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Estimation of Large Animals Dung for Power Generation – A Case Study of District Bathinda, Punjab

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Abstract: *Large animals dung based biomass has immense potential in an agricultural state Punjab. The milk production is very important part of an agricultural economy in the Punjab. Dairy farming is an age old subsidiary profession in rural areas of state. This paper presents a case study of Bathinda district of Punjab by collecting the total livestock population and the average production of large animals dung or manure on daily basis. About 13% of total animal dung in district is used for local level activities and 87% is considered as surplus animal dung which can be used for production of electrical power. Based on these collections and from the surplus animal dung the energy potential of 1385247GJ per year has been calculated. It has been estimated that electrical power of 384.8 GWH per year can be produced only from the surplus large animal dung of district Bathinda of Punjab.*

I. Introduction

Biomass energy is an energy produced from an organic matter like agricultural residues, wood and food wastes etc. Since the existence of man it has been an important energy source for household activities in rural areas [1]. In this world there are so many biomass resources available to convert into other usable forms of energy. Punjab is an agricultural rich state and livestock is playing an important and major role in farming like dairy farming. As the livestock is source of income for many small and large farmers in state, the proper disposal of animal dung is also a matter of concern for farmers [2]. The agricultural farmers generally use the some portion of animal dung for fertilizer, for domestic usage and for biogas plants at local level. The rest of it is dumped in storage areas or as lagoons. The appropriate disposal of animal dung is to use it as biomass energy which helps us to reduce energy cost and costs associated with animal dung management [2]. The aggregate analysis of the total large animal dung potential is done for converting dung into an electrical power or domestic renewable fuel livestock source. This paper focuses on the assess ment of animal dung potential in district Bathinda of Punjab to produce electrical energy.

1.1 Profile of District Bathinda of Punjab State

The Punjab state is located between 29º 33´ to 32º 32´ N latitude and 73º 53´ to 76º 50´ E longitude and spread over 50, 362 km^2 which is about 1.6% of geographical area of the country. It falls in the north Indian part of country. Administratively, the state is divided into 5 divisions, 22 districts, 81 tehsils, 142 developmental blocks, and 12,581 villages.

Bathinda district is situated in southern parts of Punjab state, in the heart of Malwa region. The total area of district is 3353 Km^2. It is situated between 32.20º North and 74.95º East. The total number of villages in district is 281.

1.2 Livestock Resource or Livestock Scenario in Punjab

India is an important agriculture dominated country and the livestock have very important role in Indian farming system. They not only provide milk and meat but also provide farm yard manure, wool, dung etc. India has emerged as the world's largest milk producer and milk production continues to grow at a fairly high rate. Milk production is very important part of the agricultural economy in the state of Punjab.

Dairy farming is an age old subsidiary profession in rural areas of Punjab. It is the second largest milk producing state in India producing 10% of country's milk production i.e 8 million tonnes annually [3]. Dairy farming is a source of supplementary income for millions of small or marginal farmers and landless labourers in Punjab. Dairying accounts for more than two third of the livestock output and is largely responsible for the rising importance of the livestock sector in the state and country.

1.3 Power Scenario in Punjab

As per the annual plan 2013-14 of Department of Planning, Government of Punjab, the installed capacity in state is 7249 MW and peak demand is 11520 MW. The per capita consumption in the state is 1131 KWH per year with high rising demand and power deficit is 37%. The state government is making an effort to make Punjab self sufficient in power by May 2014 [4]. Punjab is very fast developing state in the present scenario. It has made tremendous progress in all sectors of society. A number of projects are coming in the industrial sector so demand for power will increase in the coming time.

II. Materials and Methods

The methodology adopted for conducting the present study is as given below:

2.1 Distribution of Livestock

The assessment of livestock is done on the basis of the number of different types of animals available in the district under study. The distribution of this livestock has been evaluated in the study area on the basis of recent district wise survey done by Animal Husbandry department of Punjab as 19th Livestock census 2012 [5].

