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# Development and Performance Evaluation of Biogas Slurry Dewatering Mechanism

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**Abstract—***In India 4.75 million (MNRE, 2014) biogas units are in working condition and it produces digested slurry, which may be source of valuable organic manure. The digested slurry contains about 1.5 to 2.0 % nitrogen, 0.8-1.2 % phosphorous and 0.8-1.0 % potassium, these values are almost double of that found in FYM. But its high moisture content renders it unfit to transport and other efficient uses, the wet digested slurry has very high water content nearly 90-93 % therefore it becomes bulky and creates a problem of use, application and disposal. The moisture content can be reduced by different dehydration techniques such as filtration, coagulation and mechanical filters but these techniques followed by commercial plants. The small stakeholder will go for conventional pit drying and sun drying but these techniques having major limitation and losses nutrient from slurry due to uneven drying, also no facility to collect filtered water. Considering these limitations a dewatering mechanism has been designed and developed at Department of Renewable Energy Engineering, CTAE, MPUAT, Udaipur. It has a sieve at top, four supporting angles and an inclined collector at base to collect filtered water. The agricultural residue such as maize stalk, pigeon pea stalk placed to serve as filter material. The developed mechanism can dry the moist slurry of around 90 % to 20 % within 9 days.*

**Keywords***: Biogas, digested slurry, dewatering mechanism, maize and sorghum stalk, conventional pit drying method, NPK.*

## 1. INTRODUCTION

Biogas production technology is based on phenomenon of biological decomposition of organic materials in absence of air. The benefits of using biogas technology are cleaner gas which can be used for cooking and transportation fuel. The biogas spent slurry which comes out from the plant is either left nearby the plant or disposed in watercourse. From last few years farmer started using biogas spent slurry as a fertilizer. The wet digested slurry has very high moisture content nearly 90-93 % (Mahajan, 1997). Therefore it becomes bulky and creates a problem of use, application and transportation. The digested slurry contains about 1.5-2.0 % nitrogen, 0.8-1.2 % phosphorous and 0.8-1.0 % potassium (Mahajan. 1997).The commonly followed method for slurry drying is open sun drying and conventional pit drying method. But both these method takes long time and due to direct sunlight significant amount of nutrients were lost through evaporation. When slurry is dried up to 90 % $NH_4$ may be lost as ammonia which would dramatically reduce the benefits of biogas residue as a crop fertilizer (Arthurson, 2009). The liquid portion of slurry is being separated from the solids has many advantages for its reuse either in gas plant or using it as a starter culture for composting. In India about 4.75 million (MNRE, 2014) biogas units are in working condition and digested slurry from these plants is available. These may be source of valuable organic manure but its high moisture content renders it unfit to transport and other efficient uses. The digested slurry will provide large quantity of organic manure which is required to boost up our agricultural production. The digested slurry which comes out from the plant constitutes good quality manure free from weed seeds, foul smell, pathogens and contains high amount of plant nutrients as compared to FYM. In addition to that, the digested slurry has the traces of some major micro-nutrients i.e. zinc, boron, calcium, copper, iron, magnesium and sulfur which are necessary for growth and development of crops. Considerable quantities of plant nutrients are lost from the digested slurry if sun dried. Therefore it is better to use the fresh wet slurry or partially dried slurry as manure. Considering all these limitations biogas slurry dewatering mechanism was developed at Department of Renewable Energy Engineering, CTAE Udaipur. The performance of dewatering mechanism was evaluated with different agricultural waste materials like sorghum and maize stalk as a filter material.

## 2. MATERIAL AND METHODS

The dewatering mechanism was developed considering the availability of daily digested spent slurry. As 80 kg of spent slurry is available from 2 $m^3$ KVIC biogas plant, the dewatering mechanism was developed for 80+20 kg (20 kg as surplus) =100 kg. The stepwise procedure to design biogas slurry dewatering mechanism is given below.

