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Final Report

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Physico-chemical Analysis of Bio-slurry and Farm Yard Manure for Comparison of Nutrient Contents and other Benefits so as to Better Promote Bio-slurry

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ABBREVIATIONS

AEPC	-	Alternative Energy Promotion Centre
APP	-	Agriculture Perspective Plan
ATC	-	Agricultural Technology Centre
BSP	-	Biogas Support Programme
BSP-N	-	Biogas Sector Partnership-Nepal
BUS	-	Biogas Users Survey
CBD	-	Complete Block Design
CDR	-	Central Development Region
CMS	-	Consolidated Management Services Nepal (P) Ltd
DGIS	-	Directorate General for International Cooperation of the Netherlands
EDR	-	Eastern Development Region
FAO	-	Food and Agriculture Organization of the United Nations
FYM	-	Farm yard Manure Kg – Kilogram
GO	-	Government Organization
hh	-	Household
HMG/N	-	His Majesty's Government of Nepal
IEIA	-	Integrated Environmental Impact Assessment
KfW	-	Kreditanstalt fuer Wiederaufbau
LA	-	Latrine Attached
MWDR	-	Mid-Western Development Region
NARC	-	Nepal Agricultural Research Council
NGO	-	Non-Government Organization
NH_4+	-	Ammonium
NLA	-	Non-Latrine Attached
NPK	-	Nitrogen, Phosphorous, Potassium
R & D	-	Research and Development
SC	-	Slurry Compost
SEP	-	Slurry Extension Programme
SEPP	-	Slurry Extension Pilot Programme
SNV	-	The Netherlands Development Organization
TS	-	Total Solid
VS	-	Volatile Solid
WDR	-	Western Development Region
YSD	-	Yashoda Sustainable Development (P) Ltd

SUMMARY

1.0 INTRODUCTION

The *Physico-chemical Analysis of Bio-slurry and Farm Yard Manure for Comparison of Nutrient contents and other Benefits so as to Better Promote Bio-slurry* is a study initiated by BSP-Nepal for bio-slurry promotion through authentic findings that better convince the farmers for bio-slurry use in terms of its nutrient contents. Yashoda Sustainable Development (P) Ltd. was entrusted with the responsibility of implementing the study as Consultant.

Slurry Extension Pilot Programme (SEPP) was launched from November 1995 to July 1966 under the framework of SNV/BSP for the first time. It was then enlarged to Slurry Extension Programme-I (SEP-I), and was introduced with effect from February 1, 1997 to 1999 with general objectives of maximizing the benefits of biogas plants by making the best use of slurry for crop production. SEP-I was extended to SEP-II again and was executed from September 1, 1998 to September 1, 2001 with overall objective of increasing the effective market for biogas plants by maximizing its benefits through improvement on the use of slurry in crop production. Currently, slurry promotion programme is being implemented by BSP-N with the help of a Slurry Coordinator. Hence, the present study is considered to be of paramount importance to the farming community for persuading them about the value of bio-slurry.

2.0 OBJECTIVE

The principal objective of this study is to make comparative assessment of the nutrient contents and other physical attributes of biogas slurry (from latrine attached and non-attached plants), bio-compost and farm yard manure.

3.0 REVIEW OF RELEVANT WORK IN THE PAST

Review of relevant literature on the past studies on slurry showed that slurry has various beneficial impacts on agriculture system. Besides its manorial value for crops, it also maintains soil fertility and moisture content, repels certain crop damaging pest, reduces chances of weed growth in field, and increases crop yield. The review of past studies has been helpful to identify the gaps in exploring the potential of bio-slurry use.

4.0 APPROACHES AND METHODOLOGY

The methodology adapted for the study was in accordance with the ToR and Technical Proposal, and comprised of following major steps - desk study; training to researchers and pre-testing of sample collection; sampling and sample collection; analyses of collected samples for physico-chemical properties as given in ToR.The physico-chemical parameters of the bio-slurry (from latrine attached and non-attached plants), slurry compost and FYM were determined by following standard recommended laboratory procedures in Soil Test (P) Limited, Kathmandu. The analyzed parameters were- TS, VS, pH, Organic Matter, Ammonium Nitrogen, Total Nirogen, Total Phosphorous, Total Potassium, and CN ratio. Altogether 100 slurry samples were randomly selected for physico-chemical analyses from eight districts representing both the ecological belts - Hills and Terai. The districts selected were: Dhankuta, and Sunsari districts in EDR; Sarlahi and Dhading in CDR; Rupandehi and Lamjung in WDR, and Surkhet and Banke in MWDR.

5.0 RESULTS AND DISCUSSIONS

The physico-chemical values indicated that the lowest VS content was in FYM (41.3%) compared to highest VS in latrine attached and non-attached bio-slurry samples (around 67% in both cases). On the other hand, in both the latrine attached and non attached liquid bio-slurry, TS content was much lower compared to slurry compost and FYM.

Organic carbon values were higher in NLA (Latrine non-attached) and LA (latrine attached) liquid slurry, while lowest in FYM. The N content was lowest in FYM (1.42%), and highest in LA (2.12%) followed by NLA (1.89%). P content was highest in slurry compost prepared from latrine non-attached plant (NLA). Similarly, P content was found higher in NLA and LA samples compared to FYM. Highest percentage of K_2O was found in NLA slurry (1.85%) followed by FYM (1.71%) and LA (1.42%) slurry, while it was lower in lower in slurry compost samples compared to other categories. In contrary to the past studies K_2O content was found to be the highest in FYM. Though these findings need to be confirmed by further investigation, one of the reasons may be attributed to the addition of ash (from wood burning) in the FYM pits knowingly or unknowingly by the farmers to increase K_2O content of the manure. The next reason could be FYM contains bedding materials originating from leaves that contain K content. Ammoniac N was found to be highest in LA (0.56%) followed by NLA samples (0.18%); it was less in slurry compost (0.12%) and lowest in FYM (0.01). The C: N ratio was highest in NLA (21.70) slurry, but in other categories it ranged from 15 to 17.

A comparison of total N in bio-slurry between LA and NLA plant shows average total N content in LA-slurry is 12% more than in NLA-slurry. Similarly, ammoniacal N content on LA-slurry is more than 3 times higher than NLA-slurry. Also wider C:N ratio of NLA-slurry than NL-slurry indicates more methane (CH4) formation in the outlet tank of NLA-biogas plant as compared to LA-plant. Methane emission from outlet tank may be of some concern to CDM for which appropriate measure needs to be taken.

The data on the status of urine collection and utilization along with the conditions of cattle sheds (traditional or improved) revealed that on an average, only 28% of the biogas households have constructed pit for collection and utilization of at least some urine, while greater percentage (72%) have not done so. Similarly, as regards the condition of cattle sheds, around 43% of sampled biogas hhs possessed traditional type of sheds (earthen or wooden floor), whereas 47% possessed concrete floor to facilitate the collection of urine from cattle shed.

6.0 PRACTICAL RECOMMENDATIONS ON THE APPLICATION OF FERTLIZERS AND MANURES AT FARMER'S LEVEL

On the basis of the study conducted, following recommendations are made to the farmers:

- Soil fertility trial including treatments with recommended dose should be conducted in different agro-climatic conditions of Nepal by the relevant institutions.
- Crop yield should be tested with the application of recommended dose of chemical and different types of organic manures, under both irrigated and rainfed conditions.
- The farmers should be properly advised how to use both chemical and organic fertilizers in a balanced way.
- Farmers should be advised to go for periodical soil testing to know the status of nutrients in the soil, and hence to fulfill the soil nutrient need as required.
- Simple demonstration with few treatments on crops and vegetables should be carried out at farmer's field so as to convince them about beneficial effect of slurry use.

7.0 BIO-SLURRY RELATED CONCERNS FROM USERS' PERSPECTIVE

The findings of Biogas Users' Survey 2006 (conducted by CMS) with regard to bio-slurry use have been helpful to provide information on various relevant matters of bio-slurry use. There has been significant reduction in FYM use and increase in pit composting slurry manure use after biogas plant installation. Crop yield of three major crops - Rice, Maize and Wheat – are reported to be increased by 34%, 34% and 25% households in the hills and 31%, 16% and 22 % households in Terai respectively. 46.8% respondents viewed that biogas slurry has positive effect in agriculture production, while 50.70% respondents observed no significant effect in this respect. 70% hh have adopted stall feeding as well as fodder and forage production after the installation of biogas plant. Majority of the users have 2 slurry pits in which the compost is stored for four months with 1-3 times turning. However, in actual practice, it is found that the farmers are not willing to turn the compost periodically and the emptying the composted (decomposing) materials from the pit is synchronized with cropping season.

Applying compost by *Spreading in field uncovered in small heaps* (57.5%) is popular in hills *spreading during slack season and incorporating into soil only at the time of land preparation* (44.3) is popular in hills.

8.0 CONCLUSION AND RECOMMENDATION

Bio-slurry (both from LA and NLA) has higher manorial value than FYM and compost; and bio-slurry in liquid form has richer nutrient content than slurry compost. However, due to the necessity of applying very large quantity of organic manure to fulfill the need of crops, simultaneous use of balanced chemical fertilizer is necessary. Varied use of bio-slurry as plant nutrient, soil conditioner/vitalizer, fish feed, and pesticides have tremendous beneficial impact on agriculture system. However, there is a need of exploring its potential to maximum extent through researches so that farmers can be convinced for its proper utilization for both economic and environmental benefits.

Chapter 1
INTRODUCTION AND BACKGROUND

1.1 BACKGROUND

Biogas technology was first introduced in Nepal in 1955 at St. Xavier School, Godavari, Kathmandu. Realizing its importance as fuel and fertilizer in the rural community, the then His Majesty's Government of Nepal (HMG/N)[1] gave momentum to biogas programme in 1975 by establishing 250 family-sized plants on the occasion of "Agriculture Year". As a matter of fact, an impetus in the programme was recognized in the country from 1992 onward when Biogas Support Programmer (BSP) was created with funding from the Directorate General for International Cooperation of the Netherlands (DGIS) of the Netherlands government through the Netherlands Development Organization in Nepal (SNV/N). HMGN and the Kreditanstalt fuer Wiederaufbau of Germany (KfW) also started funding the BSP from the Phase–III, which started in March 1997 and lasted till June 2003. Until the Phase–III, BSP was directly implemented by SNV/N.

An apex government organization, namely Alternative Energy Promotion Centre (AEPC) was established in 1996 under the then Ministry of Science and Technology (MOST)[2]. AEPC's main objectives are directed towards disseminating and promoting renewable energy technology (RET) for improving the living standard of rural people, providing clean energy and conserving environmental degradation. The RET implemented under AEPC are micro-hydropower, improved water mills (IWM), biogas, solar photovoltaic, solar thermal, improved cook stoves, and wind turbines.

Initially known as SNV/BSP and now transformed into a Non-Governmental Organization (NGO), the Biogas Sector Partnership - Nepal (BSP-N), has been implementing biogas programme in Nepal under the umbrella of AEPC since December 2003.

With the rigorous efforts of various governmental and non-governmental organizations notably HMG/N, KfW and SNV/N, BSP-Nepal, Biogas Company etc., a total of 150,000 household-size biogas plants have been installed in Nepal by 28 June 2006 covering 67 of its 75 districts.

1.2 RESUME' OF PAST WORK DONE ON SLURRY EXTENSION PROGRAMME

Realizing the necessity for extending the utilization of slurry as fertilizer amidst the rural community, the Slurry Extension Pilot Programme (SEPP) was launched from November 1995 to July 1966 under the framework of SNV/BSP. Thereafter, based upon the feedbacks received from Biogas Companies and SEPP, this programme was enlarged to Slurry Extension Programme-I (SEP-I), and was introduced with effect from February 1, 1997 to 1999 with general objectives of maximizing the benefits of biogas plants by making the best use of slurry for crop production. Again, SEP-I was extended to SEP-II and was executed from September 1, 1998 to September 1, 2001 with overall objective of increasing the effective market for biogas plants by maximizing the benefit of the operated biogas plants through improvement on the use of slurry in crop production.

