SESSION FOUR

UTILIZAITON OF SLURRY AS FEED AND FERTILIZER

SESSION FOUR

Utilization of Slurry as Feed and Fertilizer

4.1 Introduction

Discussions in previous sessions might have created an impression that the inflammable gas (methane) is the main product of a biogas system and the digested slurry is the by-product of it. It should be understood that such is a case in an energy scarce area. The slurry is equally important, if not more, for its high nutrient content and multiple use as manure, soil conditioner and feed for cattle, pig and fish.

By the end of this session, the participants will be able to:

- explain nutritive value of anaerobically digested slurry for maintenance of soil fertility and increased crop production;
- enumerate different methods of utilization of slurry for crop production; and
- explain the role of slurry as a partial supplement in the rations of animals, poultry and fish.

4.2 Inter-relationship of Biogas Technology and Agriculture

More than 90 percent of the population in Nepal are 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.

By-products 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 Chart 4.1.

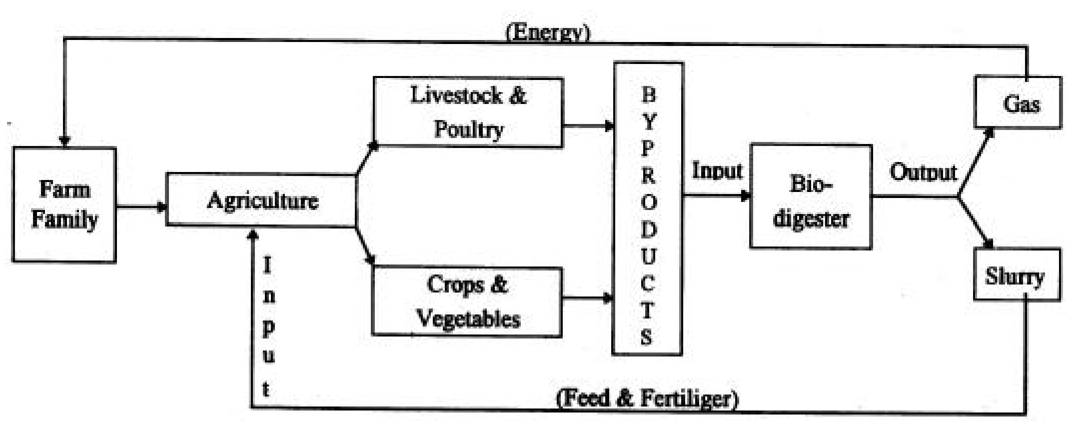

Chart 4.1 Relationship Between Biogas and Agriculture in a Farming Family

4.3 Limitations of Chemical Fertilizer Use

Table 4.1 shows the quantity of soil nutrients removed in kg/ha by the cropping rotation of maize-paddy-wheat as is commonly practised in Nepal (Sthapit. 1987). At current yield levels, rice, wheat and maize alone are estimated to be removing 700,000 tons of soil nutrients annually. With expanding area under improved varieties and high yielding crops, this extraction of soil nutrients is expected to continue at the higher rate in the future.

The present rate of commercial fertilizer use in the country replenishes only about 10 percent of the soil nutrients removed every year With the declining trend observed in the rate of application of Farm Yard Manure (FYM), soils are not replenished for more than 70 percent of the nutrients mined every year in terms of agricultural production. Thus, the productivity of soils is declining due to this continuous over mining (APROSC/JMA, 1995).

Table 4.1

Soil Nutrient Loss (Maize-Rice-Wheat System)

Crop	Quantity Removed (kg/ha)		
	Nitrogen	Phosphorus	Potash
Maize	**53**	**22**	12
Rice	**54**	**7**	74
Wheat	**30**	**23**	32

Source: Sthapit (1987)

In the early 1960s, yields of major crops such as paddy, wheat and potato were higher in Nepal than in all other South Asian countries. In early 1990s, the national average yields of these crops have become considerably lower owing to over-mining of soil nutrients in Nepal and the higher rate of agricultural growth in other countries. The availability of food grain per capita has decreased by 0.02 percent over a decade of 1981 to 1991. Out of 75 districts, 41 are now food deficit areas. This is one of the main root causes of growing poverty in Nepal (APROSC/JMA, 1995).

Pressed between the need to feed the growing population and the declining productivity of agricultural land, new areas have been brought under cultivation. Observations and data of 1992 indicate that the possibility to expand agriculture into new land, except at the expense of the remaining forest area, has been exhausted. Therefore, fertilizer has become the leading means to increase agriculture production. The present level of nutrient application of less than 25 kg per ha of cultivated land is about a quarter of Bangladesh and 10 percent of China. The much higher application rates used in neighbouring countries show profitability of fertilizer use.

In 1994, the government allocated Rs 300 million and 50 million as price and transport subsidies for chemical fertilizer, respectively. The removal of transport subsidy will make fertilizer use unprofitable in the lulls. In the remote hills, the amount of fertilizer transported depends on the level of transport subsidy. The economic implication of increasing the present level of fertilizer consumption from the present rate of less than 25 kg/ha to 152 kg/ha, as speculated by Agricultural Perspective Plan, is obvious for Nepal which has large trade deficit and all chemical fertilizer has to be imported.