## 3. DESIGN OF PLATFORM OR BED

The platform was designed considering four angles to support. The dewatering mechanism was designed to dry bed thickness of 3.5 cm.

Surface area required = $\frac{Volume\ (cum)}{Thickness(Metre)}$

$= \frac{100}{1200 \times 0.0353}$

A = 2.36 $m^2$

For suitable rectangular section,

(L X B) = 2.36 $m^2$

Assume L: B = 7:3

L = $\frac{7}{3}B$ & B = $\frac{3}{7}L$

Hence, B = $\frac{3}{7} \times 2.36$

= 1 m.

Hence suitable breadth for rectangular section is 1 m and length is 2.36 m.

### Load calculation and distribution of load

The platform should have sufficient strength in order to carry 100 kg load under gravitational force, therefore load calculation and distribution of load is necessary to design biogas slurry dewatering mechanism.

$W_T$ = 100 kg × 9.81

= 981 N

$W_T$ = 981 kg m/$s^2$

Thus, $(W_T)_0 = (W_A + W_B + W_C + W_D)$

= (0.25 + 0.25 + 0.25 + 0.25)

= 1 KN

### Design of angles to support dewatering mechanism

The design of angles to support dewatering mechanism is most crucial part of whole design because whole weight of platform is to be carried by four angles

Assumed height of pillars = 50 cm =0.5 m

Crushing strength of mild steel = 320 mpa.

Rankin's coefficient = $\frac{1}{7500}$

$$\alpha = \frac{\sigma_c}{\pi^2} = \frac{1}{7500} = \frac{320 \times 10^6}{3.14^2 \times E}$$

$$E = \frac{320 \times 7500 \times 10^6}{3.14^2}$$

E = 2.434 × $10^{11}$ Pa

$= 2.434 \times \frac{10^{11}}{10^9}$

= 2.434 × $10^2$

Now let's calculate size of each angle in order to carry load of 100 kg.

$E = \frac{(\frac{F}{A})}{\Delta L/L}$ L = 0.5 m, ΔL = 0.5 of 0.5 m

= 2.5 × $10^{-3}$.

$$210 \times 10^9\ (N/M^2) = \frac{(1000, N/A,)}{\frac{2.5 \times 10^{-3}}{0.5}}$$

$$\frac{1}{A} = \frac{2.5 \times 210 \times 10^9 \times 10^{-6}}{0.5}$$

$\frac{1}{A}$ = 105 × $10^4$

$$A = \frac{10^6}{105 \times 10^4}$$

A= 0.25 $MM^2$

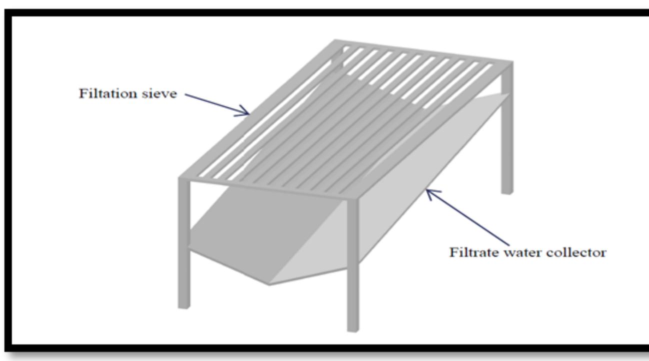



**Fig. 1: Biogas slurry dewatering mechanism**

### Performance Evaluation of Biogas Slurry Dewatering Mechanism

First of all the dewatering mechanism was tested for suitable thickness of drying, once thickness was finalized it was tested with different agricultural waste which were locally available such as maize stalk, sorghum stalk etc. The evaluation was carried out in shed net available which is in Department of Renewable Energy Engineering

**Analyzing chemical properties of filtered or collected water and dehydrated slurry**

The key nutrients such as nitrogen, phosphorous and potassium from dehydrated slurry will be determined from Kjedahl digestion apparatus. Similarly nutrient content of slurry before drying will also determined so as to calculate loss of nutrients.