Currently, slurry promotion programme is being implemented by BSP-N with the help of a Slurry Coordinator. Thus, impact of slurry extension and promotion programme has been very conducive to make

1 The HMG/N is presently known as Government of Nepal.
2 The MoEST is presently known as the Ministry of Environment Science and Technology.

the farmers conscious about the utilization of bio-slurry as fertilizer to enhance crop production and productivity of soils. Hence, the present study is considered to be of paramount importance to the farming community for persuading them about the value of bio-slurry, which is not merely a waste byproduct but is an invaluable resource or asset to them.

1.3 RATIONALE OF THE STUDY

During the promotional activity carried out by the companies, the workers are getting farmer's comment that the cow dung used for biogas production is useless for the field application after digestion. In this concern, some studies were carried out in the past to find out the effect of slurry in the crop production for which the nutrient contents in the slurry were also studied. Different workers had reported wide variation in the nutrient content of biogas slurry. Theoretically, in anaerobic condition most of the compounds will be in reduced form. Therefore, most of the nitrogen will be in the ammonium form (NH_4+) in the slurry, which is readily available to the plant. Similarly, phosphorus and potassium will also be in the form readily available to plant as they are released from organic complex during anaerobic digestion. Furthermore, in biogas digester there should be no loss of nutrients except nitrogen in NH_4+ form. Loss of nitrogen from NH_4+ form should not be major problem unless the quantity is in high concentration. Therefore, it has been very important to find out if the farmer's statement has any valid reasoning.

Furthermore, it seems quite pertinent to review the past work done regarding the nutrient value of the liquid slurry, slurry compost and FYM in the context of Nepal. To validate the analytical data, it also seems necessary to compare the results of analysis with those obtained elsewhere. Furthermore, the study intends to focus on providing sound and concrete recommendation to farmers about the utilization of bio-slurry so as to increase their production and productivity.

Keeping the aforesaid fact into consideration and also based upon the recommendation of IEIA study (BSP-2002)[3], this project has been initiated by BSP-N based upon the TOR presented in **Annex 1**.

1.4 OBJECTIVES

1.4.1 Principal Objective

The principal objective of this study is to make comparative assessment of the nutrient contents and other physical attributes of biogas slurry, bio-compost and farm yard manure, specifically the following:

- Slurry from latrine attached biogas plants;
- Slurry from latrine non-attached biogas plants;
- Compost prepared by using bio-slurry (Slurry Compost[4]) from both latrine attached and non-attached plants; and
- Farmyard manure.

The secondary objective of the study is to further provide specific and workable recommendations for better promotion of bio-slurry.

1.4.2 Specific Objectives

The specific objectives of the study are to:

- Determine the nutrient content of bio-slurry from latrine attached plants;

3 BSP (2002) An Integrated Environment Impact Assessment.

4 "Slurry Compost" means the compost or organic fertilizer prepared by utilizing anaerobically digested slurry with other biodegradable wastes.

- Determine the nutrient content of bio-slurry from latrine non-attached biogas plants;
- Determine the nutrient content of Compost prepared by using bio-slurry;
- Determine the nutrient content of Farm Yard Manure;
- Review the past work on the assessment of nutrient value of bio-slurry, compost and FYM; and
- Assess the viewpoints of biogas farmers on the utilization of organic fertilizers[5].

1.5 EXPECTED OUTPUT

The proposed research study is expected to generate following outputs:

- Farmer's viewpoints on the utilization of organic fertilizers
- Review of past work on nutrient content of organic fertilizers
- Reliable data on the nutrient content of latrine attached bio-slurry
- Reliable data on the nutrient content of latrine non-attached bio-slurry
- Reliable data on the nutrient content of the slurry compost
- Reliable data on the nutrient content of the Farm Yard Manure
- Comparative picture of the manorial value
- Practical and sound recommendation on the utilization of bio-slurry at farmers' level

1.6 STRUCTURE OF REPORT

This report comprises of seven chapters. Background, justification and objective of the study have been dealt with in Chapter One, while Chapter Two includes review of literature and physico-chemical characteristics of bio-slurry in comparison to other forms of organic manures. Similarly, approach and methodology of the investigation have been depicted in Chapter Three and the results derived from this study are discussed in Chapter Four. Likewise, Chapter Five summarizes the bio-slurry related concern from the users' perspective. Last but not the least, practical recommendation on the application of fertilizers and manure has been explained in detail in Chapter Six, and Chapter Seven concludes the report along with recommendations derived from the study.

5 Organic fertilizers include bio-slurry (liquid), slurry compost, Farm Yard Manure, etc.

Chapter 2
REVIEW OF RELEVANT WORK

2.1 REVIEW OF PAST STUDY ON NUTRIENT CONTENT OF BIO-SLURRY[6] AND ORGANIC FERTILIZER

Around 150,000 biogas plants are now in operation in Nepal. Biogas is mainly used for cooking purpose and to a lesser extent for illumination. The increasing trend in the installation of biogas plants among rural farmers indicates that biogas technology is suitable and affordable to Nepalese farmers. Biogas programme was initiated by Ministry of Agriculture in 1974/75 so that the cow dung could be saved from burning and the digested slurry coming out of it could be utilized as manure to supplement the imported costly mineral fertilizer for crop production. Initially, only cow dung was used as feed for biogas production. However with the increasing awareness among rural people, equal proportion of latrine-attached plant has come up now and its number is increasing rapidly.

The biogas plants operating in Nepal produce over two million tons of digested slurry annually. As the digested slurry can be used as manure for the improvement of physical and chemical properties of the soil, some farmers use it in liquid form and the others in sun-dried form. Besides, some farmers use it for the production of compost manure to use it as soil conditioner. According to past biogas users' survey, 77 percent of the biogas households are not using bio-slurry whereas only 23 percent use it. Again, out of slurry users, more than 67 percent use it in dried form, 20 percent in composted form and rest 13 percent use it in liquid form[7]. On the whole, liquid bio-slurry (fresh) is better in terms of manorial value than ordinary FYM and other forms of slurry (sun-dried, slurry compost). However, transportation of liquid slurry is not easy, therefore, farmers are encouraged to make compost by using slurry in conjunction with agricultural residues.

2.2 NUTRIENT STATUS OF SOILS OF NEPAL

The Soil Science and Agricultural Chemistry Division of the National Agricultural Research Centre (NARC), Khumaltar had conducted study related to nutrient status of soils of Nepal. Based on the analysis of about 1900 soil samples in the fiscal year 1994/95, the data on nutrient status of soils especially for NPK as well as acidity range has been presented in **Table 1** and **Table 2** respectively.

Table 1: Fertility Status of Soils in Lowland of Nepal

Nutrient	Total N	Available P	Available K
Range	Sample %	Sample %	Sample %
1. Low	74	22	23
2. Medium	24	7	41
3. High	1	62	27

Table 1 shows that in majority of the collected samples (74%), total nitrogen content was found "low"; in one-quarter of the samples (24%), it was "medium," while negligible percentage of the samples (1%) had "high" nitrogen range. On the other hand, more than 60 percent samples contained "high" amount of available phosphorus (P) followed by significant percentage (22%) containing P in "low" range. Only a few samples had medium P level. In case of available potassium (K) content, large number of samples (41%)

6 Bio-slurry means digested sludge from biogas plant.
7 Source: EastConsult (2003) Biogas Users Survey 2002/2003. AEPC.

showed medium K level, while moderate number of samples fell in "medium" and "low" categories. This shows that it is important that organic fertilizer systems are designed in a way that N is best collected and conserved at it is the main limiting factor. This entails consequences for bio-digester designs.

Table 2: Acidity of Soils in Lowland of Nepal

S.N.	Acidity Range	Sample Percentage
1.	Strongly acidic	9
2.	Moderately acidic	34
3.	Neutral	17
4.	Slightly alkaline	38

Table 2 shows that in lowlands, 9 % samples were strongly acidic, 34 % moderately acidic, 17% nearly neutral and 38% slightly alkaline. Based on a soil fertility survey conducted during 1994 at representative sites of river basins in the high hills of 9 hill districts of the western development region, Tripathi (1999) reported that out of 251 samples, 23%, 8% and 35% were low in organic carbon, total nitrogen, and available phosphorus and exchangeable potassium respectively.

2.3 PHYSICO-CHEMICAL ANALYSIS OF ORGANIC MANURE[8]

An attempt has been made in following sections to present the analytical data on nutrient content (NPK) of different types and forms of organic manures such as FYM, slurry compost, fresh and sun-dried slurry from biogas plant. The data have been compared in the context of fresh cow dung for both the latrine attached and non-attached biogas plants.

2.3.1 Farm Yard Manure (FYM)

Maskey and Bhattarai (1994) have reported that the nutrient value of organic manure such as FYM and compost depends upon the composition of animal feed, fodder, bedding materials, methods of preparation, length and condition of storage etc. They report that the nutrient content of FYM and compost prepared under farmers' condition may vary from 0.5-1.4 % N, 0.4-2.4 % P and 0.5-3.5 % K as calculated on oven dry basis.

Several authors have reported variations in plant nutrient content of FYM as given in **Table 3.** These variations may be attributed to the types of materials used, duration and methods of FYM preparation.

Table 3: Plant Nutrients in FYM

N (%)	P (%)	K (%)	pH	Author
0.6	0.25	0.84		Gupta,1991
1.08	1.74	1.34	6.89	Karki, 2001
0.5-1.0	0.15-0.2	0.5-0.6		Uexull et.al., 1992

2.3.2 Slurry Compost[9]

The average values of N, P and K in slurry compost as quoted by Demont et al (1991) are 0.75, 0.65 and 1.05, respectively (see **Table 4)**.

8 Organic manure means FYM, Slurry Compost, liquid and sun-dried digested slurry
9 Slurry Compost refers to the compost prepared by using digested slurry in conjunction with vegetable/agricultural residue.

Table 4: Plant Nutrients in Slurry Compost

N (%)	P (%)	K (%)	Author
0.5-1.0 (0.75)	0.5-0.8 (0.65)	0.6-1.5 (1.05)	Demont et al. 1991

Figures in parenthesis indicate the average value.

2.3.3 Characteristics of Bio-slurry[10]

The National Biodigester Programme Cambodia (NBP)/SNV, January 2006 has stated following characteristics of the biogas slurry coming out of the bio digester:

- When fully digested, effluent is odorless and does not attract flies.
- The effluent repels termites whereas raw dung attracts them; plants fertilized with farmyard manure can be harmed by termites.
- As compared to the use of FYM, when effluent is used as fertilizer weed growth is reduced by about 50%; chances of weed growth is increased with the use of FYM because of the presence of weed seed in undigested fresh dung.
- Both composted and liquid effluents have greater fertilizer value than FYM or fresh dung. This is because in digested effluent, nitrogen is available in a form that can be immediately absorbed which has proved to be even superior than chemical fertilizer for some crops.

2.3.4 Plant Nutrient in Fresh and Sun-dried Bio-slurry

Table 5 indicates the nutrient contents in fresh bio-slurry as reported by Maskey (1978) and Uexkull et al. The percentage content of P and K in bio-slurry, as reported by Maskey, was more than that reported by Uexkull et al.

Table 5: Plant Nutrients in Fresh Bio-slurry

N (%)	P (%)	K (%)	Author
1.49	2.94	2.38	Maskey,1978
1.60	1.50	0.95	Uexkull et.al

Table 6 depicts the chemical constitutions of sun-dried bio slurry as have been reported by different authors from India. Values in percentage for total Nitrogen (N) range from 0.5 to 1.6, for Phosphorus (P) from 0.6 to 1.5, and for Potassium (K) from 0.6 to 1.5.

Table 6: Nutrient Content of Sun-dried Bio-slurry

N (%)	P (%)	K (%)	Author
1.60	1.40	1.20	Gitanjali et.al in Gupta 1991
1.00	0.23	0.84	Gupta, 1991
0.5-1.0 (0.75)	0.5-0.8 (0.65)	0.6-1.5 (1.05)	Demont et.al 1991

Figures in parenthesis indicate the average value.

[10] It means liquid slurry from biogas plant

It should be understood that the data show a wide range of values for all three nutrients. Thus the terminology used is incomplete without a description on what the slurry is comprised of, e.g. does the dung include urine or not?