The most common fertilizers consumed in Nepal are Urea (46:0:0) and Diammonium Phosphate (DAP. 18:46:0). In 1992/93, the price of DAP increased by about 66 percent, potash by 293 percent and urea by 9 percent. Negligible amount of subsidy is provided in chemical fertilizers other than urea. With the on-going 12 percent annual increase in fertilizer consumption, the ability of the government to provide subsidy is ever decreasing.

More and more farmers are finding it difficult to continue the use of chemical fertilizers even at the present low level of less than 25 kg/ha due to (a) increase in prices at a rate higher than the rate of increase in farm income, (b) non-availability of chemical fertilizers at the required time in a desired form and quantity.

Not a single fertilizer factory exists yet in Nepal. A study has revealed that a factory with the production capacity of less than 270 thousand metric tons per year is not economically viable. Another limiting factor is the current deficit in the supply of electricity. Frequent load shedding will limit the factory's production output. Furthermore, the present rate of electricity tariff is too high for a such factory to be financially viable.

The Agriculture Inputs Corporation (AIC) with its distribution network scattered all over the country, is mainly responsible for procurement and distribution of the chemical fertilizers. However, despite its widespread network of more than 70 distributional offices, it has been unable to supply chemical fertilizer on time and at sites where it is required. In some cases, import of low quality fertilizers has also been reported (AIC, 1996).

The on-going degradation of forest cover has a direct impact on the cattle population and hence the production of FYM is also affected causing reduction in the availability of organic fertilizer. In this context, biogas has proved to be one of the feasible means to conserve forest as well as to reduce the burning of animal dung which otherwise could be used as fertilizer Research data indicate that under optimum condition, one m^3 of biogas is equivalent to 5 kg of firewood or 9 kg of agricultural waste or 10 kg of dung cakes.

A continuous use of chemical fertilizer alone, without the addition of organic manure, has been found to have detrimental effect on soil quality in the long run mainly because of constant loss of humus and micro-nutrients.

The above discussion leads to the conclusion that reliance on chemical fertilizer alone would not ensure sustainable development of agriculture in Nepal.

4.4 Organic Fertilizer

Average farms in Nepal are characterized by their small land holding of about 0.2 ha and integration of agriculture with a few heads of animal and birds, as shown in Table 4.2.

Table 4.2

Percentage of Households Keeping Animals and Birds by Region, 1991/92

Region	Cattle	Chauri	Buffalo	Goat	Sheep	Pigs	Horses/ Mules	Poultry	Ducks
Mountains	82.8	2.9	44.8	55.5	6.5	10.3	1.3	56.4	6.0
Hills	77.3	0.1	60.0	54.2	4.2	12.2	0.4	67.6	9.2
Terai	74.4	0.0	35.8	46.8	1.8	7.1	0.4	32.4	15.7
Nepal	76.6	0.3	48.5	51.3	3.4	9.9	0.5	51.9	11.6

Three-quarters of all households in Nepal raise cattle, and one-half raise buffalo, goats and poultry. About two-thirds of livestock owners cultivate less than 1.0 ha of land (National Sample Census of Agriculture for Nepal, 1991/92). This situation favours the production of organic manure at the household level for augmenting agricultural production through increased use of organic manure. Biogas supports such **a** strategy by preventing the burning of agricultural and animal waste for meeting household energy needs and providing slurry rich in nutrients for soils and animals.

4.5 Importance of Slurry for Crop Production

Organic matter plays an important role because of its beneficial effects in supplying plant nutrients, enhancing the cation exchange capacity, improving soil aggregation, increasing water holding capacity of soils, stabilizing its humic content and increasing its water holding capacity. Organic soil amendments support biological activities and also control root pathogens. Biogas slurry has proved to be a high quality organic manure Compared to FYM, digested slurry will have more nutrients, because in FYM, the nutrients are lost by volatilization (especially nitrogen) due to exposure to sun (heat) as well as by leaching.

The farmer needs to use chemical fertilizer to increase his crop production. However, if only mineral fertilizers are continuously applied to the soil without adding organic manure, productivity of land will decline. On the other hand, if only organic manure is added to the soil, desired increase in crop yield can not be achieved. Fertility trials carried out in Nepal and elsewhere have revealed that optimum results can be achieved through the combined application of both chemical and organic fertilizers.

In countries where biogas technology is well developed, for instance in China, there are evidences which support the fact that productivity of agricultural land can be increased to a remarkable extent with the use of slurry produced from biogas plant. In Nepal too, if properly managed, the biogas slurry could play a major role in supplementing the use of imported and expensive chemical fertilizers However, in the present context of Nepal, the focus has been only to increase the number of biodigesters for its gas use and little attention has been paid on the proper utilization of digested slurry as organic fertilizer.

4.6 Characteristics of Digested Slurry

Only approximately 10 percent of the total nitrogen content in fresh dung is readily available for plant growth A major portion of it has first to be biologically transformed in the soil and is only then gradually released for plant use. When fresh cow dung dries, approximately 30 to 50 percent of the nitrogen escapes within 10 days. While nitrogen escaping from digested slurry within the same period amounts to only 10 to 15 percent Therefore, the value of slurry as fertilizer, if used directly in the field as it comes out of the plant, is higher than when it is used after being stored and dried (Moulik, 1990).