**Comparison with Conventional Pit Drying Method**

In order to evaluate feasibility of dewatering mechanism its performance needs to be compared with conventional methods i.e. pit drying method (Mahajan, 1997). In pit drying method, the slurry from a digester is allowed to pass over filter material placed in a rectangular tank provided with proper drain. The water from the slurry filters down and flows out of the opening into a bucket through another pit. The semi sold residue left on the top of the bed has the consistency of dung and can be transported easily.

## 4. RESULTS AND DISCUSSION

**Performance evaluation at different thickness**

After evaluating the performance of dewatering mechanism at each mentioned thickness the common graph is plotted between the different thickness and number of days.

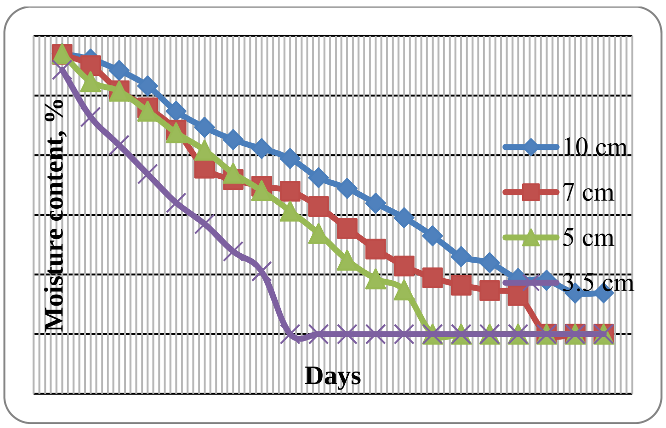



**Fig. 2: Comparative performance at different thickness**

It is clearly seen from the graph that when dewatering mechanism was evaluated at 10, 7 and 5 cm bed thickness it took more days to dry slurry from moisture content of around 90 % to 20 %. At 3.5 cm thickness the slurry was dried within 10 days from moisture content 90 % to 20 %. Hence 3.5 cm thickness is suitable to operate dewatering mechanism, later it evaluated with agricultural waste materials like sorghum and maize stalk in open sun as well as in shed net.

**Performance Evaluation of Biogas Slurry Dewatering Mechanism in Shed Net**

The biogas slurry dewatering mechanism was evaluated without any agricultural waste material and with waste material like sorghum and maize stalk. The graph is plotted between moisture content reductions with number of days.

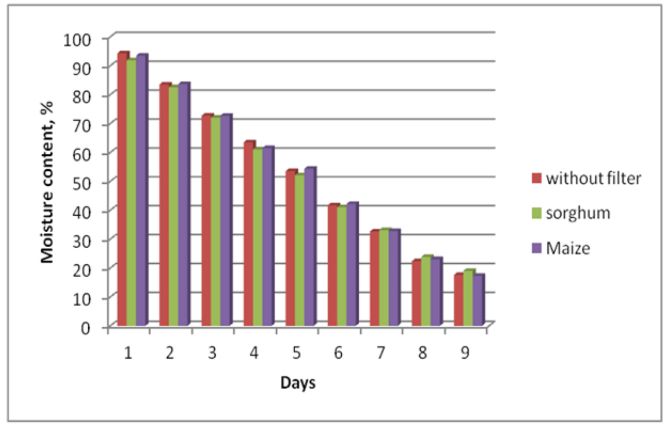
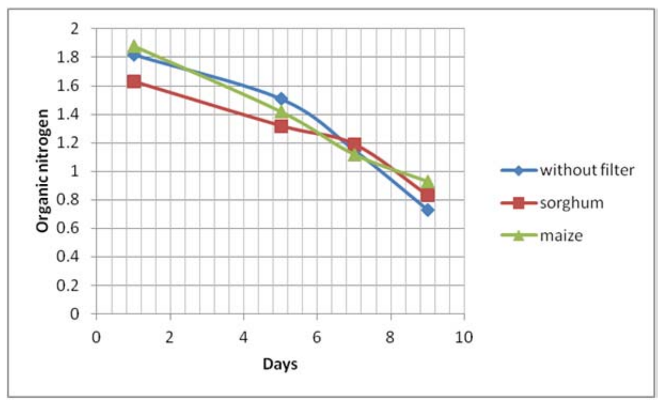
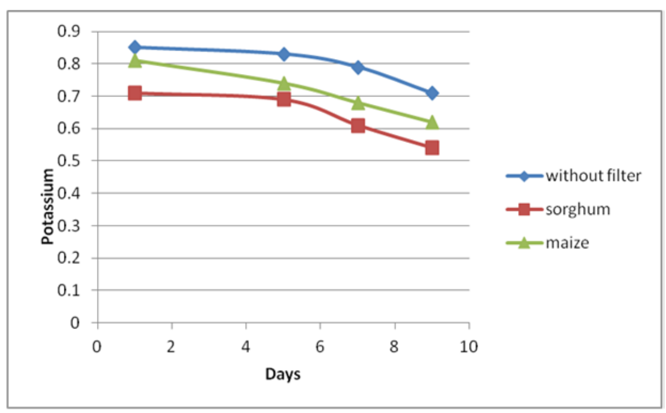



