 | 410 | 300 | 355 |
| 19 | 180 | 210 | 195 | 64 | 130 | 170 | 150 |
| 20 | 110 | 160 | 135 | 65 | 110 | 130 | 120 |
| 21 | 200 | 210 | 205 | 66 | 400 | 280 | 340 |
| 22 | 200 | 210 | 205 | 67 | 400 | 270 | 335 |
| 23 | 200 | 170 | 185 | 68 | 120 | 140 | 130 |
| 24 | 200 | 250 | 225 | 69 | 100 | 90 | 95 |
| 25 | 210 | 240 | 225 | 70 | 100 | 100 | 100 |
| 26 | 230 | 230 | 230 | 71 | 300 | 250 | 275 |
| 27 | 200 | 140 | 170 | 72 | 310 | 260 | 285 |
| 28 | 220 | 250 | 235 | 73 | 550 | 500 | 525 |
| 29 | 330 | 400 | 365 | 74 | 320 | 280 | 300 |
| 30 | 240 | 240 | 240 | 75 | 170 | 260 | 215 |
| 31 | 200 | 210 | 205 | 76 | 160 | 300 | 230 |
| 32 | 320 | 380 | 350 | 77 | 100 | 130 | 115 |
| 33 | 300 | 250 | 275 | 78 | 100 | 100 | 100 |
| 34 | 300 | 340 | 320 | 79 | 100 | 100 | 100 |
| 35 | 300 | 340 | 320 | 80 | 90 | 200 | 145 |
| 36 | 750 | 300 | 525 | 81 | 720 | 200 | 460 |
| 37 | 620 | 290 | 455 | 82 | 80 | 120 | 100 |
| 38 | 580 | 320 | 450 | 83 | 50 | 70 | 60 |
| 39 | 290 | 240 | 265 | 84 | 40 | 70 | 55 |
| 40 | 560 | 240 | 400 | 85 | 20 | 30 | 25 |
| 41 | 570 | 330 | 450 | 86 | 60 | 20 | 40 |
| 42 | 530 | 290 | 410 | 87 | 80 | 70 | 75 |
| 43 | 610 | 380 | 495 | 88 | 70 | 70 | 70 |
| 44 | 690 | 270 | 480 | 89 | 60 | 60 | 60 |
| 45 | 410 | 190 | 300 | 90 | 100 | 80 | 90 |

**Treatment 34**
**Daily biogas production of cowdung and poultry droppings as feedstock in 2:1 ratio with 5 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 90 | 120 | 105 | 46 | 140 | 180 | 160 |
| 2 | 220 | 270 | 245 | 47 | 0 | 250 | 125 |
| 3 | 390 | 370 | 380 | 48 | 240 | 240 | 240 |
| 4 | 450 | 380 | 415 | 49 | 180 | 200 | 190 |
| 5 | 310 | 260 | 285 | 50 | 220 | 220 | 220 |
| 6 | 420 | 280 | 350 | 51 | 230 | 60 | 145 |
| 7 | 920 | 590 | 755 | 52 | 180 | 120 | 150 |
| 8 | 440 | 400 | 420 | 53 | 150 | 500 | 325 |
| 9 | 340 | 350 | 345 | 54 | 200 | 150 | 175 |
| 10 | 250 | 250 | 250 | 55 | 250 | 180 | 215 |
| 11 | 320 | 290 | 305 | 56 | 210 | 110 | 160 |
| 12 | 500 | 500 | 500 | 57 | 230 | 160 | 195 |
| 13 | 280 | 250 | 265 | 58 | 20 | 160 | 90 |
| 14 | 250 | 200 | 225 | 59 | 40 | 160 | 100 |
| 15 | 120 | 130 | 125 | 60 | 80 | 90 | 85 |
| 16 | 300 | 190 | 245 | 61 | 150 | 70 | 110 |
| 17 | 460 | 300 | 380 | 62 | 70 | 40 | 55 |
| 18 | 410 | 200 | 305 | 63 | 170 | 100 | 135 |
| 19 | 280 | 220 | 250 | 64 | 100 | 30 | 65 |
| 20 | 220 | 180 | 200 | 65 | 30 | 60 | 45 |
| 21 | 170 | 220 | 195 | 66 | 220 | 160 | 190 |
| 22 | 0 | 250 | 125 | 67 | 210 | 170 | 190 |
| 23 | 160 | 180 | 170 | 68 | 90 | 60 | 75 |
| 24 | 240 | 250 | 245 | 69 | 60 | 70 | 65 |
| 25 | 240 | 250 | 245 | 70 | 50 | 60 | 55 |
| 26 | 230 | 310 | 270 | 71 | 120 | 80 | 100 |
| 27 | 220 | 220 | 220 | 72 | 110 | 90 | 100 |
| 28 | 320 | 240 | 280 | 73 | 180 | 160 | 170 |
| 29 | 400 | 320 | 360 | 74 | 100 | 100 | 100 |
| 30 | 290 | 210 | 250 | 75 | 80 | 80 | 80 |
| 31 | 490 | 260 | 375 | 76 | 50 | 100 | 75 |
| 32 | 300 | 250 | 275 | 77 | 20 | 20 | 20 |
| 33 | 240 | 170 | 205 | 78 | 20 | 20 | 20 |
| 34 | 280 | 240 | 260 | 79 | 30 | 30 | 30 |
| 35 | 200 | 150 | 175 | 80 | 40 | 30 | 35 |
| 36 | 540 | 440 | 490 | 81 | 50 | 60 | 55 |
| 37 | 330 | 300 | 315 | 82 | 30 | 30 | 30 |
| 38 | 320 | 400 | 360 | 83 | 10 | 10 | 10 |
| 39 | 180 | 110 | 145 | 84 | 0 | 0 | 0 |
| 40 | 160 | 240 | 200 | 85 | 0 | 0 | 0 |
| 41 | 240 | 210 | 225 | 86 | 40 | 80 | 60 |
| 42 | 160 | 180 | 170 | 87 | 110 | 40 | 75 |
| 43 | 210 | 240 | 225 | 88 | 130 | 60 | 95 |
| 44 | 10 | 280 | 145 | 89 | 140 | 60 | 100 |
| 45 | 190 | 200 | 195 | 90 | 100 | 40 | 70 |