The short term fertilizer value of dung is doubled after being anaerobically digested while the long term fertilizing effects are cut by half. Under tropical conditions (i.e. where biogas plants are most effective) the short term value is of greater importance because rapid biological activities degrade even the slow degrading manure fraction in relatively short time.

Cattle dung contains about one percent total nitrogen. Nitrogen is considered particularly important because of its vital role in plant nutrition and growth. The nitrogen cycle in nature is depicted in Chart 4 2 (Sasse, 1991). During anaerobic digestion, 25 to 30 percent organic matter is decomposed and hence the nitrogen percentage is raised to 1.3. Although no new nitrogen is formed during anaerobic digestion, 15 to 18 percent nitrogen is converted into ammonia (NH4) whereas nitrogen in aerobically digested organic wastes (activated sludge, compost) is mostly in oxidized form (nitrate and nitrite). Increasing evidence suggests that for many land and water plants, ammonium is more valuable as a nitrogen source than oxidized nitrogen in the soil. Ammonium is less likely to leach away and hence more apt to become fixed to exchange particles like clay and humus (Satliianathan, 1975). Experiments in China have shown that compared to fresh dung, the ammonical nitrogen in the digested slurry increases by 260 percent whereas it decreases by 17.5 percent in the FYM. The slurry thus has more free ammonia than available in composted manure.

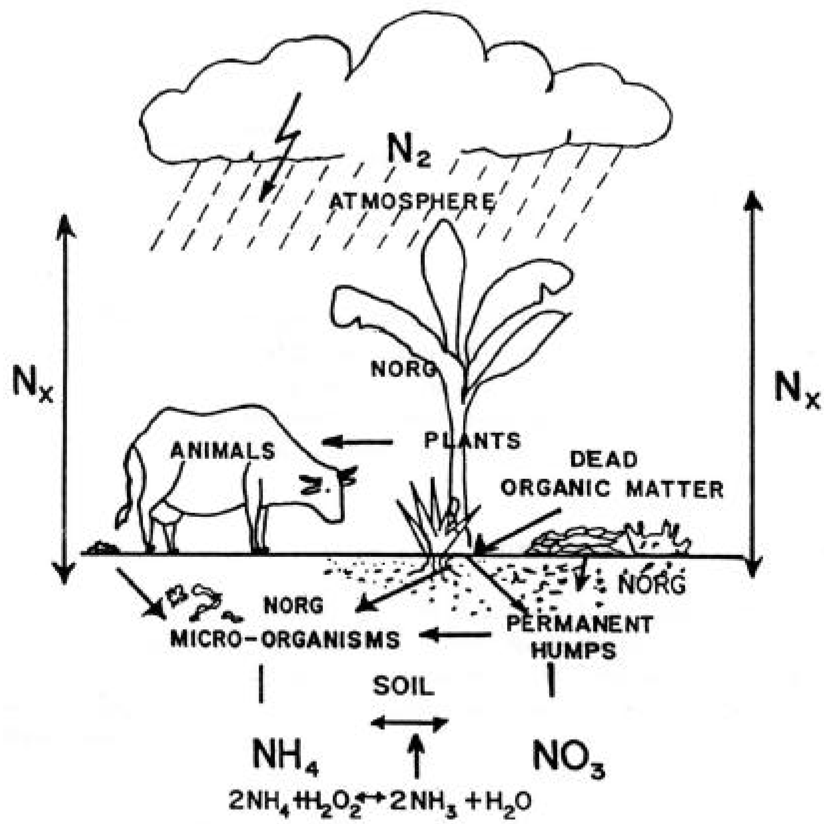

Chart – 4.2 The Njtrogen – Cycle In Nature

As a result of anaerobic fermentation, about 30 to 40 percent of organic carbon present in the dung is decomposed as carbon dioxide and methane. The rest is retained as such and contains plant nutrients. When fully digested, the slurry from a biogas plant is odourless and does not attract insects or flies. The organic fraction of slurry may contain upto 30-40 percent of lignin. undigested cellulose and lipid material, on a dry weight basis. The remainder consists of substances (mineral, salts, etc.) originally present in the raw materials but not subject to bacterial decomposition. The amount of bacterial cell mass is low (less than 20 percent of the substrate is converted to cells). Therefore, there is less risk of creating odour and insect breading problems.

Some of the major key features of biogas slurry can be summarized as follows:

- Biogas manure is ready in shortest possible time.
- There is minimum loss of nitrogen in biogas slurry due to anaerobic conditions in the plant.
- If night soil and cattle urine are added, availability of nitrogen and phosphorus in the biogas manure is increased.

4.7 Utilization of Digested Slurry

It has been observed that the use of digested slurry as manure improves soil fertility and increases crop yield. Data from field experiments suggest that the slurry should be applied at the rate of 10 tons/ha in irrigated areas and 5 tons/ha in dry farming. The manure can be used in conjunction with normal dose of chemical fertilizers. Such practice will help achieve better returns from fertilizers, minimize the loss of fertilizers from the soil and provide balanced nutrition to crops. Different methods of slurry applications are described this section.

4.7.1 Application of Slurry in Liquid Form

The digested slurry can be directly applied in the field using a bucket or a pale. An alternative to this is to discharge the slurry into an irrigation canal. However, these methods of direct application have some limitations. Firstly, not all farmers have irrigation facility throughout the year. Secondly, in the cascade system of irrigation in which water is supplied from one field to another, slurry is not uniformly distributed in the fields. Finally, since the digested slurry is in a liquid form, it is difficult to transport it to farms located far from the biogas plants.