A comparison of the two tables (**Table 5** and **Table 6**) shows that the sun drying process leads to losses of P and K.

2.3.5 Comparison of Nutrient Content in Slurry Compost, FYM and Bio-slurry

The digested slurry is an excellent material for accelerating the rate of composting of refuge, crop waste and garbage, as the dry organic matter lacks moisture and Nitrogen and the slurry adds these two components. **Table 7** and **Figure 1** below depict the nutrient content range of the composted bio-slurry (**Slurry Compost**) as cited by Gurung (1997).

Table 7: Comparison of Nutrient Content in Slurry Compost, FYM and Digested Bio-slurry

Nutrient	Improved Compost *(but not slurry compost)*		Farm Yard Manure		Digested Bio-slurry	
	Value Range (%)	Average Value (%)	Value Range (%)	Average Value (%)	Value Range (%)	Average Value (%)
Nitrogen	0.5-1.50	1.00	0.5-1.00	0.8	1.40-1.80	1.60
Phosphorus	0.4-0.8	0.6	0.5-0.8	0.7	1.10-2.00	1.55
Potassium	0.5-1.90	1.2	0.5-0.8	0.7	0.8-1.2	1.00

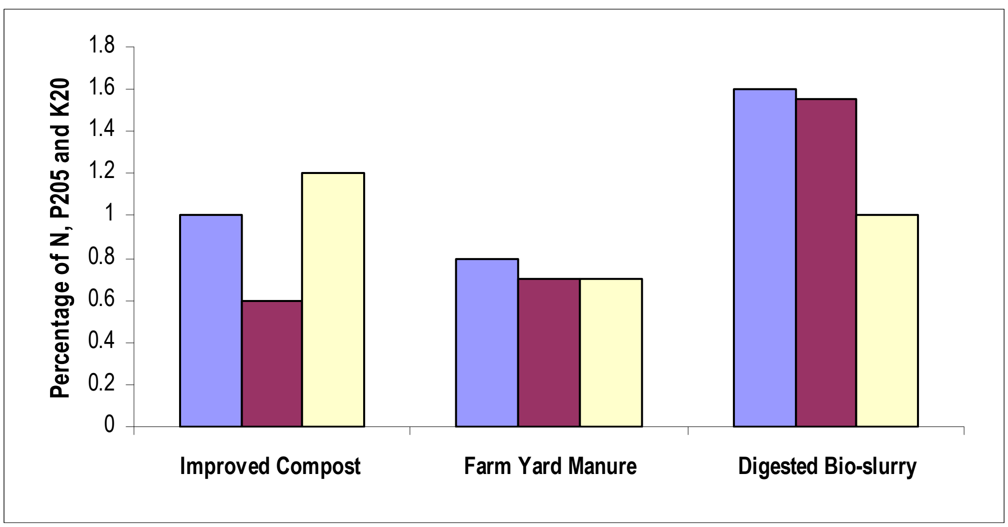

Figure 1: Comparison of Nutrient Content in Different Sources of Organic Manure

Similarly, Gupta (1991) analyzed the major plant nutrients-NPK- in composted manure, FYM and digested bio-slurry. The result of the analysis has been presented in **Table 8** and **Figure 2** below:

Table 8: Nutrients Available in FYM, Composted Manure and Digested Slurry

Nutrients	FYM		Composted Manure		Digested Slurry	
	Range (%)	Average (%)	Range (%)	Average (%)	Range (%)	Average (%)
Nitrogen (N)	0.5 to 1.0	0.8	0.5 to 1.5	1.0	1.4 to 1.8	1.60
P_2O_5	0.5 to 0.8	0.7	0.4 to 0.8	0.6	1.1 to 2.0	1.55
K_2O	0.5 to 0.8	0.7	0.5 to 1.9	1.2	0.8 to 1.2	1.00

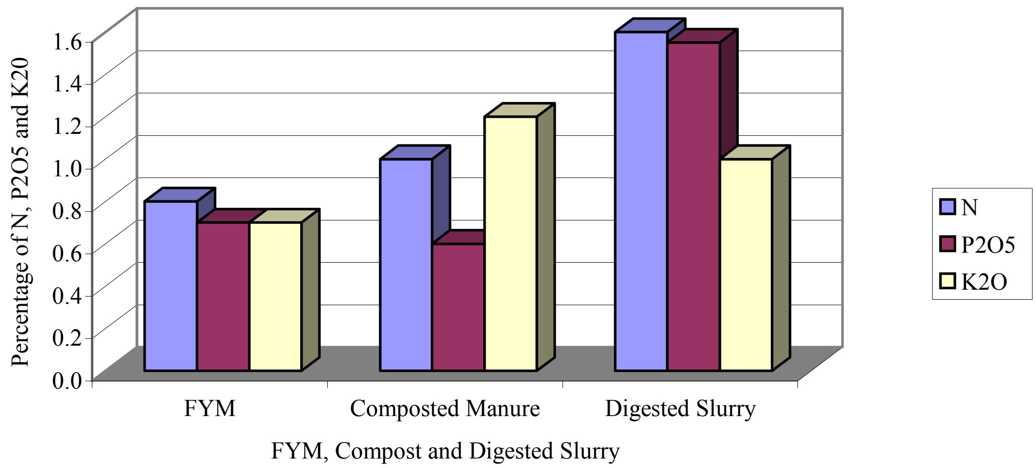

Figure 2: Major Plant Nutrients in Different Types of Organic Fertilizers

The data presented in **Table 8** and **Figure 2** suggest that the nutrient value of the effluent can outweigh the benefit accruing from the value of biogas, as it is rich in major plant nutrients compared to traditional FYM and compost. Both percentage range and average figures for digested slurry are appreciably high as compared to that for FYM and composted manure. However, this is true only under ideal conditions. Where slurry-handling techniques are not favorable or very negligent, almost whole amount of nitrogen may be lost due to volatilization of ammoniac nitrogen that is soluble in liquid slurry. Likewise, other nutrients too get lost when slurry is exposed to the sun for quite long time.

It can be seen from the above table that digester bio-slurry has better nutrient values in comparison to other organic fertilizers. The effect of compost on crop production depends upon the type and condition of the soil, and other factors. Application of compost will bring the following effects to the soil:

- Improvement in physical and chemical properties of the soil
- Improvement in soil fertility
- Increase in water holding capacity
- Enhancement in the activity of the micro-organism

2.3.6 Nutrient Content of Bio-slurry from Latrine Attached Biogas Plants

ATC (1997) also made a comparative laboratory study of the chemical constitution of the fresh slurry samples from biogas plants with and without toilet attachments. **Table 9** shows that N content is higher in toilet attached plant than non-attached one. On wet basis, there is not much difference in P and K contents of slurry from both the types of plants (with or without latrine attachment). But when calculated on dry basis, both P and K content are found to be lower in case of slurry from plants with latrine attachment than without. As no definite conclusions are derived from these results, there seems every need to carry out more research to confirm the findings.

Table 9: Nutrient Content of Fresh Bio-slurry from Latrine Attached and Non-attached Plants

Particulars		pH	Moisture %	Total Nitrogen	OM%	C:N	% P2O5	%K2O
Without latrine attachment	Wet basis	7.1	93.83	0.054	4.64	48	0.040	0.066
	Dry basis	-	-	-	71.59	48	0.648	1.070
With latrine attachment	Wet basis	7.2	92.32	0.875	4.555	40	0.039	0.064
	Dry basis	-	-	-	59.306	40	0.508	0.833

Table 10 presents the NPK contents of night soil biogas plants as reported by authors from India. Though it has not been stated whether the values are on wet or dry basis, if we compare these values with those of ATC, 1997 report for latrine attached biogas plants, the nutrient values of night soil are comparatively high.

Table 10: Nutrient Content of Latrine Attached Biogas Plants

N (%)	P (%)	K (%)	Authors
3.25	1.00	0.83	Kaul et.al.1986
3.0-3.5 (4.0)	2.5-4.4 (3.45)	0.7-1.9 (1.3)	Khandelwal,1986

2.4 IMPROVEMENT ON SOIL PROPERTIES

It appears that serious effort has not been made in Nepal to assess the impact of the application of bio-slurry and slurry compost on soil properties. Despite the general notion that the application of organic manure improves soil structure and its cat-ion exchange capacity, the characteristics which are directly related to the moisture and nutrient holding and releasing capacity of the soil, almost all the works on the application of slurry and compost are directed towards assessing their impact on crop yield.

Tripathi (1993) reported that in addition to nutrient supply, bio-slurry and its different forms improve the physical and biological quality of soil. Bio-slurry, in its different forms is relatively free from foul smell, weed seed and phytopathogenic organisms, etc. Several authors reported that bio-slurry improves soil porosity and water holding capacity (Tripathi 1993; Santosh et.al, 1993; APRBTC, 1983). Arnott (1982) reported that slurry has bulk and fibre to hold soil moisture. Lakshmanan (1993) reported that bio slurry provides energy to soil microflora including N fixing and P-solublizing organisms.

2.5 EFFECT OF BIO-SLURRY ON CROP PRODUCTION

Maskey and Bhattarai (1978) have reported from experiments conducted at agronomy farm of Khumaltar that the application of dry and wet slurry increased the wheat yield by 16.2 and 55.4 percent over control respectively.

Bhattarai (1978) reported that dry slurry gave better wheat yield than wet slurry under irrigated conditions and vice-versa under rainfed condition.

On the basis of the research conducted at agronomy farm of Khumaltar on azotobacter inoculation in different types of organic manures including biogas slurry on the grain yield of wheat, Bhattarai and Maskey (1988) reported that biogas slurry inoculated with azotobacter increased wheat yield by 12% over the control. Application of 100:40:30 NPK kg/ha of Azotobacter inoculated biogas slurry gave a mean wheat yield (2116.66kg/ha) which was lower than that given by poultry manure and far lower than that given by ordinary compost both with and without azotobacter inoculation and the same amount of chemical fertilizer.

Gurung (1997) in his comprehensive review of literature on effects of Slurry Use on crop production has made the following observations:

- A combination of biogas **slurry@12.5** t/ha and 100% NPK had pronounced effect on rice yield.
- Seed coating with a combination of 50% (W/W of seed) digested slurry + 2% inorganic nutrient + 2% bio fertilizer enhanced the growth and yield attributes of rice, soybean, black gram, green gram and jowar..
- Application of biogas slurry @ 10t/ha favorably influenced the yield of rice crop followed by the yield of black gram crop. Slurry increased rhizobium nodules thus increasing the black gram yield by around 78%.
- Gypsum enriched slurry when applied in combination with 75% recommended NPK gave maximum grain yield in rice- black gram cropping system. Estimation showed that there was a saving of 25 kg N/ha.
- Bio-slurry application on wheat, sunflower, safflower, hybrid cotton, and groundnut gave an average yield increase of 24% over the control.
- Application of bio-slurry @10t/ha in tomato, brinjal, groundnut, jowar, maize and okra gave better yields than FYM (Reports however, are usually not clear about the physical form of the slurry used).
- Yield increase due to bio slurry application have also been reported for many other crops including peas, mustard, watermelon, cabbage, banana, chilly, bajra, turmeric, sugarcane, deccan, hemp, mulberry, tobacco, castor and onion.
- A combination of liquid bio-slurry and chemical fertilizer enhanced carbon nitrogen transformation with substantive effect on crop yield. The yields in many instances are reported to be higher than that given by the combination of ordinary FYM and chemical fertilizer. In China although the average yield increment reported is not as high as in India (somewhere around 10 to 18 percent), experiments in bio slurry-chemical fertilizer utilization showed yield increment by as high as 37.8% in maize as compared to 16.8% and 9% respectively for use of effluent and chemical fertilizer alone. A comparatively lower, nonetheless increased yield has also been recorded for rice with such combination.
- Vegetable crops produced with bio-slurry have better quality as compared to those produced with chemical fertilizer. Studies have not pinpointed the differences between bio-slurry and FYM in this regard.