2.2 Categorization of Livestock

In this study the categorization of livestock is done into two broad categories the large animals and small animals. The large animals include buffalo, cow, horse, camel, elephant, pony, mules and donkeys. The small animals include sheep, goat, and pig. In this study only those large animals are considered which are having high rate of population and also having large quantity of animal dung or excreta production per day. The quantity of production of excreta of all large and small animals is also identified.

2.3 Potential of Animal Waste

The data related to production of animal dung or excreta has been obtained by consulting Animal Husbandry Department, of Govt. of Punjab and from available literature [6]. The average of per day animal dung of per large animal is also determined from literature. The total quantity of animal dung (QAD) in one day is determined from total number of animals (N) and the average value of per day dung of each animal (D).

$$(QAD)i = \sum_{i=1}^{n} (N)i\ X(D)i$$

The gross potential of animal dung is determined by using residue to product ratio (RPR). The potential of the entire animal dung in each tehsil of district Bathinda has been cumulated on the basis of following model [7]:

$$(\ PAD)i = (RPR)i\ X(QAD)i$$

Where PAD is the potential of animal dung of i^{th} type of animal in ton in one day, RPR of the i^{th} type of animal and QAD is the total quantity of animal dung of i^{th} type in one day.

2.4 Utilization of Animal Dung for Activities at District level

The utilization of animal dung at rural areas of district is done for domestic purposes like heating, fertilizer and family type biogas plants. The 8-10% of the total animal dung in district is used for household activities such as fuel, heating and fertilizer [8]. As per the Central Sector Scheme on National Biogas and Manure Management Programme, which mainly caters to setting up of family type biogas plants, the Punjab Energy Development Agency (PEDA), Punjab has established family type biogas plants in villages of Bathinda district [9].

2.5 Availability of Surplus Animal Dung for Energy

The total amount of animal dung cannot be utilized as an energy source, because some amount has already been used for domestic purposes, heating, family type biogas plants and fertilizer in rural areas. The surplus animal dung means that quantity which is not used for any household above said activities and generally available in storage areas in rural parts. The availability of unused or surplus dung for energy is determined by subtracting the current utilization of animal dung from total production of animal dung [7]. This is the actual availability of animal dung that can be supplied for energy generation.

2.6 Energy from Surplus Animal Dung

Energy potential from surplus animal dung can be determined by multiplying the net supply potential of surplus animal dung by higher heating value (HHV). Each type of large animal dung has a different HHV. The modification of Bhattacharya model is done for estimating the energy potential [7]:

$$Qi = \sum_{i=1}^{n} (SADi\ X\ HHVi) X\ \eta c$$

Where Q_i is energy potential in GJ/year, SAD is surplus animal dung for different types of animals in tonnes/year. HHV is high heating value in GJ/tonnes for air dry dung. η_c is conversion efficiency. The availability of unused animal dung in each tehsil of Bathinda district is determined for the year 2012-13.

III. Data Reporting and Results

3.1 Distribution and Categorization of Livestock

The geographical area of Bathinda district is 3401 Km^2. It has 3 tehsils and 8 blocks. The livestock is scattered or distributed in whole district. The distribution of this livestock has been evaluated in district Bathinda on the basis of recent district wise survey done by Animal Husbandry Department of Punjab as 19th Livestock census 2012 [5], as shown in Table 1.

For the sake of study the categorization of livestock is done into two broad categories the large animals and small animals. Only those large animals are considered for study having high rate of population and also having large quantity of production of animal dung per day. In category of large animals Buffaloes, Cows and Stray Cattles are considered for study.

Punjab State & District Bathinda –at a glance

Geographical location of Punjab 29º 33´ to 32º 32´ N latitude North
73º 53´ to 76º 56´ E longitude East
Land use pattern Total Geographical Area: 50362 Km^2
Geographical location of Bathinda 29º-33´ to 30º-36´ longitudes
74º-38´ to 75º-46´ latitudes, Southern part of State
Land use pattern Geographical Area: 3401 Km^2
Administrative Setup Tehsils : 3, Blocks: 7, Villages : 281