The sludge and slurry could be applied to the crop or to the soil both as basal and top dressings. Whenever it is sprayed or applied to standing crop, it should be diluted with water at least at the ratio of 1:1. If it is not diluted, the high concentration of available ammonia and the soluble phosphorus contained in the slurry will produce toxic effect on plant growth. However, such method of application is not yet practised in Nepal.

4.7.2 Application of Slurry in Dried Form

The high water content of the slurry causes difficulties in transporting it to the farms. Even if it is applied wet in the field, tilling is difficult. Due to such difficulties, the farmers usually dry the slurry before transporting it into the fields. When fresh slurry is dried, the available nitrogen, particularly ammonium, is lost by volatilization. Therefore, the time factor has to be considered while applying the slurry and in this regard, immediate use can be a way of optimizing the results.

4.7.3 Utilization of Slurry for Compost Making

The above mentioned difficulties can be overcome by composting the slurry. If the slurry is composted by mixing it with various dry organic materials such as dry leaves, straw, etc., the following advantages can be realised:

- The dry waste materials around the farm and homestead can be utilized.
- One part of the slurry will be sufficient to compost about four parts of the plant materials. Thus, increased amount of compost will be available in the farm.
- Water contained in the slurry will be absorbed by dry materials. Thus, the manure will be moist and pulverized. The pulverized manure can be easily transported to the fields.

A schematic diagram for use of slurry in making compost is shown in Chart 4.3. The ideal arrangement would be to dig three similar pits which may be filled in turn. The size of these pits should be such that by the time the third one is filled, the first one is dry enough to transport the compost to the field.

The availability of nutrients in composted manure, FYM and the digested slurry are presented in Table 4.3 (Gupta, 1991).

Table 4.3

Nutrients Available in Composted Manure, FVM and Digested Slurry

Nutrients	Composted Manure		FVM		Digested Slurry	
	Range	Average	Range	Average	Range	Average
Nitrogen (N)	0.5 to 1.5	1.0	0.5 to 1,0	0.8	1.4 to 1.8	1.60
P205	0.4 to 0.8	0.6	0.5 to 0,8	0.7	1.1 to 2.0	1.55
K20	O.5tol.9	1.2	0.5 to 0.8	0.7	0.8 to 1.2	1.00

Furthermore, the complete digestion of cattle dung in a biogas plant destroys weed seeds and organisms that can cause plant diseases.

4.8 Size of Compost Pit

It is advisable to construct at least two compost pits beside the biogas plant so that each of them can be emptied alternatively. The pit volume should be equal to die volume of the biogas digester. The recommended pit sizes corresponding to different sizes of biogas plants are given in Table 4.4.

Table 4.4
Recommended Size of Compost Pits Corresponding to the Sizes of Biogas Plants

Capacity of Biogas Plant	Depth (m)	Width	Length (m)
4	1.2	1.3	3.2
6	1.3	1.3	3.9
8	1.3	1.3	5.2
10	1.3	1.5	5-2
15	1.3	1.5	7.7

Sometimes, there is a limitation of space for compost making. In such case, the length of pit can be shortened by increasing the width but the depth should remain around 1.2 to 1.3 m.