**Treatment 35**

**Daily biogas production of cowdung and poultry droppings as feedstock in 1:1 ratio with 10 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 990 | 800 | 895 | 46 | 280 | 340 | 310 |
| 2 | 395 | 610 | 502.5 | 47 | 490 | 450 | 470 |
| 3 | 1000 | 980 | 990 | 48 | 500 | 530 | 515 |
| 4 | 840 | 870 | 855 | 49 | 370 | 480 | 425 |
| 5 | 1010 | 950 | 980 | 50 | 430 | 490 | 460 |
| 6 | 1330 | 1100 | 1215 | 51 | 440 | 550 | 495 |
| 7 | 1050 | 1070 | 1060 | 52 | 350 | 250 | 300 |
| 8 | 350 | 480 | 415 | 53 | 520 | 470 | 495 |
| 9 | 430 | 530 | 480 | 54 | 310 | 320 | 315 |
| 10 | 350 | 420 | 385 | 55 | 300 | 270 | 285 |
| 11 | 415 | 360 | 387.5 | 56 | 150 | 270 | 210 |
| 12 | 600 | 790 | 695 | 57 | 300 | 360 | 330 |
| 13 | 360 | 400 | 380 | 58 | 280 | 420 | 350 |
| 14 | 400 | 400 | 400 | 59 | 270 | 370 | 320 |
| 15 | 500 | 365 | 432.5 | 60 | 110 | 130 | 120 |
| 16 | 450 | 370 | 410 | 61 | 230 | 200 | 215 |
| 17 | 500 | 300 | 400 | 62 | 60 | 90 | 75 |
| 18 | 400 | 230 | 315 | 63 | 240 | 250 | 245 |
| 19 | 320 | 280 | 300 | 64 | 120 | 150 | 135 |
| 20 | 280 | 240 | 260 | 65 | 180 | 190 | 185 |
| 21 | 260 | 290 | 275 | 66 | 260 | 340 | 300 |
| 22 | 200 | 340 | 270 | 67 | 260 | 340 | 300 |
| 23 | 240 | 280 | 260 | 68 | 280 | 310 | 295 |
| 24 | 390 | 370 | 380 | 69 | 210 | 260 | 235 |
| 25 | 380 | 370 | 375 | 70 | 200 | 240 | 220 |
| 26 | 500 | 200 | 350 | 71 | 210 | 390 | 300 |
| 27 | 340 | 350 | 345 | 72 | 330 | 360 | 345 |
| 28 | 340 | 440 | 390 | 73 | 400 | 520 | 460 |
| 29 | 610 | 630 | 620 | 74 | 220 | 320 | 270 |
| 30 | 560 | 520 | 540 | 75 | 200 | 200 | 200 |
| 31 | 400 | 390 | 395 | 76 | 180 | 200 | 190 |
| 32 | 540 | 480 | 510 | 77 | 130 | 130 | 130 |
| 33 | 420 | 500 | 460 | 78 | 120 | 120 | 120 |
| 34 | 520 | 620 | 570 | 79 | 100 | 120 | 110 |
| 35 | 500 | 190 | 345 | 80 | 160 | 160 | 160 |
| 36 | 1050 | 1300 | 1175 | 81 | 170 | 170 | 170 |
| 37 | 800 | 900 | 850 | 82 | 100 | 80 | 90 |
| 38 | 680 | 640 | 660 | 83 | 60 | 60 | 60 |
| 39 | 360 | 400 | 380 | 84 | 50 | 50 | 50 |
| 40 | 730 | 660 | 695 | 85 | 30 | 30 | 30 |
| 41 | 550 | 550 | 550 | 86 | 80 | 120 | 100 |
| 42 | 460 | 540 | 500 | 87 | 60 | 100 | 80 |
| 43 | 510 | 590 | 550 | 88 | 60 | 80 | 70 |
| 44 | 640 | 420 | 530 | 89 | 70 | 90 | 80 |
| 45 | 260 | 380 | 320 | 90 | 50 | 50 | 50 |