With the support from Alternative Energy Promotion Centre (AEPC), an experiment was conducted at farmers' field in Lalitpur district to study the influence of bio-slurry on the yield of maize and cabbage (Karki, K.B. and Karki, A.B. 2001). The research revealed that the application of slurry compost at the rate of 10 ton/ha increased the maize yield by 23% over control (no addition of fertilizer). The same experiment also reported 10 percent increment in yield over control with the application of bio-slurry (liquid form) at the rate of 10 ton per hectare, while the application of full dose of chemical fertilizers (120:60:40 NPK kg/ha) yielded only 8 percent more than the control. The author also reported up to 7 percent increase in the yield of soybean over the control. In a similar experiment conducted on cabbage, application of slurry compost and liquid slurry each at the rate of 10 ton per hectare resulted in yield increment by 28 and 18 percent respectively over the control. Application of slurry compost (10 ton/ha) with the recommended dose of chemical fertilizer (120:60:50 NPK kg/ha) yielded 36 percent more than the control.

East Consult (2005) based on the Biogas Users' Survey conducted during the fiscal year 2004/5 reported that amongst the users surveyed, 58% obtained increased paddy yield with the application of slurry. This type of response in other crops like tomato, potato and vegetables were reported by 70%, 44% and 44% users respectively.

Chapter 3
APPROACHES AND METHODOLOGY

In accordance with TOR and Technical Proposal, following approaches and methodology are adopted to carry out the research activities envisioned in this project.

3.1 RECRUITMENT OF THE PROJECT PERSONNEL

After the award of the project, the Consultant assigned professionals and support staff having experience in biogas technology, field survey work and soil testing. Apart from Consultant's Expert Team, BSP-N provided the services of two experienced researchers; one from BSP-N and the other from Nepal Biogas Promotion Group, specifically to carry out the sample collection from the field (see **Section 3.3**).

3.2 DESK STUDY PHASE

Literature and related documents were collected from BSP-N, AEPC, CMS, East Consult, YSD, Soil Science Division of Nepal Agricultural Research Centre (NARC), and Soil Testing Service Section of the Department of Agriculture/NG (DOA), etc. The materials so gathered were reviewed and synthesized thoroughly. Similarly, appropriate information on various aspects of the nutrient content in bio-slurry was also downloaded from the websites.

3.3 TRAINING TO THE RESEACHERS AND PRE-TESTING OF SAMPLE COLLECTION

On 10th May 2006, the principal professionals provided one day orientation training to the team of researchers involved in R&D project of bio-slurry at BSP-N Training Hall. They were provided theoretical as well as practical training regarding the method of sample collection; preservation and its safe transportation from the field to the soil testing laboratory with all necessary precautions (see **Section 4.4.2**). Ms. Bindu Manandhar from BSP-N and Mr. Christopher Kellner, SNV Senior Energy Advisor assisted the professionals to conduct training and pre-testing of sample collection.

Immediately after orientation training, the pre-testing of sample collection was done at Chapagaon village of Lalitpur District. A total of four bio-digesters were visited and field research team was demonstrated the methodology of sample collection as explained during the orientation training. Following the prescribed methods, samples of bio-slurry, FYM and Slurry Compost were collected from these bio-digesters and transported to the Laboratory for analysis.

Mr. Ramesh Regmi, Slurry Coordinator of BSP-N, and Mr. Yagya Prasad Gurung of NPBG were mobilized for sample collection in the field for this study.

3.4 SAMPLING AND SAMPLE COLLECTION

3.4.1 Choice of Sampling Districts and Sample Number

A total of eight districts representing different ecological belts of the country (Hills and Terai) were chosen for collecting the slurry samples for physico-chemical analyses. The districts selected were: Dhankuta, and Sunsari districts in EDR; Sarlahi and Dhading in CDR; Rupandehi and Lamjung in WDR, and Surkhet and Banke in MWDR. From the selected plants, altogether 100 samples (as given below) were randomly collected for physico-chemical analyses.

- 25 samples of slurry from latrine-attached plant

- 25 samples of slurry from latrine non-attached plants
- 25 samples of Slurry Compost
- 25 samples of Farm Yard Manure (FYM)

The overall distribution of the samples has been depicted in **Table 11**.

Table 11: Sampled District for Collecting Slurry Samples and FYM

Survey Group	Development Region	Sampled District	Total Number of Plants Established in the Sampled Districts by 2005/06 [11]	Samples				
				NLA (No.)	LA (No.)	SC (No.)	FYM (No.)	Total (No.)
A	EDR	1.Sunsari (T)	2952	3	3	3	3	12
		2.Dhankuta (H)	2135	2	2	2	2	8
B	CDR	3.Sarlahi (T)	2560	6	6	6	6	24
		4.Dhading (H)	1840	2	2	2	2	8
C	WDR	5.Rupendehi(T)	4233	5	5	5	5	20
		6.Lumjung (H)	5301	3	3	3	3	12
D	MWDR	7.Surket (T)	1552	2	2	2	2	8
		8.Banke (H)	1432	2	2	2	2	8
		Total	**22,005[12]**	**25**	**25**	**25**	**25**	**100**

NLA = Liquid Slurry from latrine non-attached plant; LA= Liquid Slurry from Latrine attached plant
SC = Slurry Compost (Compost prepared by using slurry); FYM= Farm Yard Manure
T = Terai; H = Hills

3.4.2 Technique for Sampling, Storage and Transportation to the Laboratory

A. Pre-sampling Method

Pre-sampling step was carried out in the office before proceeding to the field. Since the nitrogen formed during the anaerobic digestion is mostly in the ammonium form which is highly soluble in water and is generally lost by volatilization in the air if the solution is alkaline and temperature of solution is raised, pre-sampling step is highly important. To prevent the loss of ammonium, preservative has to be added and mixed with the biogas slurry samples. FYM and slurry compost do not have such problem and the addition of preservative is not necessary.

In case of liquid slurry, two samples were collected from the *slurry outlet tank of biogas plant* separately in 100 ml and 250-ml capacity polyethylene bottles with screw cap having inner lid to prevent loss during transportation. The smaller bottle contained the bio-slurry without any preservatives added, which was used for pH determination. The larger bottle contained the calculated amount of preservative reagent of required strength added to the bio-slurry to prevent the loss of ammonium nitrogen as gas. Bio-slurry sample thus preserved can be used to determine ammonium nitrogen even after a month.

The method for the preparation of the preservative is as follows:

- Dilute the concentrated sulphuric acid to 6 Normality;
- Mark 50 numbers of 250 ml size bottles and add 10 ml of preservative and 10 ml of water in each; and

[11] Source: BSP-N Year Book, May 2006
[12] The total number of plants installed throughout the country in 2005/2006 is 140,549.

- Loosen the cap quarter turned to avoid possible bursting due to accumulation of gas.

B. Collection of Slurry Sample

The slurry samples were collected by following the steps given below:

- The last third slab of the outlet tank was opened;
- The slurry in the tank was stirred in circular movement with a stick for 20 seconds; precaution was taken to avoid scratching the bottom and corners;
- 10 samples were collected with 0.5 litre scoop in a bucket;
- the sample was mixed in the bucket;
- About 150 ml of this sample was taken into the sampling/transporting bottle containing preservatives and the cap was loosened quarter turned; and
- About 50 ml slurry sample was taken in smaller bottle of 100 ml size from the same bucket and the lid was closed by loosening the cap quarter turned.

C. Collection of FYM and Slurry Compost Sample

Slurry compost as well as Farm Yard Manure samples were collected from 4-5 places from the middle of the heap[13] and were sampled separately in similar polyethylene bottle of 250-ml capacity.

Prior to the field mobilization, random sampling of biogas households was done by means of BSP-N's computerized database. In accordance with the convenience of the researchers' group, the samples were collected and delivered to the identified laboratory in batches (20-25 samples per batch) enabling to run the analysis continuously.

3.4.3 Provision of Sampling Gear

The identified laboratory was responsible to provide the Sampling Gear which included the following items:

- Sample bottles of 250 ml capacity with inner lid and screw cap
- Sample bottles of 100 ml capacity with inner lid and screw cap for Liquid Slurry (Nos. 50)
- Jerry can
- Syringes 10 ml cap.
- Preservative acid
- Scoop with handle (Nos. 4)

3.5 PHYSICO-CHEMICAL ANALYSES OF BIO-SLURRY, COMPOST SLURRY AND FYM

3.5.1 Type of Analysis Performed

Following the procedures of recommended standard, the organic fertilizers like Bio-slurry (liquid), Slurry Compost and FYM collected from biogas user households were analyzed to determine the following physical and chemical parameters.

- Total Solids
- Volatile Solids
- pH
- Organic Matter
- Ammonium Nitrogen
- Total Nitrogen
- Total Phosphorus

13 The sample should be well decomposed.

- Total Potassium
- C/N ratio

Since prime consideration was given to the reliability of the sample test, appropriate soil test laboratory was identified as a prerequisite. For this, the Consultant Expert Team accompanied by BSP-N's R & D unit staffs, visited two soil testing laboratories (namely Agriculture Technology Centre, Pulchowk; and Soil Test (P) Limited, Environment Assessment & Material, Battisputali, Kathmandu) to assess their experiences, equipment and facilities so as to ensure the quality output. Finally based upon these criteria, the later one, i.e. Soil Test (P) Ltd was selected for the conduction of physic-co chemical analysis of bio-slurry.

3.5.2 Analytical Procedure

Standard and well established methodology was adopted and ensured while carrying out the physico-chemical analyses in the Laboratory. Few test samples were analyzed prior to performing the analysis of the actual samples of bio-slurry collected from the field.

The methods of analysis for different nutrient contents are presented in **Annex 2**.

Chapter 4 RESULTS AND DISCUSSIONS

The description of the samples collected from the field survey has been presented in **Annex 3**. The description includes detailed information on name of owners and their address, BSP File No., plant size, construction date and nature of the samples collected. Similarly, the relevant data on the analyses for different groups of organic manures are presented in **Annex 4A** to **Annex 4E.**

4.1 COMPARISON OF ANALYTICAL VALUE OF THE DIFFERENT CATEGORIES OF ORGANIC MANURES

Based upon the analyses in Soil Testing Laboratory, the results of different groups of organic manures are presented and discussed in the following sub-heading in the context of ecological belts (i.e. Terai and Hills):

- Liquid Slurry from Latrine Non-attached Biogas Plant (NLA)
- Liquid Slurry from Latrine attached Biogas Plant (LA)
- Slurry Compost prepared by using Bio-slurry (latrine non-attached) (SCNLA)
- Slurry Compost prepared by using Bio-slurry (Latrine attached) (SCLA)
- Farm Yard Manure (FYM)

A comparison of the major plant nutrients (NPK) contained in aforesaid groups of organic manures are illustrated in **Figure 3** in the context of hills and Terai, respectively.

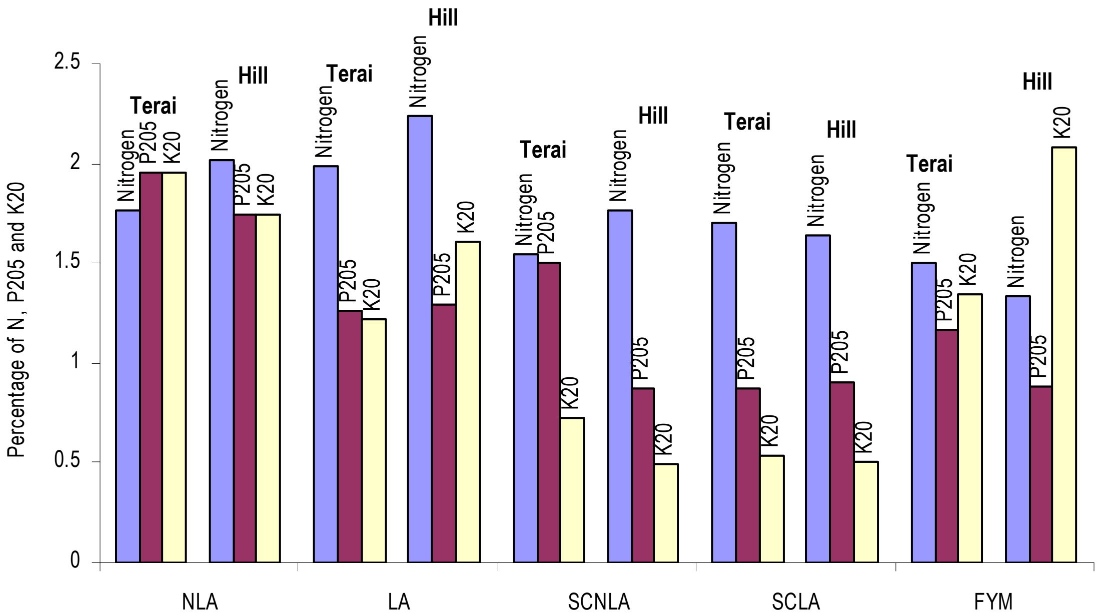

Figure 3: Comparison of Plant Nutrients Content in Different Groups of Organic Manure in Hills and Terai

The relevant data on the comparative values of the physico-chemical analyses of above samples are summarized in **Tables 12** to **17**.