**Fig. 3: performance evaluation of dewatering mechanism**

It is clearly seen from the graph that for all these trials it took similar days to dewater slurry from moisture content of 90 % to 20 %. Within 10 days the moisture was removed from the slurry up to safe moisture level of slurry. Now it is important to analyze nutritional status of slurry.

**Nutritional status of slurry dried in shed net**



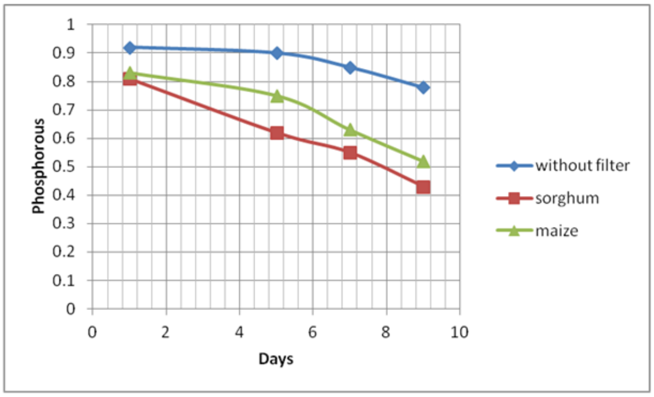
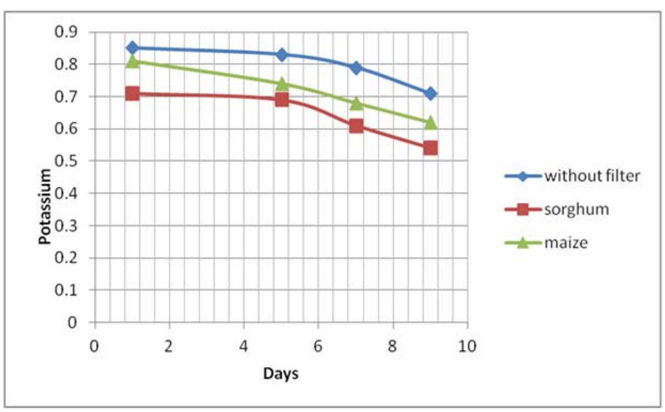