**Treatment 36**
**Daily biogas production of cowdung and poultry droppings as feedstock in 2:1 ratio with 15 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 1680 | 1300 | 1490 | 46 | 420 | 320 | 370 |
| 2 | 420 | 470 | 445 | 47 | 560 | 850 | 705 |
| 3 | 1000 | 410 | 705 | 48 | 730 | 870 | 800 |
| 4 | 1770 | 1600 | 1685 | 49 | 550 | 850 | 700 |
| 5 | 1320 | 1100 | 1210 | 50 | 650 | 810 | 730 |
| 6 | 1620 | 1260 | 1440 | 51 | 620 | 780 | 700 |
| 7 | 1300 | 1430 | 1365 | 52 | 500 | 610 | 555 |
| 8 | 250 | 30 | 140 | 53 | 700 | 620 | 660 |
| 9 | 550 | 600 | 575 | 54 | 490 | 550 | 520 |
| 10 | 490 | 550 | 520 | 55 | 450 | 610 | 530 |
| 11 | 500 | 550 | 525 | 56 | 430 | 680 | 555 |
| 12 | 1000 | 1200 | 1100 | 57 | 500 | 630 | 565 |
| 13 | 150 | 250 | 200 | 58 | 580 | 960 | 770 |
| 14 | 850 | 400 | 625 | 59 | 600 | 880 | 740 |
| 15 | 600 | 350 | 475 | 60 | 200 | 150 | 175 |
| 16 | 600 | 550 | 575 | 61 | 350 | 950 | 650 |
| 17 | 900 | 800 | 850 | 62 | 120 | 100 | 110 |
| 18 | 300 | 400 | 350 | 63 | 400 | 830 | 615 |
| 19 | 290 | 400 | 345 | 64 | 300 | 470 | 385 |
| 20 | 270 | 370 | 320 | 65 | 380 | 390 | 385 |
| 21 | 300 | 240 | 270 | 66 | 540 | 560 | 550 |
| 22 | 350 | 230 | 290 | 67 | 560 | 560 | 560 |
| 23 | 325 | 320 | 322.5 | 68 | 480 | 410 | 445 |
| 24 | 420 | 270 | 345 | 69 | 460 | 490 | 475 |
| 25 | 410 | 280 | 345 | 70 | 470 | 410 | 440 |
| 26 | 500 | 230 | 365 | 71 | 480 | 400 | 440 |
| 27 | 500 | 350 | 425 | 72 | 430 | 420 | 425 |
| 28 | 530 | 340 | 435 | 73 | 780 | 760 | 770 |
| 29 | 1000 | 510 | 755 | 74 | 420 | 460 | 440 |
| 30 | 890 | 290 | 590 | 75 | 240 | 280 | 260 |
| 31 | 570 | 300 | 435 | 76 | 250 | 270 | 260 |
| 32 | 740 | 790 | 765 | 77 | 150 | 280 | 215 |
| 33 | 520 | 320 | 420 | 78 | 160 | 230 | 195 |
| 34 | 750 | 520 | 635 | 79 | 100 | 220 | 160 |
| 35 | 710 | 550 | 630 | 80 | 150 | 600 | 375 |
| 36 | 1270 | 1340 | 1305 | 81 | 180 | 320 | 250 |
| 37 | 870 | 840 | 855 | 82 | 100 | 200 | 150 |
| 38 | 920 | 600 | 760 | 83 | 100 | 190 | 145 |
| 39 | 420 | 390 | 405 | 84 | 80 | 100 | 90 |
| 40 | 900 | 550 | 725 | 85 | 40 | 60 | 50 |
| 41 | 650 | 310 | 480 | 86 | 180 | 300 | 240 |
| 42 | 500 | 500 | 500 | 87 | 100 | 230 | 165 |
| 43 | 620 | 690 | 655 | 88 | 140 | 280 | 210 |
| 44 | 440 | 680 | 560 | 89 | 140 | 180 | 160 |
| 45 | 290 | 360 | 325 | 90 | 160 | 210 | 185 |