4.1.1 Liquid Slurry from Latrine Non-attached Biogas Plant (NLA)

The results of analysis on liquid bio-slurry from latrine non-attached biogas plant are depicted in **Table 12**.

Table 12: Analytical Results of Liquid Slurry from Latrine Non-attached Biogas Plant

Ecological Belts	Total Solid%	Volatile Matter%	pH	Organic Carbon	Total Nitrogen%	Ammonical Nitrogen%	C/N Ratio	P_2O_5%	K_2O%
Terai	7.07	66.61	6.8	35.50	1.76	0.20	20.57	1.95	1.95
Hills	5.59	69.80	6.9	42.54	2.02	0.12	22.84	1.74	1.74
Average	**6.33**	**68.20**	**6.8**	**39.02**	**1.89**	**0.18**	**21.70**	**1.84**	**1.85**

The data presented in **Table 12** and **Figure 3** reveal that in case of latrine non-attached bio-slurry, total solid and volatile materials were a little bit higher in the Terai than in the hills. Among the chemical characteristics evaluated, no difference in pH value was observed, whereas total nitrogen, organic carbon and C:N ratio were registered higher in the hills than in Terai. Ammonical nitrogen, phosphorus and potassium were found higher in Terai than in the hills.

4.1.2 Liquid Slurry from Latrine Attached Biogas Plant (LA)

The results of analysis on liquid bio-slurry from Latrine attached biogas plant are given in **Table 13**.

Table 13: Analytical Results of Liquid Slurry from Latrine attached Biogas Plant

Ecological Belts	Total Solid	Volatile Matter%	pH	Organic Carbon	Total Nitrogen%	Ammonical Nitrogen	C/N Ratio	P_2O_5%	K_2O%
Terai	7.79	67.8.0	6.8	35.16	1.99	0.45	18.54	1.26	1.22
Hills	7.06	66.18	7.1	34.57	2.24	0.67	16.17	1.29	1.61
Average	**7.42**	**67.00**	**6.9**	**35.05**	**2.12**	**0.55**	**17.36**	**1.27**	**1.42**

Table 13 shows that the liquid bio-slurry from latrine attached biogas plant contain higher total solid and volatile materials in Terai samples than those in hills, whereas pH, total and ammonical nitrogen, phosphorus and potassium contents were higher in the hill samples.

A comparison of total N in bio-slurry between LA and NLA plant shows average total N content in LA-slurry is 12% more than in NLA-slurry. Similarly, ammonical N content on LA-slurry is more than 3 times higher than NLA-slurry. Also wider C:N ratio of NLA-slurry than NL-slurry indicates more methane (CH4) formation in the outlet tank of NLA-biogas plant as compared to LA-plant. Methane formation in outlet tank escapes in atmosphere, which may be a concern to CDM.

4.1.3 Slurry Compost Prepared by using Bio-slurry from Latrine Non-attached Plant (SCNLA)

The analytical results of slurry compost prepared by using bio-slurry from latrine non-attached biogas plant are given in **Table 14**.

Table 14: Analytical Results of Slurry Compost Prepared by using Bio-slurry (Latrine Non-attached)

Ecological Belts	Total Solid%	Volatile Matter%	pH	Organic Carbon%	Total Nitrogen%	Ammonical Nitrogen%	C/N Ratio	P_2O_5%	K_2O%
Terai	26.74	46.74	7.0	25.20	1.54	0.01	16.49	1.50	0.73
Hills	25.48	52.70	6.6	32.06	1.76	0.01	18.36	0.87	0.49
Average	**26.11**	**49.72**	**6.8**	**27.63**	**1.65**	**0.01**	**17.43**	**1.19**	**0.61**

From **Table 14** it is clear that the slurry compost prepared from latrine non-attached bio-slurry has higher total solid in Terai, and higher volatile materials in hill. Similarly, pH, phosphorus and potassium content were found higher in Terai samples while higher values of rest of the parameters were registered in the hill samples.

4.1.4 Slurry Compost Prepared by using Bio-slurry (Latrine attached) (SCLA)

The analytical results of slurry compost prepared by using bio-slurry from latrine attached biogas plant are given in **Table 15**.

Table 15: Slurry Compost Prepared by Using Bio-slurry (Latrine attached)

Ecological Belts	Total Solid%	Volatile Matter%	pH	Organic Carbon%	Total Nitrogen%	Ammmonical Nitrogen%	C/N Ratio	P_2O_5%	K_2O%
Terai	30.84	40.60	7.0	23.16	1.70	0.23	13.51	0.87	0.54
Hills	33.68	45.40	6.6	27.68	1.64	0.01	17.70	0.90	0.50
Average	**32.26**	**43.00**	**6.8/**	**25.42**	**1.76**	**0.12**	**15.69**	**0.89**	**0.52**

According to **Table 15**, the results of analysis of the slurry compost prepared from latrine attached plant also followed almost the same trend as in those of the latrine non-attached slurry compost samples.

4.1.5 Farm Yard Manure (FYM)

The analytical results of sampled Farm Yard Manure are presented in **Table 16**.

Table 16: Analytical Results of Farm Yard Manure

Ecological Belts	Total Solid%	Volatile Matter%	pH	Organic Carbon%	Total Nitrogen%	Ammonical Nitrogen%	C/N Ratio	P_2O_5%	K_2O%
Terai	31.52	39.77	7.5	19.70	1.50	0.01	13.49	1.17	1.34
Hills	32.24	42.90	6.0	22.77	1.33	0.01	16.87	0.88	2.08
Average	**31.88**	**41.34**	**6.7**	**21.24**	**1.42**	**0.01**	**15.18**	**1.02**	**1.71**

In case of FYM, only pH and the phosphorus values were higher in the Terai samples and rest of the parameters was higher in the hill samples.

4.2 COMPARATIVE ASSESSMENT OF THE DIFFERENT CATEGORIES OF ORGANIC MANURES

Based upon the different categories of organic manures analyzed in the soil testing laboratory, the physico-chemical properties of the five different categories of organic materials have been compared as presented in **Table 17**.

Table 17: Comparison of Nutrients in Different Categories of Organic Manures

Group	Total Solid	Volatile Matter	pH	Organic Carbon	Total Nitrogen%	Ammonical Nitrogen%	C/N Ratio	P_2O_5%	K_2O%
NLA	6.33	67.20	6.8	39.02	1.89	0.18	21.70	1.84	1.85
LA	7.42	67.00	6.9	35.05	2.12	0.56	17.36	1.27	1.42
SC(NLA)	26.11	49.72	6.8	27.63	1.65	-	17.43	1.19	0.61
SC(LA)	32.26	43.10	6.8	25.42	1.76	0.12	15.69	0.89	0.52
FYM	31.88	41.34	6.7	21.24	1.42	0.01	15.18	1.02	1.71

NLA = Liquid Slurry from Latrine Non-attached plant; LA= Liquid Slurry from Latrine attached plant
SC = Slurry Compost (Compost prepared by using slurry); FYM= Farm Yard Manure

The physico-chemical values presented in **Table 17** indicate that the lowest VS content was found in FYM (41.3%) compared to highest one in case of latrine attached and non-attached bio-slurry samples (around 67% in both cases). On the other hand, TS content was found in reverse order, that is, in both the latrine attached and non attached liquid bio-slurry, it was much lower compared to slurry compost and farm yard manure. There was consistency in pH value in the tested samples. The average pH of the sample was found to be 6.8.

Organic carbon values were higher in NLA and LA liquid slurry, while FYM had the lowest organic carbon value. The N content was found lowest in FYM (1.42%), and highest in LA (2.12%) followed by NLA (1.89%). P content was found highest in slurry compost prepared from latrine non-attached plant (NLA). Similarly, P content was found higher in NLA and LA samples compared to FYM. Highest percentage of K_2O was found in NLA slurry (1.85%) followed by FYM (1.71%) and LA (1.42%) slurry. On the other hand, K_2O content was found lower in slurry compost samples compared to other categories. In contrary to the past studies K_2O content was found to be the highest in FYM. Though these findings need to be confirmed by further investigation, one of the reasons may be attributed to the addition of ash (from wood burning) in the FYM pits knowingly or unknowingly by the farmers to increase K_2O content of the manure. The next reason could be attributed to the presence of bedding material originating from leaves and twigs of the plants that contain high content of K.

Ammoniac N was found to be in highest percentage in LA (0.56%) followed by NLA samples (0.18%); it was less in slurry compost (0.12%) and lowest in FYM (0.01). The C: N ratio was highest in NLA (21.70) slurry, but in other categories it ranged from 15 to 17.

The NPK contents present in all categories of the organic manure have been illustrated below in **Figure 4**. Low C/N ratio in the slurry from LA biogas plant compared to NLA plant indicated less gas production potential of slurry in the outlet tank. Thus methane release to atmosphere from the LA plant may be low compared to NLA plant.

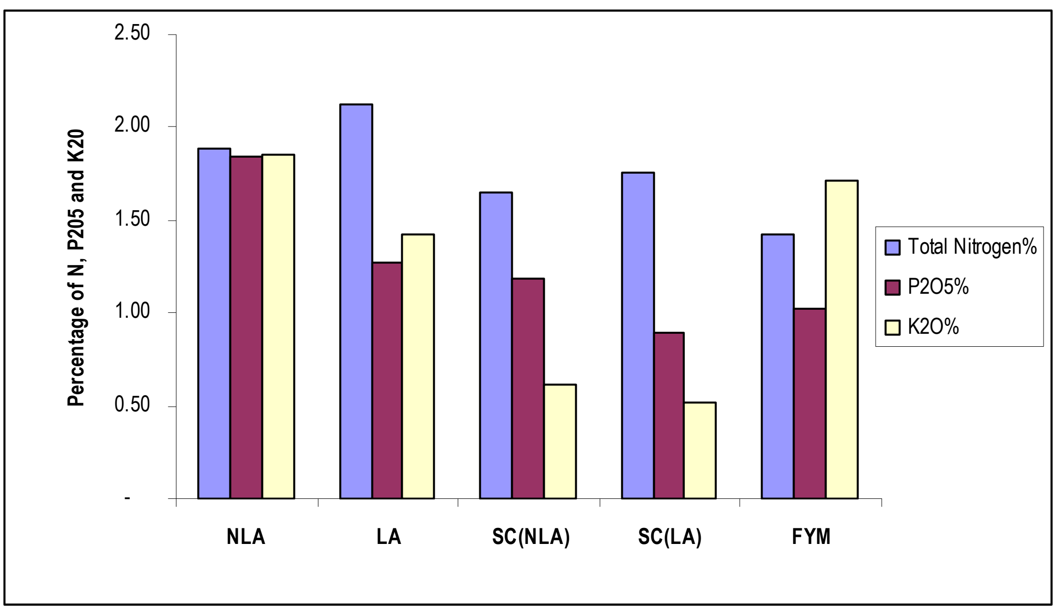

Figure 4: NPK Content Present in Different Types of Organic Manures

4.3 MANAGEMENT OF CATTLE SHED AND URINE COLLECTION

The field survey data on livestock, cattle shed condition and urine collection are given in **Annex 5** (see **Annex 5A** to **5D**).

Photo 1: Collection of Urine in Improved Cattle Shed

Cattle urine is a resource to the farmers which shoul not be wasted. Therefore, every care should be taken to prevent its loss and to utilize it profitably. It can be conserved by improving the cattle shed and making a pit for urine collection (see **Photo 1**). It can be used instead of water to mix the dung so as to feed into the bio-digester or can be put in the composting materials to enrich the product.