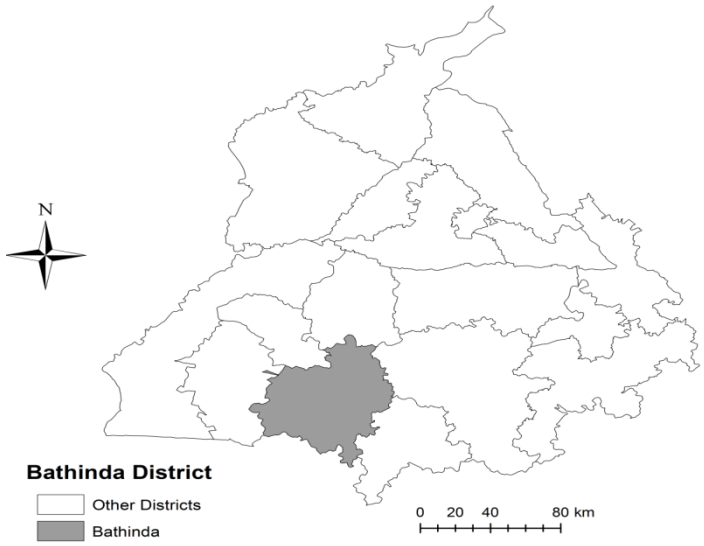

Fig 1- Bathida in Punjab Map

Table 1- Geographical Distribution of Livestock in District Bathinda

Livestock Categories	Tehsil 1 Bathinda	Tehsil 2 Rampura Phul	Tehsil 3 Talwandi Sabo	Total
Buffaloes	116717 14461M 102256 F	81326 8778 M 72548 F	76833 9239 M 67594 F	274876 32478 Male 242398 Female
Cows E (Exotic/ Cross breeds)	52050 9349 M 42701 F	24333 2634 M 21699 F	23108 3582 M 19526 F	99491 15565 Male 83926 Female
Cows I (Indigenous breeds)	11481 6008 M 5473 F	11905 6655 M 5250 F	15431 6678 M 8753 F	38817 19341 Male 19476 Female

Sheep	4763	938	2612	8313 2020 Male 6293 Female
Goats	19649	5459	10546	35654 6277 Male 29377 Female
Pigs	818	191	104	1113
Horses & others	1092	630	495	2217
Camels & Ass	80	94	108	282
Rabbits, Dogs & Elephants	13354	8265	5515	27134
Stray Cattles	5415	1575	3201	10191
Stray Dogs	7642	4050	4249	15941

3.2 **Potential of Animal Dung**

The geographical area of Bathinda district is 3401 Km^2 and it has three tehsils and 281 villages. Dairy farming is a source of supplementary income for millions of small or marginal farmers and landless labourers in villages of Bathinda district of Punjab. Dairying accounts for more than two third of the livestock output and is largely responsible for the rising importance of the livestock sector. The data related to availability of animal dung or excreta has been obtained and calculated as total production of animal dung for one day, month and year. The potential or amount of animal dung at district level was calculated by using appropriate RPR value on dry basis. The RPR value of all animal types under study is calculated experimentally and found that ratio is coming out be in between 16-18%.

Table 2 – Quantity of Animal Dung in One Day

Large Animals Types Under study	Daily Average Excreta or Animal Dung per Animal Wet Weight (Kg)	Large Animal Population in Bathinda District	Total Quantity of Excreta or Animal Dung (wet) per day (Kg)
Cow E	11.6	99491	1154095.6
Cow I	11.6	38817	450277.2
Buffaloes	12.2	274876	3353487.2
Stray Cattle	12	10191	122292

Total Quantity of Animal Dung in one day = 5080152 Kg = 5080.2 tonnes
Total Quantity of Animal Dung in one month = 152404560 Kg = 152404.6 tonnes
Total Quantity of Animal Dung in one year = 1854255480Kg =1854255.5 tonnes

Table 3 – Potential of Animal Dung in One Day

Large Animals Types	Total Quantity of Excreta or Animal Dung (wet) per day (Kg)	Potential of Animal Waste per day on dry basis (Kg)
Cow E	1154095.6	184655.3
Cow I	450277.2	72044.4
Buffaloes	3353487.2	590213.8
Stray Cattle	122292	20789.7