**Treatment 37**
**Daily biogas production of poultry droppings as feedstock in 100 per cent with 5 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 275 | 160 | 217.5 | 46 | 100 | 80 | 90 |
| 2 | 120 | 170 | 145 | 47 | 120 | 120 | 120 |
| 3 | 300 | 230 | 265 | 48 | 110 | 20 | 65 |
| 4 | 250 | 180 | 215 | 49 | 60 | 60 | 60 |
| 5 | 200 | 170 | 185 | 50 | 80 | 40 | 60 |
| 6 | 340 | 210 | 275 | 51 | 70 | 70 | 70 |
| 7 | 400 | 100 | 250 | 52 | 50 | 60 | 55 |
| 8 | 200 | 0 | 100 | 53 | 90 | 100 | 95 |
| 9 | 220 | 80 | 150 | 54 | 40 | 30 | 35 |
| 10 | 105 | 10 | 57.5 | 55 | 50 | 40 | 45 |
| 11 | 100 | 30 | 65 | 56 | 50 | 50 | 50 |
| 12 | 50 | 20 | 35 | 57 | 60 | 50 | 55 |
| 13 | 70 | 40 | 55 | 58 | 80 | 60 | 70 |
| 14 | 110 | 0 | 55 | 59 | 100 | 80 | 90 |
| 15 | 40 | 20 | 30 | 60 | 100 | 120 | 110 |
| 16 | 100 | 70 | 85 | 61 | 40 | 20 | 30 |
| 17 | 40 | 40 | 40 | 62 | 50 | 50 | 50 |
| 18 | 30 | 80 | 55 | 63 | 80 | 70 | 75 |
| 19 | 80 | 60 | 70 | 64 | 40 | 20 | 30 |
| 20 | 30 | 30 | 30 | 65 | 40 | 30 | 35 |
| 21 | 70 | 50 | 60 | 66 | 110 | 170 | 140 |
| 22 | 50 | 50 | 50 | 67 | 100 | 170 | 135 |
| 23 | 60 | 50 | 55 | 68 | 100 | 150 | 125 |
| 24 | 50 | 50 | 50 | 69 | 80 | 120 | 100 |
| 25 | 50 | 60 | 55 | 70 | 90 | 110 | 100 |
| 26 | 70 | 80 | 75 | 71 | 120 | 100 | 110 |
| 27 | 40 | 40 | 40 | 72 | 140 | 90 | 115 |
| 28 | 70 | 60 | 65 | 73 | 180 | 150 | 165 |
| 29 | 100 | 100 | 100 | 74 | 200 | 160 | 180 |
| 30 | 70 | 60 | 65 | 75 | 90 | 60 | 75 |
| 31 | 60 | 60 | 60 | 76 | 130 | 80 | 105 |
| 32 | 110 | 60 | 85 | 77 | 80 | 40 | 60 |
| 33 | 60 | 40 | 50 | 78 | 70 | 50 | 60 |
| 34 | 100 | 80 | 90 | 79 | 60 | 40 | 50 |
| 35 | 70 | 70 | 70 | 80 | 30 | 60 | 45 |
| 36 | 250 | 220 | 235 | 81 | 80 | 60 | 70 |
| 37 | 190 | 180 | 185 | 82 | 60 | 40 | 50 |
| 38 | 170 | 160 | 165 | 83 | 5 | 5 | 5 |
| 39 | 40 | 50 | 45 | 84 | 0 | 0 | 0 |
| 40 | 160 | 180 | 170 | 85 | 0 | 0 | 0 |
| 41 | 120 | 150 | 135 | 86 | 40 | 70 | 55 |
| 42 | 80 | 100 | 90 | 87 | 40 | 50 | 45 |
| 43 | 110 | 100 | 105 | 88 | 50 | 70 | 60 |
| 44 | 230 | 160 | 195 | 89 | 60 | 60 | 60 |
| 45 | 120 | 110 | 115 | 90 | 100 | 100 | 100 |