Based upon the detailed survey data compiled in **Annex 5A** to **Annex 5D**, the summarized findings on cattle shed management, urine collection and utilization has been presented in **Table 18**.

Table 18: Urine Collection, Utilization and Conditions of Cattle Shed

S.N.	Sample Type (Biogas HHs)	Urine Collection and Utilization		Condition of Cattle Shed			
				Earthen/wooden floor		Stone/concrete floor	
		Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)
1.	NLA	32	68	28	72	72	28
2.	LA	24	76	44	56	58	42
3.	SC	44	56	36	64	64	36
4.	FYM	12	88	64	36	36	64
	Average	**28**	**72**	**43**	**57**	**47**	**53**

NLA = Liquid Slurry from Latrine Non-attached plant; LA= Liquid Slurry from Latrine attached plant
SC = Slurry Compost (Compost prepared by using slurry); FYM= Farm Yard Manure

The data presented in **Table 18** depict the status of urine collection and utilization along with the conditions of cattle sheds whether they are traditional or improved ones. The results of survey reveals that on an average, only 28% of the biogas households have constructed urine collection pit for utilization, while greater percentage (72%) have not done so. Similarly, as regards the condition of cattle sheds, around 43% of sampled biogas HHs possessed traditional type of sheds (earthen or wooden floor), whereas 47% possessed concrete floor to facilitate the collection of urine from cattle shed.

4.4 COMPARISON OF NUTRIENT IN FRESH DUNG AND URINE OF A COW WITH FYM AND SLURRY COMPOST

It is very striking to note that in **Table 19**, total nitrogen content is exceedingly high in fresh cow urine compared to fresh dung, FYM and Slurry compost. Similarly, ammoniacal nitrogen, total phosphorus and organic carbon are also highest in fresh urine compared to dung and other type of organic manure. Next to cattle urine, ammoniacal nitrogen is higher in slurry compost prepared from latrine attached bio-slurry compared than other forms. Therefore, **Table 19** will reflect how important is the value of urine in recycling process (see **Photo 2** & **3**).

Table 19: Comparison of Nutrient in Fresh Dung and Urine of a cow with FYM and Slurry Compost

S.N	Analysis	Fresh Cowdung	Fresh Urine	FYM	Slurry Compost	
					Latrine Attached (LA)	Non-Latrine Attached (NLA)
1.	Total Solid (%)	20	2.0	31.9	32.7	26.11
2.	Volatile Solid (%)	71	52.2	41.3	43.0	49.72
3.	Total nitrogen (%)	1.5	25	1.4	1.76	1.65
4.	Phosphorus as P2O5 (%)	2.33	3.3	1.0	0.89	1.19
5.	Ammoniacal Nitrogen (%)	0.06	0.25	0.01	0.12	0.01
6.	Organic Carbon (%)	35.1	43.1	21.2	25.4	27.63
7.	Potassium as K2O (%)	0.52	1.87	1.7	0.52	0.61
8.	C/N ratio	23.4	1.72	15.2	25.4	17.43

Photo 2: An Inlet Close to the Stable Leads to Convenient Feeding and therefore encourages more regular feeding. However, the urine is still lost.

Photo 3: For Slurry Utilization a Plot of Elephant Grass was Established; Look how Green is the Area! due to Bio-slurry Use

As conceptualized by Christopher Kellner, out of total cattle excreta, 66% of the Nitrogen is present in the urine and only 34% in the dung. Since the urine is not channelized directly to the bio-digester in most of the cases, most of the urine gets lost before entering the bio-digester. Moreover, the practice of collecting only clean manure for the digester, leaving out the bedding material, causes loss of about 50% of the dung itself. This means Nitrogen content of the dung entering the bio-digester is only 17%. Again, it is assumed that almost 50% of the remaining Nitrogen gets lost in the process of composting, transportation, and incorporation into the field through leaching and volatilization. This heavy Nitrogen loss from the slurry till the time crops utilize it should be the main reason behind farmers giving little importance to slurry use. Hence, connecting cattle shed floor directly to the bio-digester will come out with tremendous beneficial effects of high nutrient content in the slurry.

Figure 5 summarizes roughly how much N was available as being discharged from a cow and how much of it is lost under the given circumstance. Under the given assumptions the farmer remains with 8,5% of the stated scenario. For P and K the same analysis would not be so distinct. Thus the argument on loosing nutrients is limited to nitrogen only.

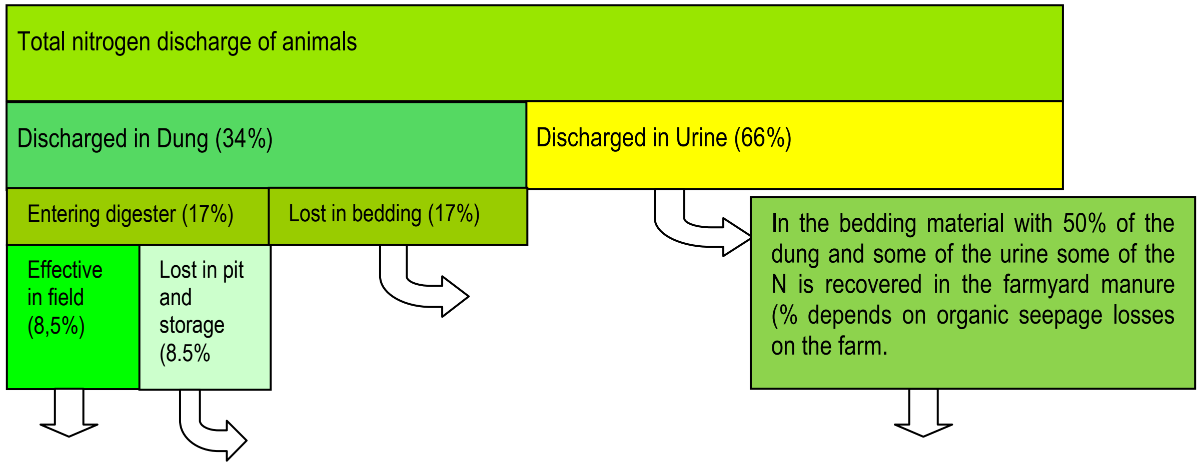

Figure 5: Availability of Discharge N from a Cow

Chapter 5
BIO-SLURRY RELATED CONCERN FROM USERS PERSPECTIVE

This Chapter is based upon the experiences and perceptions of biogas farmers in handling and utilizing bio-slurry as manure and for other integrated applications. The relevant findings are derived from Biogas Users' Survey 2006 in which a total of randomly selected 400 households (300 biogas-using households and 100 non-users) were interviewed from selected 15 districts of the country (CMS, 2006).

5.1 APPLICATION OF MANURE AND FERTILIZER

The results of survey revealed that with the installation of biogas, use of Farm Yard Manure (FYM) is reduced in all the field types (upland, lowland and kitchen garden). Reduction in FYM use and increase in slurry and slurry compost use has been reported resulting in increased use of organic manures in totality. The increase of organic manures in kitchen garden after the biogas plant installation is quite remarkable. Though there is remarkable increase in organic manure use, use of chemical fertilizers also has increased slightly. This could be due to high input responsive technologies being adapted by the farmers.

Within the last five years slight increase has been recorded in the use of manures and chemical fertilizers in all the land types, which could be due to the adaptation of new improved technologies.

5.2 APPLICATION OF MANURE AND FERTILIZER

In most of the crops, majority of the respondents observed no change in crop productivity after the installation of the biogas plant and application of slurry to crops. However among those who observed some change, majority found increased yield with a few stating even reduction in yield. Majority of the respondents reported increased yields in vegetables in both Terai and hills. Crop yield of three major crops - Rice, Maize and Wheat – are reported to be increased by 34%, 34% and 25% households in the hills and 31%, 16% and 22 % households in Terai respectively.

Vegetables and potato are the major crops grown in the kitchen garden. Majority of respondents reported increased yield in both these crops with only a few households reporting decreased yield.

Though no significant increment in the production is observed, 46.8% respondents viewed that biogas slurry has positive effect in agriculture production. However, on an average 50.70% respondents observed no significant effect in this respect.

5.3 LIVESTOCK, STALL FEEDING AND SHED MANAGEMENT

5.3.1 Animal Husbandry Practices after Biogas Plant Installation

Majority of the biogas users (70%) have adopted stall feeding as the common practices associated with shed construction as well as other husbandry practices like fodder and forage production after the installation of biogas plant. Only about 14% of the respondents in Terai seem to be aware of the importance and benefits of urine and dung collection for biogas production as against about 34% in the hills.

5.3.2 Livestock Shed Management

After the installation of biogas plant, number of households has increased significantly in each of the three indicators of shed condition both in hills as well as Terai indicating towards significant improvement of the livestock shed condition.

5.4 FODDER AND DUNG COLLECTION

5.4.1 Fodder Collection Practices

Among the biogas users, more than 57% of the households (hhs) collect fodder from jungle and 55% has own production. The practice of producing fodder by farmers themselves is more in hill than in Terai. Among the non-users, 84% of the hhs collect fodder from forest with about 44% collecting fodder from forest as well as having own production. Percentage of households collecting fodder from forest only is significantly higher among biogas non-users (84%) than the biogas users (57%) indicating the popularity of stall feeding practices among the biogas users.

5.4.2 Dung Availability and Production

Since dung is the main feeding material for the biogas plant; its availability with the biogas users very much determines the efficiency of the plant. On an average, per day dung availability is much higher in Terai than in hills. With regards to the change in the availability after the installation of biogas plant, majority of the respondents both in Terai and hills reported no change. However among those who reported change, the respondents observing decreased availability slightly out numbered those observing increased availability.

5.5 BIO-SLURRY AND COMPOSTING PRACTICES

Despite high manorial value of bio-slurry, the biogas users seem to give much importance towards the gas only without giving due importance to the slurry that comes out as the byproduct of anaerobic digestion process,. The present survey has tried to assess the use of slurry and its composting practices. In fact, AEPC/BSP-N in the recent past had launched various programs to enhance the use of slurry as manure.

5.5.1 Bio-Slurry Application Mode

It is strange to note that slurry use as manure is still not popular in Terai. Compared to Terai (25%), significantly higher percentage of hill households (90%) have been found to be using slurry as manure. On an average, 72% of the sample households use slurry as manure both in the form of slurry compost as well as liquid slurry. Slurry compost is more popularly used than liquid slurry as such.

5.5.2 Bio-Slurry Composting

As pointed our earlier, bio-slurry that comes out from the outlet of a bio-digester is considered to be organic manure of very high quality. Since all of them are not immediately used, the practice of composting of slurry in pits is recommended. However, the number of pits may vary with households. On an average, majority of the biogas hhs (75%) have two slurry pits for composting purpose. On the other hand, slightly less than one-fourth (23%) of the biogas hhs possess only one pit and only very negligible number of households have no pits. In Terai, more than 90% households have 2 pits and only few percentage of hhs (7%) have single pit whereas these figures in the hills are 69% and 29 % respectively.

5.5.3 Composting Method

Heap and pit are the two popular methods of composting among the Nepalese farmers. The pit method is considered technically superior and efforts are being put both from government (GO) as well as non-government organizations (NGOs) in promoting the pit method of composting. In case of pit method, the biogas farmers are advised to make two compost pits near the plant so that the pits can be filled in and emptied alternately (see **Figure 6** below).

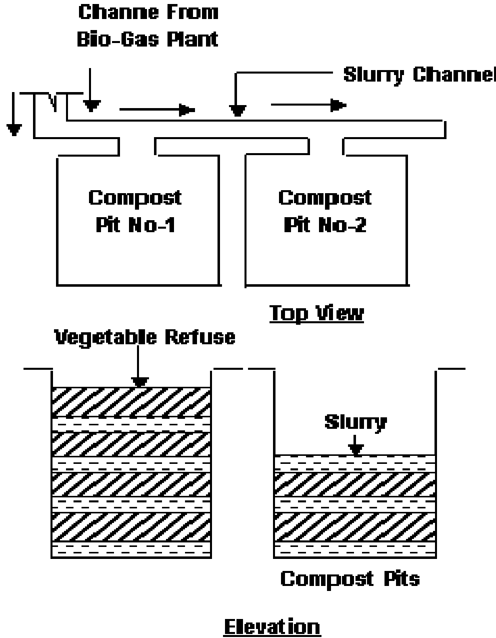

Figure 6: Use of Slurry in Making Compost

Among the biogas users more than 95% of the hhs follow pit method. The results also indicate that heap method is almost non-existent in Terai while in hills there are a few hhs which are still following the heap method. In case of the non-users, pit and heap methods of composting organic residue are found in the ratio of 57:43 both in Terai and hills.