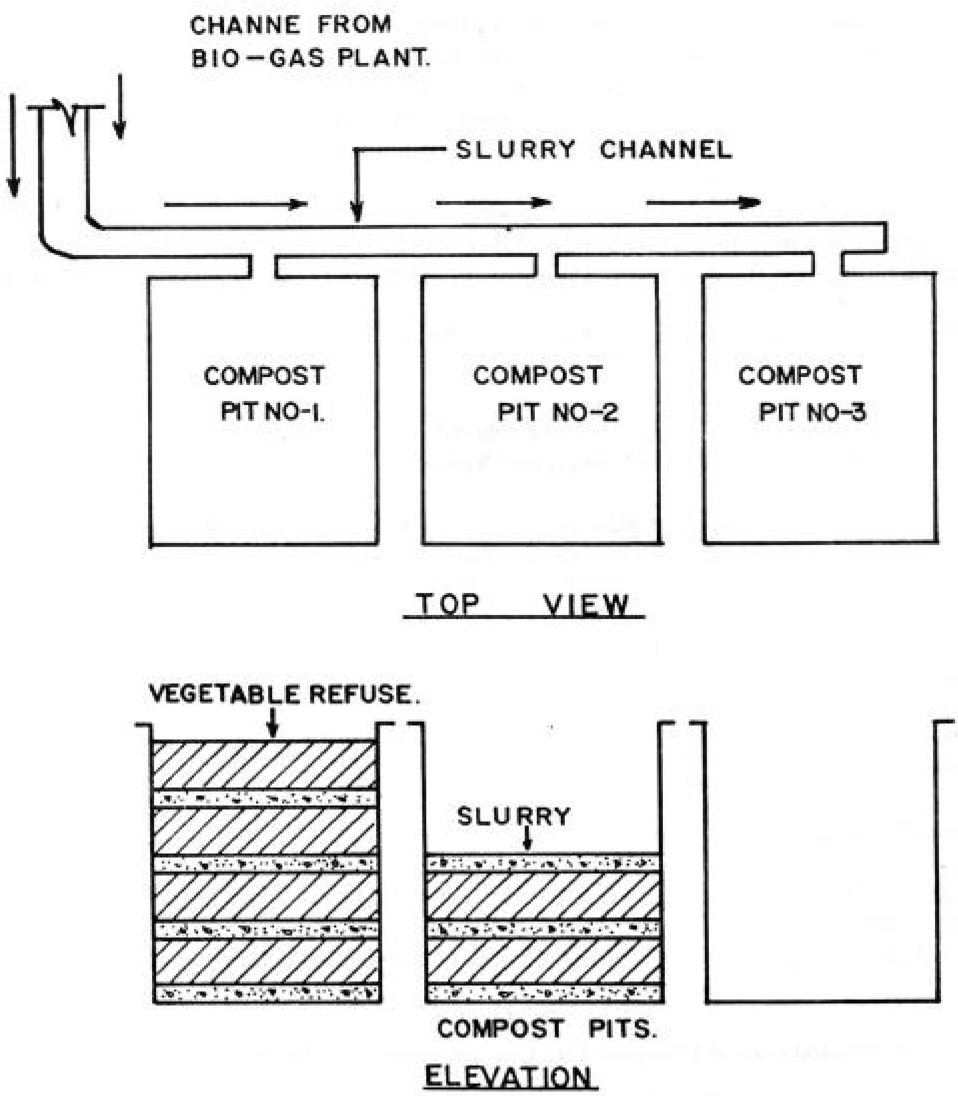

CHART-43 USE OF SLURRY IN MAKING COMPOST

4..9 Quality Assessment of Compost and Digested Slurry

To derive maximum benefit from organic manure application, the compost should be well decomposed and be of good quality. Use of undecomposed organic manure should be avoided as it will do more harm than good. Undecomposed materials when applied to the soil attract insects and take a longer time (i.e. more time than the life cycle of the crop) before the plant nutrients present in them are converted in the form that can be assimilated by the plants.

It is essential to know whether the compost has attained the stage of maturity before applying it in the field. In practice, mature compost can be identified from its physical appearance. Matured compost has a dark brown colour whereas undigested slurry is light brown or greenish. When pressed between two fingers, matured compost is friable in consistency and can be easily distributed in the field. Similarly, if bubbles are still rising in the slurry pit, it indicates that the slurry could still produce some gas and hence, has not completed the required retention time

4.10 Influence of Slurry on the Yield of Crops and Vegetables

Little attention has been given by the promoters and the scientists in generating sufficient scientific data in the Nepalese context regarding the influence of slurry on the growth and yield of crops and vegetables. The preliminary experiment carried out so far in Nepal indicated that the yield of crops and vegetables could be increased from 10 to 30 percent through slurry application. There is a need to design a suitable field experiment (that can be carried out by agricultural scientists) to generate information in this area. Following guidelines could be useful for this purpose.

4.11 Field Experiment

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.

- Control
- FYM (traditionally prepared) @ 5 and 10 tons/ha
- Wet slurry @ 5 and 10 tons/ha
- Composted slurry @ 5 and 10 tons/ha
- Recommended dose of chemical fertilizers
- Recommended dose of chemical fertilizer and wet 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, barley 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 bicarbonate (chemical fertilizer) increased the rice and maize yields by 12.1 percent and 37.6 percent, respectively.

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

4.12 Effluent as a Supplement in Ration of Animal and Fish

Digested slurry has been used to supplement feed for cattle, hogs, poultry and fish in experimental basis. The encouraging results obtained from experiments arc yet to be commonly practiced by the users. The following subsections describe various experiments carried out in this area.

4.12.1 Digested Slurry as a Feed to Animals

Results from the Maya Farms in the Philippines showed that in addition to the plant nutrients, considerable quantity of Vitamin Bi_2 (over 3,000 mg of Bi: per kg of dry sludge) are synthesiscd in the process of anaerobic digestion. The experiment has revealed that the digested slurry from biogas plant provides 10 to 15 percent of the total feed requirement of swine and cattle, and 50 percent for ducks (Gunnerson and Stuckey, 1986). Dried sludge could be substituted In cattle feed with satisfactory weight gains and savings of 50 percent in the feed concentrate used (Alviar. et al.. 19X0). The growth and development of Salmonella chloreasuis and Coli bacillus were inhibited under anaerobic fermentation.

This is also relevant in Nepal, since about one-third of the livestock are generally underfed (Pariyar. 1993). The low availability of good quality forage is the result of low productivity of rangeland as well as limited access to it. Only 37 percent of rangelands arc accessible for forage collection (HMG/AsDB/ FINN1DA. 1988). Therefore, addition of dried sludge in cattle feed would improve the nutrient value of the available poor forgae.

An experiment was carried out at BRTC, Chengdu. China in 1990 to study the effects of anaerobic ally digested slurry on pigs when used as food supplement. Effluent (digested slurry) was added at the rate of 0.37 to 1.12 litres of kg of feed in the normal mixed feed rations. The pigs were fed with this ration until their body weight reached 90 kg. The piglets in this experiment grew faster and showed better food conversion than the control group. Negative effects on the flavour or hygienic quality of the meat were not noticed (Tong, 1995). Subject to further trials, digested slurry might be safe as animal feed.