**Treatment 38**
**Daily biogas production of poultry droppings as feedstock in 100 per cent with 10 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 600 | 650 | 625 | 46 | 250 | 100 | 175 |
| 2 | 1200 | 1270 | 1235 | 47 | 80 | 250 | 165 |
| 3 | 1050 | 1100 | 1075 | 48 | 80 | 270 | 175 |
| 4 | 700 | 710 | 705 | 49 | 50 | 280 | 165 |
| 5 | 370 | 240 | 305 | 50 | 30 | 280 | 155 |
| 6 | 500 | 360 | 430 | 51 | 30 | 280 | 155 |
| 7 | 750 | 885 | 817.5 | 52 | 40 | 250 | 145 |
| 8 | 310 | 360 | 335 | 53 | 30 | 680 | 355 |
| 9 | 410 | 420 | 415 | 54 | 10 | 300 | 155 |
| 10 | 0 | 240 | 120 | 55 | 20 | 260 | 140 |
| 11 | 140 | 220 | 180 | 56 | 20 | 260 | 140 |
| 12 | 50 | 380 | 215 | 57 | 30 | 150 | 90 |
| 13 | 100 | 260 | 180 | 58 | 50 | 260 | 155 |
| 14 | 70 | 170 | 120 | 59 | 80 | 280 | 180 |
| 15 | 50 | 150 | 100 | 60 | 110 | 120 | 115 |
| 16 | 100 | 450 | 275 | 61 | 20 | 200 | 110 |
| 17 | 100 | 210 | 155 | 62 | 50 | 200 | 125 |
| 18 | 100 | 120 | 110 | 63 | 50 | 200 | 125 |
| 19 | 60 | 100 | 80 | 64 | 10 | 160 | 85 |
| 20 | 60 | 80 | 70 | 65 | 30 | 40 | 35 |
| 21 | 120 | 110 | 115 | 66 | 140 | 200 | 170 |
| 22 | 130 | 130 | 130 | 67 | 130 | 210 | 170 |
| 23 | 110 | 80 | 95 | 68 | 210 | 180 | 195 |
| 24 | 110 | 130 | 120 | 69 | 180 | 150 | 165 |
| 25 | 100 | 120 | 110 | 70 | 170 | 160 | 165 |
| 26 | 90 | 110 | 100 | 71 | 30 | 220 | 125 |
| 27 | 80 | 120 | 100 | 72 | 50 | 250 | 150 |
| 28 | 170 | 120 | 145 | 73 | 70 | 400 | 235 |
| 29 | 200 | 180 | 190 | 74 | 80 | 380 | 230 |
| 30 | 120 | 110 | 115 | 75 | 30 | 200 | 115 |
| 31 | 100 | 120 | 110 | 76 | 40 | 210 | 125 |
| 32 | 160 | 150 | 155 | 77 | 20 | 170 | 95 |
| 33 | 140 | 130 | 135 | 78 | 40 | 160 | 100 |
| 34 | 60 | 80 | 70 | 79 | 30 | 140 | 85 |
| 35 | 110 | 120 | 115 | 80 | 20 | 120 | 70 |
| 36 | 180 | 330 | 255 | 81 | 20 | 160 | 90 |
| 37 | 150 | 300 | 225 | 82 | 30 | 130 | 80 |
| 38 | 130 | 270 | 200 | 83 | 0 | 100 | 50 |
| 39 | 40 | 150 | 95 | 84 | 0 | 50 | 25 |
| 40 | 120 | 270 | 195 | 85 | 0 | 20 | 10 |
| 41 | 80 | 250 | 165 | 86 | 10 | 60 | 35 |
| 42 | 40 | 180 | 110 | 87 | 10 | 30 | 20 |
| 43 | 70 | 140 | 105 | 88 | 20 | 50 | 35 |
| 44 | 110 | 270 | 190 | 89 | 30 | 50 | 40 |
| 45 | 60 | 100 | 80 | 90 | 20 | 10 | 15 |