5.5.4 Turning over of Slurry-compost/Compost

The frequency of turning is considered to have direct relationship with the quality of compost. More the number of turnings better is the quality of compost produced. More than 40% of the respondents among the biogas users both in hills and Terai do not turn the compost pits. Among those who turn, most respondents do only one turning both in Terai and hills. Among the non-users also, almost 50% of the respondents do not turn the compost. The percentage of non turners is higher in Terai (60.7%) than in hills (44.4%).

5.5.5 Composting Period

Composting period also has direct relationship with quality. However the composting duration very much depends upon the temperature or seasons. In general, composting period in the hills is much higher than in Terai.

Among the biogas users more than 50% of the hhs keep compost in the pit for four months. However, it is strange to note that more than 55% of the Terai hhs had kept compost in the pits for four months compared to about 48 % in the hills. In fact, the composting period is more or less determined by the time of application of manure to the crops rather than decomposition time. Among the non-users also the duration of four months seems to be most popular both in Terai and hills.

5.5.6 Slurry/Compost Storage and Application

Since the place of slurry/compost preparation and their application place and time vary, their storage and application mode also vary. The present biogas users' survey also reveals various modes of storage and application in the field.

In Terai, most popular practice of compost storage is *Spreading in field uncovered in small heaps* (57.5%) while this is the second most popular practice (22.2%) in hill area. The most popular practice of compost storage in hill is *spreading during slack season and incorporating into soil only at the time of land preparation* (44.3%). Similarly, *spreading in the field and incorporating in the soil immediately* is the second popular practice (29.9%) in Terai and third popular practice (21.7%) among hill respondents.

5.6 IMPACT OF BIO-SLURRY ON THE INCIDENCE OF DISEASE AND PESTS

If the plant is well fed in terms of nutrient provision, it is healthy and likely to be attacked less by the pests. It is proven that pest control with filtered bio-slurry, BIOL, acts to some extent to nourish plants via the leaves on which it is applied. So, again pest resistance takes place from general good, balanced nutrition and organic fertilizers, which originate from plant matter doing so much better than artificial fertilizers. That's why artificial fertilized farms need pest control complementary.

Since the bio-slurry is considered decomposed and digested manure, the chance of the occurrence of active pathogens is considered minimum as compared to the FYM/compost. And hence it is expected that the chances of the incidence of pests and diseases will also be lesser with the application of bio-slurry. The present survey has also tried to assess the impact of bio-slurry application on diseases and pests. In this connection, *No Change* and *Do not know* are the two perceptions given by most of the respondents both in Terai and hills. However the number of households observing increase and decrease in pest incidence with bio-slurry use is found almost equal. Since these are the mere perceptions of user farmers, no definite conclusion can be drawn without a focused R & D in this regard.

5.7 USE OF BIO-SLURRY AS FISH FEED

The digested slurry is considered to be an excellent feed for fish as well. But in the Nepalese context, fishery at household level is still not popular and most of the sampled biogas users do not have fish pond. The Biogas Users' Survey 2006 has tried to assess slurry use as fish feed and its impact on fish production (**Photo 4**).

Photo 4: Rearing of Fish by Using Bio-slurry

Fishery is still not a popular component in the farming systems of the biogas users. However a few households in the hills reported using slurry in the fish ponds at the rate of 16 liters per annum which resulted in almost 50 percent increased fish production per annum (information on species of fish fed with slurry and area of fish pond was not gathered during the users' survey; it needs to explore how trials were conducted in farmers' pond?).

5.8 STATUS OF LATRINE AND LATRINE ATTACHED BIOGAS PLANTS

5.8.1 Status of Latrine

Possession of latrine keeps the household surroundings clean and hygienic. In this connection, the results of survey reveal that among the user households, the percentage ratio of households with and without latrine was almost 50:50 prior to the installation of biogas. However, after the installation of biogas the percentage of biogas user households possessing latrines has increased up to 93%. This change is more pronounced in hills (95.7%) than in Terai (86.2%). Among the non-user households, the percentage ratio of those having latrines with those not having is 72:28.

5.8.2 Biogas Connected Latrines

The main objective of connecting latrine with the biogas plant is to increase feeding in the plant and keep the surroundings clean and healthy. Furthermore, this also resolves the waste management problem remarkably. Among the respondents, 65% have connected their latrines with the plant, which is similar to BUS 2002/03 report (64%). The practice of connecting latrines with biogas plants seems more popular in hills than in Terai.

Chapter 6
PRACTICAL RECOMMENDATIONS ON THE APPLICATION OF FERTLIZERS AND MANURES AT FARMER'S LEVEL

Various aspects of bio-slurry utilization, its nutrient content and manorial value with respect to FYM, other manure as well as chemical fertilizers were dealt with in greater detail in the foregoing chapters. This chapter focuses to enhance the theoretical as well as practical understanding on bio-slurry utilization in broad horizon. Furthermore, the need for conducting simple demonstrative trials with bio-slurry at farmer's level has been duly stressed. An attempt has been made to depict the sound and practical recommendation of fertilizers and manures at farmer's level.

6.1 INTER-RELATION OF BIOGAS TECHNOLOGY AND AGRICULTURE

More than 90 percent of the population in Nepal is engaged in agriculture. Therefore, any technology that can influence agriculture or gets influenced by the agricultural practices becomes a subject of concern not only to the biogas user but also to the nation as a whole.

Byproducts of agriculture, mainly animal wastes and crop residues, are the primary inputs for biogas plants. The digested slurry as one of the outputs of a biogas plant can be returned to the agricultural system. Proper application of the slurry as organic fertilizer increases agricultural production because of its high content of soil nutrients, growth hormones and enzymes. Dried slurry can also safely replace a part of animal and fish feed concentrates. Furthermore, slurry treatment also increases the feed value of fodder with low protein content. When the digested slurry is placed into the food chain of crops and animals, it leads to a sustainable increase in farm income.

This close relation between biogas and agriculture can be taken as an indicator of "environmental friendly" nature of the technology as shown in **Figure 7** (FAO/CMS, 1996).

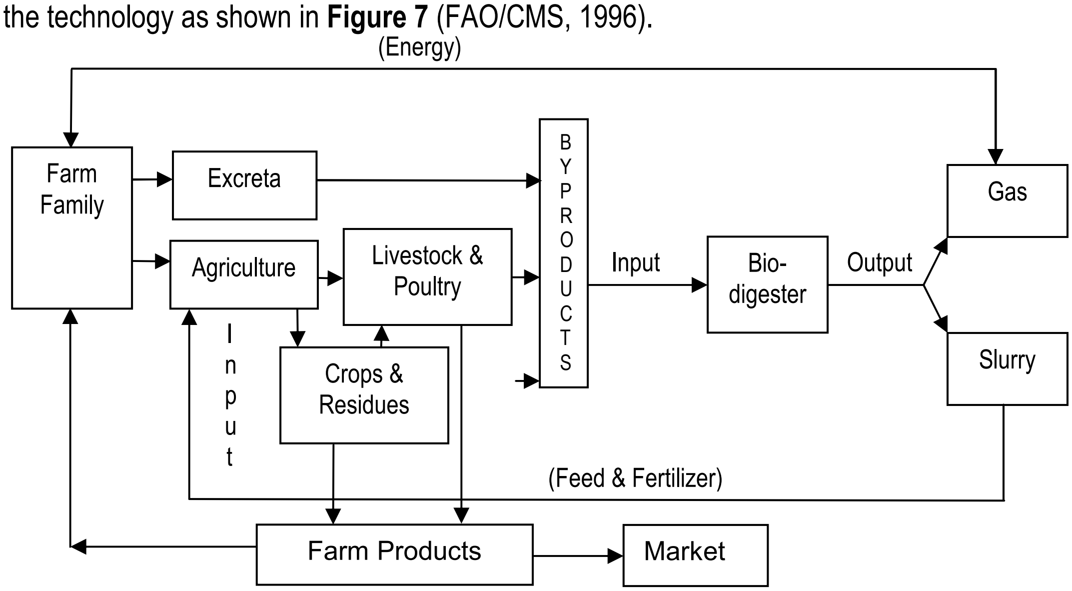

Figure 7: Recycling with Biogas Technology on Household Level

6.2 IMPORTANCE OF ORGANIC MANURE IN ENHANCING FERTILITY OF SOILS

The continuous cultivation of crops without replenishing the lost nutrients from the soils results in the depletion of soil organic matter, the loss of which is associated with lowered nutrient levels, especially nitrogen, soil structural degradation and associated declines in yield as well as the protein content of grains. Farming systems in order to be sustainable must maintain soil organic matter at minimum required level. Soil organic matter therefore is considered as a key indicator of sustainability. Various studies have shown that continuous application of chemical fertilizer alone deteriorates soil health and fails to respond to the application of chemical fertilizer in terms of yield. Therefore to recuperate from such impoverishment in soil condition in order to have sustained growth in yield, judicious application of organic manures along with chemical is a must.

As pointed out in the preceding chapters, organic manures mean: a. traditionally prepared Farm Yard Manure; b. Improved Compost; c. Slurry Compost prepared by using digested slurry (Bio-slurry) from the biogas plants; and d. digested bio-slurry both in liquid and dry forms.

Following beneficial effects accrue due to application of organic manure in soil:

- Organic matter improves the soil structure thus maintaining favorable condition of aeration and permeability.
- It helps increase the water holding capacity of soil.
- It serves as a reservoir of chemical elements that are essential for plant growth.
- Organic mulches reduce the water loss due to evaporation.
- It prevents I nutrient loss from leaching.
- It is helpful to reduce surface runoff and erosion making more water available for plant growth.
- It serves as a source of energy for the growth of soil flora, fauna and microbes.

The beneficial effects of organic manure greatly depend upon its composition and quality. It is important to know what kind of materials are used for its preparation, how it is prepared, stored and used. Such assessment is useful to judge the quality of manure.

6.3 BALANCED USE OF ORGANIC MANURE AND CHEMICAL FERTILIZERS

Crops absorb nutrients from soil for their growth and yield. The nutrients removed from the soils must be replenished through outer sources like organic manures and chemical fertilizers. Application of chemical fertilizers alone is not sufficient as crops in course of their growth remove also the elements other than what are available in the chemical fertilizers which in most cases contain nitrogen, phosphorus and potash only. Along with chemical fertilizers, organic manures need to be applied to maintain the minimum soil organic matter level for the maintenance of physical, chemical and microbial properties of soil. Therefore, application of nutrients (both chemical and organic) as per the needs of the crops being grown is quite essential for sustaining the soil fertility. Hence in the national context, application of NPK is recommended through chemical fertilizers, including the use of organic manures.

According to the available nutrients contained in the organic manure, it needs to be applied in bulks compared to inorganic fertilizers. There is no adverse side effect of excessive application of organic manure to the soil; the excess of nutrients present in it becomes available for subsequent crops due to its residual effects. On contrary to it, if mineral fertilizers are applied in very heavy amounts, it is detrimental to the soil conditions, thereby affecting crop production. Besides, it will also have adverse indirect impacts on food chain through land, water and air pollution resulting from leaching, run off and spraying respectively.

As mentioned previously, it should be noted that farmers can not solely depend upon organic manure as it has to be applied in large amount and the entire nutrient contained in it is not in readily available form compared to mineral fertilizer. On the other hand, there are improved or hybrid variety of crops which are responsive to high inputs and as such desired yield can not be achieved unless recommended dose of plant nutrients are supplied in the form of mineral fertilizers.

Hence, there is a need to apply both chemical and organic fertilizers in a balanced way to get expected output or the crop yield. We can't entirely substitute mineral fertilizer by the organic manure.