4.12.2 Digested Slurry as a Feed to Fish

A comparative study on fish culture fed only with digested chicken slurry was carried out by National Bureau of Environmental Protection (NBEP). Nanjing. China in 1989. The results showed that the net fish yields of the ponds fed only with digested slurry and chicken manure were 12,120 kg/ha and 3,412.5 kg/ha, respectively. The net profit of the former has increased by 3.5 times compared to that of the latter. This is an effective way to raise the utilization rate of waste resources and to promote further development of biogas as an integrated system in the rural areas (Jiayu, Zhengfang and Qiuha, 1989).

An experiment was carried out in Fisheries Research Complex of the Punjab Agricultural University, Ludhiana, India to study the effects of biogas slurry on survival and growth of common carp. The study concluded that growth rates offish in terms of weight were 3.54 times higher in biogas slurry treated tanks than in the control. Biogas slurry proved to be a better input for fish pond than raw cow dung since the growth rate of common carp in raw cow dung treated tanks were only 1.18 to 1.24 times higher than in the control. There was 100 percent survival of fish in ponds fed with digested biogas slurry as compared to only 93 percent survival rate in ponds fed with raw cow dung.

A model for integrating fish farming system has been illustrated in Chart 4.4. In an integrated Magur fish (Clavias batrachus) farming system, wastes from poultry' and duck house, cattle dung and slurry are

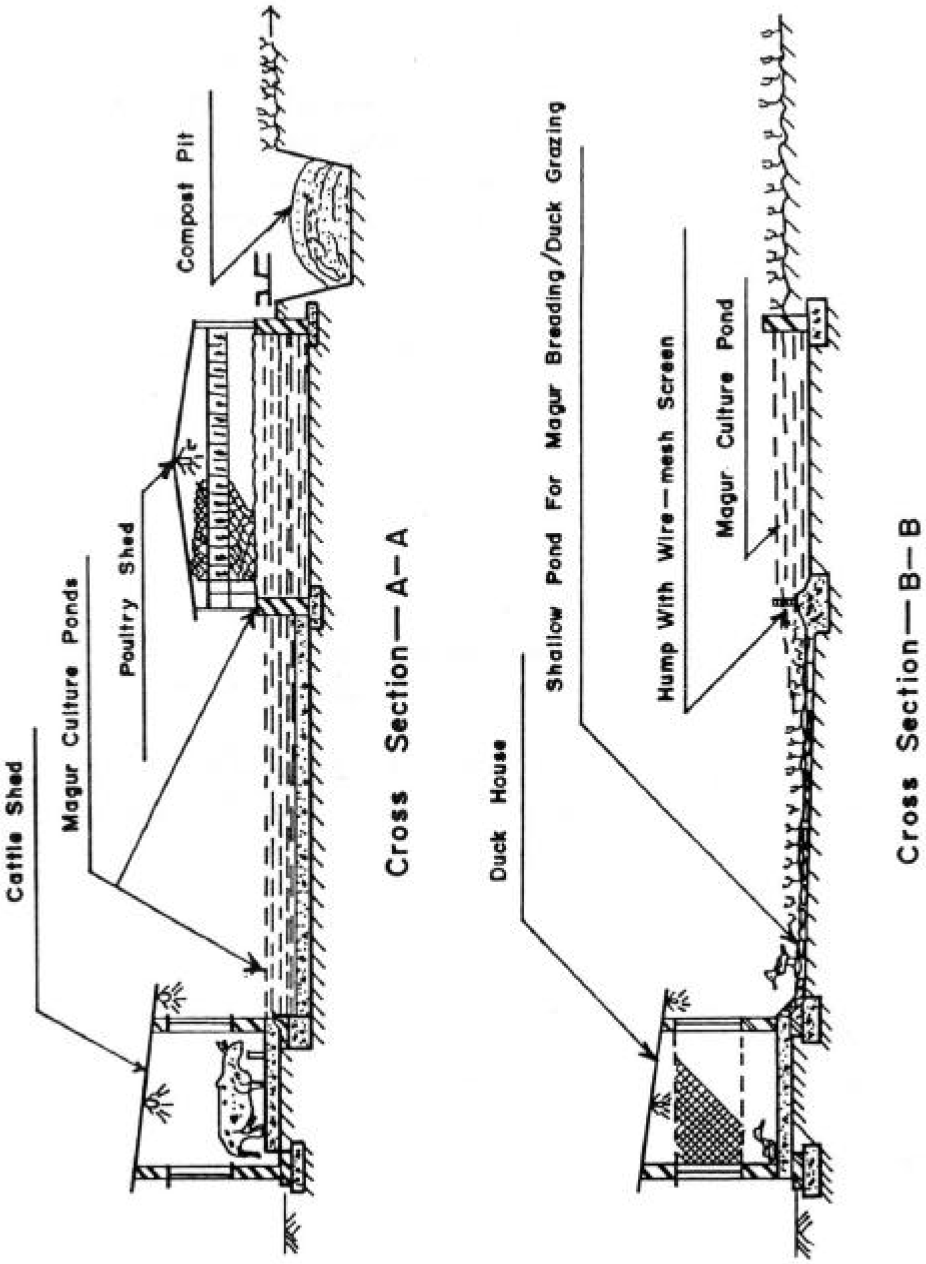

Chart - 4·4. A Model For Intergrating Fish Farming.

used as manure. It may be directly consumed by fish or may be recycled through a biological food-web of trash fish, molluscs or earthworms introduced in the system and consumed by the fish. The poultry shed is constructed above the culture pond and the duck house is placed adjoining the breeding pond. The leftover feed of ducks and poultry are utilized by the fish directly. Care has to be taken to ensure that the excess slurry from the biogas plant is not discharged into the system. Otherwise, there would be a depletion of dissolved oxygen which has an adverse effect (Singh, 1992).