**Treatment 39**
**Daily biogas production of poultry droppings as feedstock in 100 per cent with 15 per cent TS**

| Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) | Day | Rep.1 (ml) | Rep.2 (ml) | Average (ml) |
|---|---|---|---|---|---|---|---|
| 1 | 610 | 810 | 710 | 46 | 180 | 300 | 240 |
| 2 | 560 | 840 | 700 | 47 | 270 | 410 | 340 |
| 3 | 1140 | 1170 | 1155 | 48 | 370 | 370 | 370 |
| 4 | 1150 | 1120 | 1135 | 49 | 330 | 350 | 340 |
| 5 | 890 | 920 | 905 | 50 | 370 | 510 | 440 |
| 6 | 1100 | 1350 | 1225 | 51 | 0 | 580 | 290 |
| 7 | 180 | 620 | 400 | 52 | 310 | 450 | 380 |
| 8 | 240 | 540 | 390 | 53 | 380 | 300 | 340 |
| 9 | 100 | 400 | 250 | 54 | 0 | 580 | 290 |
| 10 | 340 | 460 | 400 | 55 | 400 | 590 | 495 |
| 11 | 420 | 510 | 465 | 56 | 350 | 550 | 450 |
| 12 | 460 | 560 | 510 | 57 | 420 | 640 | 530 |
| 13 | 240 | 200 | 220 | 58 | 450 | 650 | 550 |
| 14 | 230 | 230 | 230 | 59 | 500 | 900 | 700 |
| 15 | 200 | 210 | 205 | 60 | 90 | 180 | 135 |
| 16 | 200 | 180 | 190 | 61 | 400 | 430 | 415 |
| 17 | 480 | 200 | 340 | 62 | 470 | 510 | 490 |
| 18 | 160 | 150 | 155 | 63 | 520 | 700 | 610 |
| 19 | 160 | 130 | 145 | 64 | 390 | 600 | 495 |
| 20 | 100 | 100 | 100 | 65 | 380 | 480 | 430 |
| 21 | 130 | 100 | 115 | 66 | 470 | 720 | 595 |
| 22 | 120 | 150 | 135 | 67 | 480 | 710 | 595 |
| 23 | 110 | 100 | 105 | 68 | 700 | 900 | 800 |
| 24 | 120 | 140 | 130 | 69 | 680 | 810 | 745 |
| 25 | 100 | 100 | 100 | 70 | 640 | 790 | 715 |
| 26 | 120 | 120 | 120 | 71 | 400 | 680 | 540 |
| 27 | 100 | 100 | 100 | 72 | 480 | 690 | 585 |
| 28 | 120 | 130 | 125 | 73 | 650 | 720 | 685 |
| 29 | 150 | 170 | 160 | 74 | 400 | 700 | 550 |
| 30 | 110 | 110 | 110 | 75 | 300 | 340 | 320 |
| 31 | 80 | 90 | 85 | 76 | 320 | 300 | 310 |
| 32 | 130 | 150 | 140 | 77 | 270 | 260 | 265 |
| 33 | 110 | 100 | 105 | 78 | 200 | 240 | 220 |
| 34 | 140 | 150 | 145 | 79 | 200 | 180 | 190 |
| 35 | 150 | 160 | 155 | 80 | 190 | 270 | 230 |
| 36 | 350 | 320 | 335 | 81 | 220 | 260 | 240 |
| 37 | 280 | 330 | 305 | 82 | 140 | 160 | 150 |
| 38 | 230 | 270 | 250 | 83 | 0 | 120 | 60 |
| 39 | 70 | 110 | 90 | 84 | 20 | 100 | 60 |
| 40 | 280 | 320 | 300 | 85 | 10 | 60 | 35 |
| 41 | 220 | 250 | 235 | 86 | 60 | 100 | 80 |
| 42 | 200 | 230 | 215 | 87 | 50 | 70 | 60 |
| 43 | 320 | 350 | 335 | 88 | 70 | 100 | 85 |
| 44 | 10 | 450 | 230 | 89 | 70 | 110 | 90 |
| 45 | 130 | 350 | 240 | 90 | 100 | 120 | 110 |

## APPENDIX- B

# STATISTICAL ANALYSIS

### Analysis of variance for methane production

| Source | Degrees of freedom | Sum of squares | Mean sum of squares | F value | Significance |
|---|---|---|---|---|---|
| t | 38 | 196753.92 | 5177.73 | 233.74 | |
| w | 14 | 240264.38 | 17161.74 | 774.75 | |
| tw | 532 | 245601.95 | 461.66 | 20.84 | ** |
| Error | 585 | 12958.50 | 22.15 | 1.00 | |

| | SEd | CD (0.05) |
|---|---|---|
| t | 1.2152 | 2.3868 |
| w | 0.75365 | 1.48020 |
| tw | 4.7065 | 9.2438 |

### Analysis of variance of gas production

| Source | Degrees of freedom | Sum of squares | Mean sum of squares | F value | Significance |
|---|---|---|---|---|---|
| t | 38 | 98816850.54 | 2600443.44 | 364.18 | |
| d | 89 | 17371120.83 | 869338.47 | 121.75 | |
| td | 3382 | 187683562.92 | 55494.84 | 7.77 | ** |
| Error | 3510 | 25063062.50 | 7140.47 | 1.00 | |

| | SEd | CD (0.05) |
|---|---|---|
| t | 8.907 | 17.48 |
| d | 13.53 | 26.55 |
| td | 84.50 | 165.82 |

## Appendix - C

Temperature reading under the heat source of 300x300 cm base area for biogas brooder and LPG brooder are given in the tables.

All the values obtained in grid points are in degree centigrade (°C).