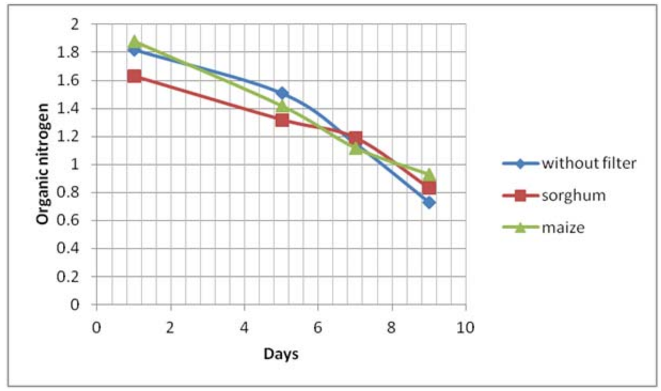

Fig. 4: Nutritional status of slurry (Nitrogen, Potassium and Phosphorous)

## Performance Evaluation of Biogas Slurry Dewatering Mechanism in open Sun

In order to compare the performance and nutrient loss, the dewatering mechanism was tested in open sun drying without any filter material, with sorghum and maize stalk as filter material and following results were found. The open sun drying is harmful for dying because the slurry is in direct contact with the sunlight and that is the main reason nitrogen is evaporated through water. Direct sunlight also affects potassium and phosphorous content of the slurry. The common followed method for dehydrating biogas spent slurry is pit drying and open sun drying. These methods having certain disadvantages such as it takes more time to dry slurry and nutrient loss. The performance of dewatering mechanism was similar to shed net drying as far as drying performance is concerned. Now nutritional status of slurry should be analyzed

## Nutritional status of slurry dried in open sun



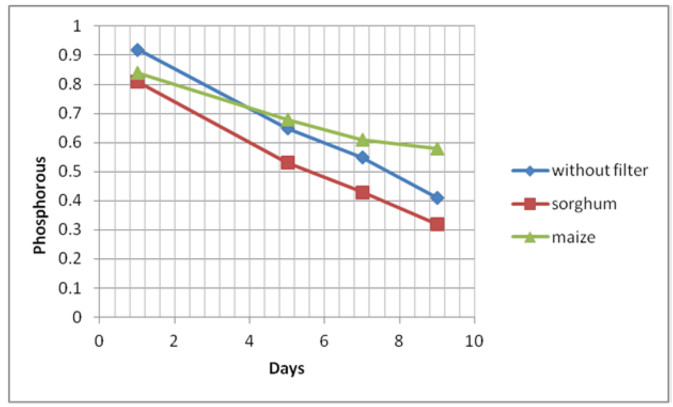




Fig. 5: Nutritional status of slurry (Nitrogen, Potassium and Phosphorous)

It is clearly seen from the graph that all these nutrients were lost as drying was continued. When dewatering mechanism was evaluated without any waste material the nutrient content of dried slurry was lower whereas the nutrient content of the collected waste water was high. When dewatering mechanism was evaluated with maize stalk and sorghum stalk the nutrient content in the dried slurry was higher whereas the nutrient content in the collected waste water was high.

## Comparison with Conventional Pit Drying Method

In order compare the performance with dewatering mechanism, the performance of conventional pit drying method was analyzed for 10 days with stone ballast, brick ballast, sorghum stalk and maize stalk which is available from CTAE farm.