4.12.3 Improving the Quality of Feed

Straw was treated with biogas slurry liquid (BSL) and the treated samples were ensiled for 0. 3. 6, 9, 12 and 15 days. The findings showed that due to high nitrogen content of BSL, it could be considered as a rich source of nitrogen in upgrading the feeding quality of crop residues and ensiling of poor quality grasses. During the growth period, the microbes utilize the available nitrogen and convert it into quality proteins and nucleic acid. Thus, the protein content of fodder or grass increases, crude fibre content significantly decreases, and the overall digestibility of fodder increases. Such results suggest that substantial improvement in feeding value of straw could be achieved with BSL treatment (Perera. et al,. 1940).

All the foregoing information indicate that although the aspect of utilization of digested slurry for animal feed is well developed in some countries, no effort has been made so far by the biogas promoters in Nepal to carry out appropriate R&D for the utilization of slurry as a feed and fertilizer for which immense potential exists.

4.13 Other Uses

Many extensive experiments performed in China have proved that the digested slurry, when used as fertilizer, has strong effects on plant tolerance to diseases such as potato wilt (Pseudomonas salanacearum. late blight, cauliflower mosaic, etc. and thus can be used as bio-chemical pesticide.

A series of experiments and analyses conducted in China in a period of three years show that the cold-resistant property of early season rice seedling are effectively enhanced by soaking seeds with digested slurry. The survival rate increased by 8 to 13 percent and the quality of seedlings raised by soaking seeds with digested slurry is much higher than that of the control group during the recovering period after low temperature stress. The seedlings germinated faster, grew well and resisted diseases (Biogas Technology In China, 1989).

Foliar application of diluted slurry increases rate of wheat plant growth, resists to lodging and increases size of grains and length of the ear Foliar application in grapes have been found to increase yield, length of fruit-year, sugar content, fruit size, colour, and resistance to mildew diseases. In cucumbers, it has been observed to increase resistance to wilt diseases. In peach, it develops better fruit colour and early maturation.

Digested slurry can effectively control the spreading and occurrence of cotton's weathered disease. It decreases the rate of the disease with an efficiency rate of 50 percent for one year. 70 percent for more than two years along with increase in production.

Wheat aphids are effectively cured when digested slurry mixed with a 30 to 40 percent of Rogor is sprayed saving the cost of Rogor chemical which also has an adverse environmental impact.

Biogas can be used to inhibit the process of post-maturation of fruits and vegetables and thus increase their safe storage time. When biogas is filled for the first time in the storage tank, box or bin, the valve on the exhaust tube should be opened in order to exhaust air or gas in the jar as completely as possible. When ail other gas are pushed out by the biogas in the bin, the valve should be closed. In this way, all the pests can be destroyed (Biogas Technology In China, 1989).

4.14 Session Plan

Activity No	Topic and Area of Discussion	Time (ntin.)	Methods of Training	Teaching Aids
1.	Highlight the objective of session	2	Discussion	O/H projector, screen
2.	Interrelation of biogas technology and agriculture	2	Discussion	O/H projector, screen
3.	Limitation of chemical fertilizer use	3	Discussion	O/H projector, screen
4.	Organic Fertilizer	*3*	Lecture cum discussion	O/H projector, screen, flip chart
5.	Importance of slurry for crop production	4	Lecture cum discussion	O/H projector, screen, flip chart
6.	Characteristics of Digested slurry	4	Lecture cum discussion	O/H projector, screen, flip chart
7.	Utilization of digested slurry	4	Lecture cum discussion	O/H projector, screen, flip chart
8.	Size of compost pit	3	Lecture cum discussion	O/H projector, screen, flip chart
9.	Method of assessment of quality of compost	.1	Lecture cum discussion	O/H projector, screen. flip chart
10.	Influence of slurry on the yield of crops and vegetables	3	Lecture cum discussion	O/H projector, screen, flip chart
II.	Field experiment		Lecture cum discussions	O/H projector, screen, flip chart
12.	Effluent as a supplement in ratio of animal and fish	.1	Lecture cum discussion	O/H projector, screen, flip chart
13.	Other uses of slurry	3	Lecture cum discussion	O/H projector, screen, (lip chart
14.	Questions and answers	10	Discussion	
Total Time		50		

4.15 Review Questions

- Why is organic matter important for the maintenance of soil fertility?
- Is application of only mineral fertilizer beneficial for soil and crop production?
- Explain the role of digested slurry in decreasing the rate of deforestation and enhancing crop production.
- Enumerate different methods of slurry applications.
- What is the significance of the use of digested slurry as a feed to animal and fish?
- What appropriate R&D is needed in Nepal in view of proper utilisation of effluent?

4.16 References

AIC (1996) Annual Progress Report 1995/96.