**BIOGAS BROODER**

Room temperature = 30 °C

Height of the biogas burner = 1 m from the ground level

Level = Ground level

| Grid points | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 30 | 31 | 32 | 32 | 33 | 33 | 33 | 32 | 31 | 31 | 30 |
| 2 | 31 | 32 | 33 | 33 | 33 | 34 | 33 | 32 | 31 | 30 | 30 |
| 3 | 32 | 32 | 32 | 33 | 34 | 34 | 33 | 33 | 32 | 31 | 31 |
| 4 | 32 | 33 | 33 | 33 | 34 | 35 | 34 | 33 | 33 | 32 | 32 |
| 5 | 33 | 33 | 33 | 34 | 35 | 35 | 35 | 34 | 34 | 33 | 33 |
| 6 | 34 | 34 | 35 | 35 | 35 | 36 | 35 | 35 | 35 | 34 | 34 |
| 7 | 34 | 34 | 34 | 34 | 35 | 35 | 35 | 35 | 34 | 33 | 33 |
| 8 | 33 | 33 | 33 | 34 | 35 | 35 | 35 | 35 | 34 | 33 | 32 |
| 9 | 33 | 33 | 33 | 33 | 34 | 34 | 34 | 34 | 33 | 33 | 32 |
| 10 | 32 | 33 | 33 | 33 | 33 | 33 | 33 | 32 | 32 | 32 | 31 |
| 11 | 31 | 31 | 31 | 32 | 32 | 33 | 33 | 32 | 31 | 30 | 30 |

**BIOGAS BROODER**

Room temperature = 32 °C

Height of the biogas burner = 1m from the ground level

Level= 5 cm from the ground level

| Grid points | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 33 | 33 | 33 | 34 | 34 | 34 | 35 | 34 | 34 | 33 | 32 |
| 2 | 34 | 34 | 34 | 34 | 35 | 35 | 35 | 34 | 34 | 33 | 33 |
| 3 | 35 | 35 | 35 | 35 | 36 | 36 | 35 | 35 | 35 | 34 | 34 |
| 4 | 35 | 35 | 35 | 35 | 36 | 36 | 35 | 35 | 35 | 34 | 34 |
| 5 | 35 | 35 | 35 | 35 | 36 | 36 | 36 | 35 | 35 | 34 | 34 |
| 6 | 35 | 35 | 35 | 36 | 36 | 36 | 36 | 35 | 35 | 35 | 35 |
| 7 | 34 | 34 | 34 | 35 | 35 | 36 | 36 | 35 | 35 | 35 | 34 |
| 8 | 34 | 34 | 34 | 35 | 35 | 35 | 35 | 35 | 34 | 34 | 34 |
| 9 | 33 | 34 | 34 | 35 | 35 | 35 | 35 | 35 | 35 | 34 | 34 |
| 10 | 33 | 34 | 34 | 35 | 35 | 35 | 35 | 35 | 34 | 34 | 33 |
| 11 | 32 | 32 | 32 | 33 | 34 | 34 | 34 | 34 | 34 | 33 | 32 |

**BIOGAS BROODER**

Room temperature = 32 °C

Height of the biogas burner = 75 cm from the ground level

Level = Ground level

| Grid points | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 33 | 33 | 32 | 33 | 34 | 34 | 33 | 33 | 33 | 32 | 32 |
| 2 | 33 | 33 | 33 | 34 | 35 | 35 | 34 | 34 | 33 | 33 | 32 |
| 3 | 34 | 34 | 34 | 35 | 36 | 35 | 35 | 35 | 34 | 34 | 33 |
| 4 | 35 | 35 | 35 | 36 | 36 | 36 | 36 | 36 | 35 | 35 | 34 |
| 5 | 35 | 35 | 36 | 36 | 37 | 37 | 37 | 36 | 36 | 35 | 34 |
| 6 | 35 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 35 | 35 |
| 7 | 35 | 35 | 35 | 35 | 35 | 36 | 36 | 35 | 35 | 35 | 34 |
| 8 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 34 | 34 |
| 9 | 34 | 34 | 34 | 35 | 34 | 35 | 35 | 34 | 34 | 34 | 33 |
| 10 | 34 | 34 | 33 | 34 | 34 | 34 | 34 | 33 | 33 | 33 | 32 |
| 11 | 33 | 33 | 32 | 33 | 33 | 34 | 33 | 33 | 32 | 32 | 32 |

**BIOGAS BROODER**

Room temperature = 32 °C

Height of the biogas burner = 75 cm from the ground level

Level = 5 cm from ground level

| Grid points | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 34 | 34 | 34 | 35 | 35 | 35 | 35 | 34 | 35 | 34 | 34 |
| 2 | 34 | 34 | 35 | 36 | 36 | 36 | 36 | 36 | 35 | 34 | 34 |
| 3 | 35 | 35 | 36 | 37 | 37 | 37 | 37 | 37 | 36 | 35 | 35 |
| 4 | 35 | 35 | 36 | 37 | 38 | 38 | 38 | 38 | 37 | 36 | 36 |
| 5 | 35 | 36 | 37 | 38 | 38 | 39 | 39 | 38 | 37 | 36 | 36 |
| 6 | 35 | 36 | 37 | 38 | 39 | 39 | 39 | 38 | 37 | 36 | 35 |
| 7 | 36 | 36 | 37 | 38 | 38 | 38 | 38 | 37 | 37 | 36 | 36 |
| 8 | 35 | 36 | 36 | 37 | 38 | 38 | 38 | 37 | 36 | 35 | 35 |
| 9 | 34 | 35 | 36 | 36 | 37 | 37 | 37 | 36 | 36 | 35 | 35 |
| 10 | 33 | 34 | 35 | 35 | 36 | 36 | 36 | 36 | 36 | 35 | 34 |
| 11 | 33 | 35 | 34 | 34 | 35 | 35 | 35 | 35 | 35 | 34 | 33 |

**LPG BROODER**

Room temperature = 29 °C

Height of the LPG burner = 1 m from the ground level.