6.4 IMPORTANCE AND NECESSITY OF SOIL TEST

As has been stated above, crops absorb nutrients required for their growth from soils. Nutrients requirements vary with crops and nutrients availability vary with soils. Hence it is essential to know the status of nutrients in the soils where a specific crop is to be grown. Based on what is available in the soils and how much of what is needed for crop growth, nutrients to be applied should be calculated and there comes the role of soil test. It measures the nutrient supplying capacity of soil and therefore gives an account of total nutrient reserve.

In above backdrop, it is of utmost importance to create awareness to the farmers regarding fertility status of their soils. For this purpose, agricultural extension workers should suggest them to get their soils examined especially for major plant nutrients such as NPK, organic manure and pH. Based upon the results of analyses in standard soil testing laboratory, sound recommendation on the application of organic and inorganic fertilizers should be suggested to them.

Based upon the results of analysis, the fertility status of the soils is rated: High, Medium and Low; and the fertilizer recommendation are based accordingly. Analysis of pH value will reveal whether the soil is acidic or alkaline. And if it is acidic, appropriate quantity of lime application is recommended to amend the soil depending upon pH, soil texture, type of crops to be grown, etc.

In Nepal also, fertilizer recommendations are made on the basis of soil test values. While doing so following criteria are followed (see **Table 20**).

Table 20: Criteria for Fertilizer Recommendation

S.N.	Fertilizer dose Recommended as of National Recommendation Level	Nutrient Status	Soil Type
1.	100% of N,P and K	Low	Light
2.	75% of N and 60% P and K	Medium	Medium to heavy
3.	80% N and 70% P and K	Medium	Light
4.	50%N and 40% P and K	High	Heavy

Source: Joshy and Deo, 1976

Table 20 will relate the statements to **Table 19** in terms of quantities advised to be applied in Nepalese context.

6.5 SIMPLE DEMONSTRATION OF BIO-SLURRY AT FARMER'S FIELD

In extension, it is said that "Seeing is believing". It has been pointed out earlier that reasonable number of biogas farmers are not yet convinced about the value and quality of bio-slurry. Therefore, it is essential to do everything possible to improve the quality and quantity of organic fertilizer available on the farm and carry out simple demonstration with bio-slurry at their field so that they could see the results themselves and be convinced. To begin with, it is proposed to carry out following simple demonstration with few treatments on crops and vegetables (FAO, CMS, 1996).

T_0	Control[14]
T_1	Farm Yard Manure
T_2	Slurry Compost
T_3	Liquid Slurry

It should be noted that the quantity of manure for different treatments (T_1, T_2 and T_3) will differ in accordance with the N content. It is strongly advised to take opinion of a Soil Scientist or an Agronomist in conducting the experimentation in a scientific manner to derive meaningful results.

BSP-Nepal has been carrying out above types of simple demonstrative trials at farmer's field by involving Biogas Companies. It needs to compile the findings for information dissemination.

6.6 SOIL FERTILITY EXPERIMENTATIONS

In the present context, a fertility trial including following treatments, if necessary with some modifications, is worth conducting in different agro-climatic conditions of Nepal by the relevant institutions.

- Control
- FYM (traditionally prepared) @ 5 and 10 tons/ha
- Wet slurry @ 5 and 10 tons/ha
- Composted dose of chemical fertilizers
- Recommended dose of chemical fertilizers and wet slurry @ 5 and 10 tons/ha
- Recommended dose of chemical fertilizers and composted slurry @ 5 and 10 tons/ha
- Recommended dose of chemical fertilizers and composted slurry @ 5 and 10 tons/ha

These treatments should be replicated four times for conducting statistical analysis.

Similar experiments carried out in China have produced the following results (see Biogas Technology in China, 1983)

- Compared to the control, application of digested slurry increased the late rice, barly and early rice yields by 44.3 percent, 79.8 percent and 31 percent respectively.
- Compared to FYM, application of digested slurry increased the rice, maize and wheat yields by 6.5 percent, 8.9 percent and 15.2 percent, respectively.
- Compared to FYM, application of digested slurry along with ammonium bio-carbonate (chemical fertilizer) increased the rice and maize yields by 12.1 percent and 37.6 percent respectively.

The results of study in China indicate that bio-slurry is of superior quality than FYM. Crop productivity can be increased significantly if the slurry is used in conjunction with appropriate nature and dose of chemical fertilizer.

6.7 RECOMMENDED DOSE OF CHEMICAL FERTILIZERS AND ORGANIC MANURES

6.7.1 Recommended Dose of Chemical Fertilizers

Generalized recommendation of the chemical and organic fertilizers for major crops and vegetables are presented in **Table 21** for reference.

[14] It is important to know how 'control' is regarded in carrying out demonstration at farmers' field? - according to the farmers tradition or not at all? The latter is not a helpful comparison.

Table 21: Recommended Dose of Chemical Fertilizers*

(in kg /ha)[15]

S.N.	Crops and Vegetables	Recommended Dose of Chemical Fertilizers (kg)			Organic Manure
		N	P	K	(in tons)
1.	Rice	100 (Irrigated) 60 (Rain fed)	30 (Irrigated) 30 (Rain fed)	30 (Irrigated) 20 (Rain fed)	6
2.	Maize	60	30	30	6
3.	Wheat	100 (Irrigated) 60 (Rain fed)	50 (Irrigated) 20 (Rain fed)	25 (Irrigated) 20 (Rain fed)	6
4.	Millet	20	10	10	6
5.	Pulse	20	20	20	4-6
6.	Oilseeds	60	40	20	6
7.	Vegetables	70	50	40	32

** Source: Agriculture Diary (2060)*

6.7.2 Recommended Dose of Organic Manures

Based upon available data, an attempt has been made to recommend the quantity of various organic manures to be applied to major crops and vegetables (see **Table 22a** to **Table 22d**).

Table 22a: Recommended Dose of Different Types of Organic Manures

(m.ton/ha)

S.N.	Crops and Vegetables	FYM	Slurry Compost (SC)	Liquid Slurry (Bio-slurry)
1.	Rice	13	12	10
2.	Wheat	10	9	8
3.	Maize	13	12	10
4.	Millet	8	7	6
5.	Pulse	8	7	6
6.	Oilseeds	10	9	8
7.	Vegetables	35	30	27

Table 22b: Recommended Dose of Different Types of Organic Manures

(m.ton/bigha)

S.N.	Crops and Vegetables	FYM	Slurry Compost (SC)	Liquid Slurry (Bio-slurry)
1.	Rice	8.5	7.5	6.0
2.	Maize	6.5	6.0	5.0
3.	Wheat	8.5	7.5	6.0
4.	Millet	4.8	4.2	3.5
5.	Pulse	4.8	4.2	3.5
6.	Oilseeds	6.5	6.0	5.0
7.	Vegetables	24.0	20.0	18.0

[15] Necessary Conversion:
1 Kattha = $333m^2$
1 Ropani = $508\ m^2$
1 ha = 1.48 Bigha
1 ha = 19.66 Ropani

Table 22c: Recommended Dose of Different Types of Organic Manures

(Calculated on Kattha Basis)

S.N.	Crops and Vegetables	FYM		Slurry Compost (SC)		Liquid Slurry (Bio-slurry)	
		Kg/kattha	*Doko*[16]/kattha	Kg/kattha	Doko/kattha	Kg/kattha	Bucket[17]/kattha
1.	Rice	425	21	375	19	310	31
2.	Maize	325	16	300	15	245	25
3.	Wheat	425	21	375	19	310	31
4.	Millet	245	12	210	10	180	18
5.	Pulse	245	12	210	10	180	18
6.	Oilseeds	325	16	300	15	245	25
7.	Vegetables	1200	60	1000	50	880	88

Table 22d: Recommended Dose of Different Types of Organic Manures

(Calculated on Ropani Basis)

S.N.	Crops and Vegetables	FYM		Slurry Compost (SC)		Liquid Slurry (Bio-slurry)	
		Kg/Ropani	Doko/Ropani	Kg/Ropani	Doko/Ropani	Kg/Ropani	Bucket/kattha
1.	Rice	650	32	575	29	475	48
2.	Maize	500	25	450	22	375	38
3.	Wheat	650	32	575	29	475	48
4.	Millet	375	19	325	16	275	28
5.	Pulse	375	19	325	16	275	38
6.	Oilseeds	500	25	450	22	375	38
7.	Vegetables	1850	92	1550	78	1350	135

16 One *Doko* is equivalent to 20 kg
17 One bucket is equivalent to 10 litres

Chapter 7
CONCLUSIONS AND RECOMMENDATIONS

Following conclusions and recommendations are derived from this study:

7.1 CONCLUSIONS

The physico-chemical analyses of 100 samples from eight districts helped to derive a conclusion that bio-slurry (both from latrine attached and non-attached plants) has higher manorial value than FYM and compost; and bio-slurry in liquid form has richer nutrient content than slurry compost. The plant nutrients in digested bio-slurry are in readily available form and hence are superior to even chemical fertilizers for some crops. However, due to the necessity of applying very large quantity of organic manure to fulfill the need of crops, simultaneous use of balanced chemical fertilizer is necessary.

It is evident that the stable system and the traditional manure handling are leading to large losses in nutrients. Even though the two pit composting system with sun shade is designed to help minimize such losses, they are still very high. The user survey showed that the sizes of compost pits are much smaller than recommended ones and therefore, does not accommodate all available organic matter available on the farm within the time unit where the pit is filled and emptied again. The pit can also not hold the moisture in the slurry, but large parts of it will trickle down underground; this will result into leaching of soluble nutrients.

Many farmers are establishing a stoned or concreted cattle-shed floor after the biogas plant construction. This reduces the necessity of bringing water and enriches the slurry particularly with nitrogen, while the water dilutes it and will lead to loss of nutrients from the slurry pit.

The data on cattle shed management helped to conclude that the process of constructing concrete floor shed and urine collection pit, though slow, is in progressing trend. This fact is also supported by the Biogas Users' Survey, 2006 (CMS, 2006).

In Nepal where more than 90 percent of the population is engaged in agriculture, biogas technology with its varied benefits has proved to be sustainable in rural context since by products of agriculture, mainly animal wastes and crop residues, are the primary inputs for biogas plants. Besides biogas, the use of bio-slurry for various purposes in agriculture system can save expenditure on imported agro-chemicals to significant amount both at farmers' level and national level. Varied use of bio-slurry as plant nutrient, soil conditioner/vitalizer, fish feed, and pesticides have tremendous beneficial impact on agriculture system. However, there is a need of exploring its potential to maximum extent thorough researches so that farmers can be convinced for its proper utilization for both economic and environmental benefits.

7.2 RECOMMENDATIONS

- Field experiments should be conducted to improve quantity and quality of raw materials to be fed in the digester to reduce N loss.
- Establish a large number of demonstration farms having different well supervised slurry utilization systems

- Reconsider GGC 2047 standard digester on the inlet side to allow for more nutrients and less water to enter the digester and on the outlet tank side to encourage the use of liquid slurry as convenient as possible.
- Conduct research to devise appropriate tools for liquid slurry handling
- Slurry Extension Programme to increase awareness on slurry use should be continued.
- A separate research should be done regarding pest repellent characteristic of bio-slurry.
- Separate study should be carried out to come to a concrete conclusion regarding slurry use as fish feed; detail experiments as per the species of fish fed, quantity of slurry required, area of the pond etc should be done.
- Both laboratory and field level studies should be conducted to know about the presence of chemicals having hormonal property in bio-slurry.
- Extensive awareness programmme about bio-slurry use should be conducted in through effective information dissemination tools like pictorial pamphlets/posters, audio-visuals, training programmes etc.
- Effective training on proper storage and handling of bio-slurry should be conducted to every biogas user household.
- Identify methods to encourage farmers to experiment with slurry.
- Awareness raising and training should be carried out to overcome the reluctances of farmers to use slurry from latrine attached bio-digesters.
- Periodical interaction with stakeholders should be carried out so that other organizations involved in biogas promotion besides biogas companies are made well aware about the beneficial impacts of bio-slurry use.
- In cases where it is technically feasible biogas plants should be linked with cattle-shed in a way that all the urine is collected and can be utilized conveniently for mixing with the dung.

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