Alviar. C. J., et al. (1980) Cow Manure Biogas Production and Utilization in an Integrated Farm System at the Alabang Dairy Project. Paper presented at the 47th Annual Convention of the Philippines Veterinary Medical Association.

APROSC/JMA (1985) Nepal Agriculture Perspective Plant (Final Report)- Prepared for NPC7HMG/N andAsDB(TANo. 1854-NEP).

Bhattarai, S. S. Maskey and R. Shah (1987) Use and Promotion of Biofertilizers in Nepal - A Review Paper presented at the Working Group Meeting on Biofertiiizers Technology organised by DSSAS/NARC/ARPP. Kathmandu, Nepal.

Biogas Technology in China (1989) Chengdu Biogas Research Institute, Chendu, China.

Gunncrson, C. G. and D. V. Stuckey (1986) Integrated Resource Recovery Anaerobic Digestion-Principles and Practices for Biogas Systems. World Bank Technical Paper Number 49.

Gupta. D R. (1991) Bio-fertilizer from Biogas Plants. Changing Villages. January-March 1991. HMG/AsDB/FINNIDA(1988) Master Plan for Forestry Sector. Kathmandu. Nepal

Jiayu, M., L. Zhengfang and W. Qiuhua (1989) Studies on the Design and Construction of Fish Culture fed only with Digested Liquid Slurry. Rural-Eco-Environment, China, No.2, pp 12-17.

Karki, A. B. and K. Dixit (1984) Biogas Fieldbook. Sahayogi Press, Kathmandu, Nepal.

Karki, A. B., K. M. Gautam and U. Gautam (1996) Biological Waste Treatment through Biogas Digesters in Rural Nepal. In "Management of Urban Biodegradable Wastes." Published by International Solid Waste Association (ISWA), Copenhagen. Denmark.

Kaur, K.. K. Gurpreet and H. S. Sehagal (1987) Effect of Biogas Slurry in Carp Culture. Biological Wastes 22, pp 139-146

Khandelwal, K. C. (1980) Biogas System and Production of Manure in Compost Technology-Improving Soil Fertility through Organic Recycling. FAO/UNDP Regional Project RAS/75/ 004, Project Field Document No. 13.

Moulik, T. K. (1990) Diffusion of Biogas Technology: Strategics and Policy. International Conference on Biogas Technologies and Implementation Strategy Report. GTZ/BORDA.

National Sample Census of Agriculture for Nepal (1991 /92).

Pariyar, D. (1993) Existing Feed Situation in Different Regions of Nepal and Strategies Developed to Increase Fodder Production. Paper presented at the International Symposium on Grassland Resources. Huhehot, Inner Mongolia, China.

Perera, A. N. F., E. R. K. Perera and D. K. Jayatilaka (1990) Ensiling of Rice Straw With Biogas Slurry Liquid Department of Animal Science, University of Peradeniya, Sri Lanka.

Sasse, L. (1991) The Biodigester at the hills of Central Java. BORDA.

Sathianathan, M. A. (1975) Biogas Achievements and Challenges. Association of Voluntary Agencies of Rural Development, New Delhi, India.

Singh, et al. (1995) Effect of Biogas Digested Slurry on Pea, Okra, Soybean and Maize Biogas Forum. Volume FV, No. 63. pp 4-7.

Singh, R B. (1992) Integrated Farming with Magur Fish is Profitable to the Farmers. Indian Farming, November 1992.

Sthapit, B. R. (1987) Lumle Report on Soil Fertility Research. Technical Paper 87/3, Lumle Agricultural Research Centre, Pokhara, Nepal.

Technology of Biogas Production and Applications in Rural Areas (1989) A Report by World Energy Conference. London. United Kingdom.

Tong. W. (1995) Research on Feeding Pigs with Anaerobic Digested Effluent as Supplementation of Mixed Concentrate Rations. Biogas Forum. Vol. IV. No. 63. pp 8-15.

Yadav, L. S. and P. R. Hesse (1981) The Development and Use of Biogas Technology in Rural Areas of Asia (a Status Report 1981). Improving Soil Fertility through Organic Recycling, FAO/ UNDP Regional Project RAS/75/004, Project Field Document No. !0.

AA1 Other Reading Materials

ETSU (1994) Biogas from Municipal Solid Waste - Overview of Systems and Markets for Anaerobic Digestion of MSW. Harwell, United Kingdom.

Karki. A. B, R. Gautam and U. Gautam (1995) Municipal Solid Waste in Kathmandu Valley: A Review. Consolidated Management Services Nepal (P) Ltd.

Ni Ji-Qin and E J. Nyns (1993) Biomethanization : A Developing Technology in Latin America BORDA pp 67-68.

Rural Energy-Medium and Large Scale Biogas Systems in the Asia-Pacific Region (1995) ISSN 1011-6443 RAP Bulletin, 10th Anniversary issue. RAPA, Bangkok, Thailand.

UNDP/ESCAP/FAO/CHINA (1983) Biogas Technology. BRTC, Chengdu, China.

UNEP (1981) Biogas Fertilizer System. Technical Report on a Training Seminar in China. United Nations Environmental Programme, Nairobi, Kenya.

Updated Guidebook on Biogas Development - Energy Resources Development Series (1984), No. 27. United Nations. New York, USA.