Level= Ground level

| Grid points | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 28 | 29 | 29 | 29 | 30 | 30 | 30 | 30 | 29 | 28 | 29 |
| 2 | 30 | 30 | 30 | 30 | 31 | 31 | 31 | 31 | 31 | 30 | 29 |
| 3 | 30 | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 30 | 30 | 29 |
| 4 | 30 | 31 | 32 | 32 | 32 | 33 | 32 | 32 | 32 | 31 | 30 |
| 5 | 31 | 31 | 32 | 32 | 33 | 33 | 33 | 32 | 32 | 32 | 31 |
| 6 | 31 | 32 | 32 | 32 | 32 | 33 | 33 | 32 | 32 | 32 | 32 |
| 7 | 31 | 31 | 31 | 31 | 32 | 32 | 32 | 32 | 31 | 31 | 30 |
| 8 | 30 | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 30 | 30 |
| 9 | 29 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 29 | 29 |
| 10 | 28 | 29 | 29 | 29 | 30 | 30 | 29 | 29 | 30 | 29 | 29 |
| 11 | 28 | 27 | 27 | 28 | 29 | 29 | 28 | 28 | 28 | 27 | 28 |

**LPG BROODER**

Room temperature = 29 °C

Height of the LPG burner = 1 m from the ground level.

Level = 5 cm height from ground level

| Grid points | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 30 | 30 | 31 | 31 | 32 | 32 | 31 | 31 | 30 | 30 | 29 |
| 2 | 30 | 31 | 32 | 32 | 33 | 33 | 32 | 32 | 31 | 30 | 29 |
| 3 | 31 | 31 | 32 | 32 | 33 | 33 | 33 | 33 | 32 | 31 | 30 |
| 4 | 32 | 32 | 32 | 32 | 33 | 34 | 33 | 34 | 32 | 31 | 31 |
| 5 | 33 | 33 | 33 | 33 | 34 | 34 | 34 | 34 | 33 | 32 | 32 |
| 6 | 32 | 32 | 33 | 33 | 34 | 34 | 34 | 33 | 33 | 33 | 32 |
| 7 | 31 | 31 | 32 | 32 | 33 | 33 | 33 | 33 | 32 | 32 | 32 |
| 8 | 30 | 30 | 30 | 31 | 32 | 32 | 33 | 32 | 32 | 31 | 31 |
| 9 | 29 | 30 | 30 | 31 | 31 | 32 | 33 | 32 | 31 | 30 | 30 |
| 10 | 29 | 30 | 30 | 31 | 31 | 32 | 32 | 31 | 30 | 30 | 29 |
| 11 | 28 | 28 | 28 | 29 | 30 | 31 | 31 | 30 | 30 | 30 | 29 |

## APPENDIX - D

## ENERGY CONSUMPTION IN BROODERS

**a. For biogas brooder ( burner type )**

| | |
|---|---|
| The biogas consumption per hour in biogas burner | = $0.35\ m^3$ |
| The biogas required per day per brooder | = 0.35 x 24 |
| | = $8.4\ m^3$ |
| The total biogas energy required for brooding of first two weeks | = 24 x 0.35 x 14 |
| | = $117.6\ m^3 = 118\ m^3$ |
| For third week of brooding, the brooders were operated for 15 hours per day | = 15 x 0.35 x 7 |
| | = $36.75\ m^3 = 37\ m^3$ |
| The total biogas required for 21 day of the brooding period | = first two week biogas consumption + third week biogas consumption |
| | = $118 + 37 = 155\ m^3$ |
| Cost of brooding for 21days in biogas brooder | = 155 x Rs. 5.48/ $m^3$ = Rs. 850/- |

**b. For LPG brooder**

| | |
|---|---|
| The total LPG required per hour | = 0.15kg |
| The LPG required per day | = 0.15 x 24 |
| | = 3.6 kg |
| The total LPG required for the first two week of brooding | = 3.6 x 14 |
| | = 50.4 kg |
| For the third week of brooding, LPG was operated only 15 hours per day | = 15 x 0.15 x 7 |
| | = 17.85 kg |
| The total LPG required during the brooding period of 3 weeks | = 50.4 + 17.85 = 68.25 kg. |
| Cost of brooding in LPG brooder for 21 days | = 68.25 x Rs.26/kg = Rs.1775/- |