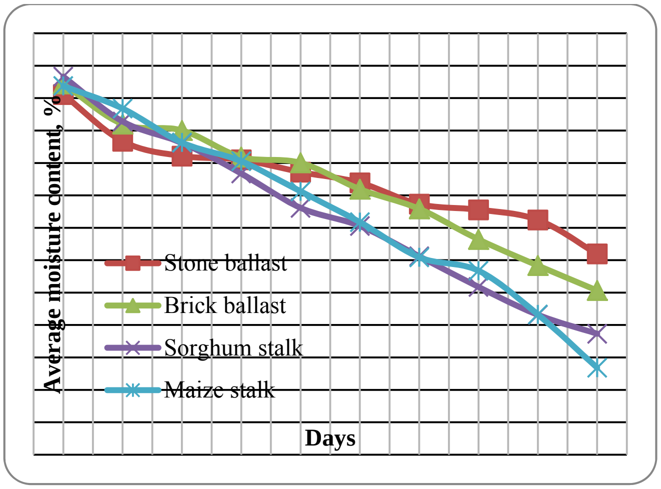



**Fig.6. Performance evaluation of conventional pit drying method**

It is clearly seen from the graph that within 10 days only 15-20 % moisture was removed from the slurry. The higher moisture was present in the slurry dried with stone ballast and brick ballast. The lower amount of moisture was present in the slurry dried with sorghum and maize stalk. The nutritional was higher because slurry was in directly contact with the sunlight. When stone ballast was used as filter material, initially the NKP content was 1.78, 0.81 and 0.81 which is obvious because many literatures quoted the same. . On 10$^{th}$ day the nutrient content was 1.06, 0.68 and 0.54 which were not sufficient to use as fertilizer to improve productivity. . Secondly the brick ballast was used as filter material, initially the nutrient content were 1.83, 0.85 and 0.88 and at end of experiment the NKP content was 0.97, 0.59 and 0.56 which similar to the nutrient status of slurry when used with stone ballast. Thirdly the sorghum stalk was used as filter material in a pit. On first day the NKP content was 1.89, 0.87 and 0.91 and when experiment was completed the nutritional status was 1.18, 0.62 and 0.67. Lastly the maize stalk used as filter material to evaluate the performance of pit drying method. Initially the nutritional status was 1.92, 0.85 and 0.93 and finally the NKP content was 1.39, 0.71 and 0.51.

## REFERENCES

[1] Arthurson, V. 2009. Closing the Global Energy and Nutrient Cycles Through Application of Biogas Residue to Agricultural Land-Potential Benefits and Drawbacks. Energies, **2**: 226-242.

[2] Banik, S. and Nandi, R. 2000. Effect of Supplementation of Rice Straw and Biogas Residual Slurry Manure on the Yield, Protein and Mineral Contents of *Volvariella volvacea* Mushroom. *Journal of scientific and industrial research*. **59**: 407-412.

[3] Hjorth. M., Christnesen and M. L.and Sommer. S. G. 2009. Solid-Liquid Separation of Animal Slurry in Theory and Practice: A Review. Agronomy for Sustainable Development. *Springer Verlag*.**30**:153-180.

[4] Kaushik. P., Yadav Y. K., Dilbaghi. N. and Garg V. K. 2007. Enrichment of Vermicompost Prepared from Cow Dung Spiked Solid Textile Mill Sludge Using Nitrogen Fixing Phosphate Solubilizing Bacteria. *Environmentalist*. **28**: 283-287.

[5] Mahajan, J. Sharma, D. 1997. Study of different biogas slurry dehydration techniques. A thesis submitted to Maharana Pratap University of Agriculture and Technology, Udaipur in the partial fulfillment of M.Tech degree.

[6] Math. N and Srinivasa. M. N. 2014. Effect of Microbial Enrichment of Organic Manures on Microbial Population and Nutrient Status of Organic Manures. *Karnataka journal of agricultural sciences*. **27**: 156-159.

[7] Sekar. K. 2012. The Effects of Biochar and Anaerobic Digester Effluent on Soil Quality and Crop Growth in Karnataka, India. A thesis submitted to Ohio State University in the partial fulfillment of M. S degree.

[8] Sharma. S. 2013. International Workshop on Promotion of Biogas Upgrading and Bottling in India and European Union, IIT Delhi.

[9] Tiwari. V. N., Tiwari. K.N. and Upadhay. R.M. 2000. Effect of Crop Residues and Biogas Slurry in Wheat on Yield and Soil Fertility. *Journal of Indian society of soil science*. **48**: 515-520.

[10] Vasudeo. G. 2002. Biogas Manure: A Viable Input in Sustainable Agriculture- A Integrated Appraoch. **2**: 1-5.

**Fig. 6: Collected waste water and dewatering mechanism.**