Potential of animal dung per day = 867703.0352 Kg = 867.8 tonnes
Potential of animal dung per month = 2631091 Kg = 2631 tonnes
Potential of animal dung per year = 316711607.9Kg = 316711.7 tonnes

3.3 **Utilization of Animal Waste for Activities at District level**

The utilization of animal dung at rural areas of district is done for domestic purposes, heating, fertilizer and family type biogas plants. The availability of surplus amount of animal dung can be calculated by considering the amount of animal dung used at other kind of activities. The 8-10% of the total animal dung in district is used for household activities such as fuel, heating, fertilizer and family type biogas plants. The PEDA has sanctioned 867 subsidized connections to farmers up to year 2011-2012. The utilization of animal dung for these biogas plants is 218 tonnes per day. The 4% of the total animal dung per day in Bathinda district is used for running the family type biogas plants.
The availability of surplus animal dung for energy is shown in Table 4.

Table 4- Status of Family Type Biogas Plants Established by PEDA in Bathinda District

Year	No. of Family type biogas plants	Consumption of Animal dung or Excreta per day (Kg)
2007-2008	151	21475
2008-2009	327	48400
2009-2010	52	7950
2010-2011	332	49950
2011-2012	599	9000

Grand Total of Consumption of animal dung per day for Family Type Biogas Plants = 217775 Kg
= 218 tonnes

Consumption of animal dung for other local activities on per day basis = 457213.68 Kg
= 457.3 tonnes

3.4 Availability of Surplus Animal Dung for Energy

The availability of surplus animal dung for energy is determined by subtracting the current utilization of animal dung (consumption for family type biogas plants +other activities) from total production of animal dung. This is the actual availability of animal dung that can be supplied for energy potential.

Surplus animal dung for energy potential per day = 4405163.32 Kg
= 4405.2 tonnes

3.5 Potential of Energy from Surplus Animal Dung

The energy potential of animal dung was estimated for all the types of the large animals under study by using HHV. The average value of HHV is considered for evaluating the energy potential from surplus animal dung. To convert the animal dung into energy, S. Swaran Singh National Institute of Renewable Energy Sources (NIRE), Jalandhar, Punjab has calculated and analyzed the calorific value for the samples of animal dung under study. The average value of HHV for various types of large animals has been reported in Table 6. The total theoretical energy potential of animal dung was estimated for Bathinda district. This is only the first basis of evaluation, which should be corrected to take into account the efficiency of the conversion process.

Table 5- Average Heating Value of Animal Dung

Animal Types	Animal Excreta	Sub Species	Average Value of HHV (Kcal/ Kg)	Average Value of HHV (GJ/ Tonne)
Cow E	Dung	Adult Heifer Calf	3384.1	14.2
Cow I	Dung	Adult Heifer Calf	3384.1	14.2
Buffaloes	Dung	Adult Heifer Calf	3449.3	14.44
Stray Animals	Dung	Cows Bulls Buffaloes	3416.7	14.3

Table 6- Surplus Animal Dung in One Day

Animal Types	Average Value of HHV (GJ/ Tonne)	Surplus Animal Dung (SAD) on dry basis (tonnes/ day)
Cow E	14.2	157.7
Cow I	14.2	281.6
Buffaloes	14.44	3016
Stray Animals	14.3	122.3

Surplus animal dung for energy potential per day = 4405.2 tonnes
Surplus animal dung for energy potential per month = 132156 tonnes
Surplus animal dung for energy potential per year = 1607898 tonnes

The conversion efficiency for estimation of energy potential depends on the process adopted for conversion of energy potential to electric energy. The energy from biogas can be converted to electricity with a typical efficiency of 34–40% for large turbines and with an efficiency of 25% for smaller generators. For this

study a range of turbine efficiency from 25–40% is used. The average dairy cow produces the equivalent of 80 kWh per day at 35% conversion efficiency.

Table 7: Energy Potential from Surplus Animal Dung

Conversion Efficiency η (% age)	Energy Potential per Day (GJ/ day)	Energy Potential per Month (GJ/ month)	Energy Potential per Year (GJ/ year)
25	2710.855	81325.65	989462.075
35	3795.197	113855.91	1385246.905
40	4337.368	130121.04	1583139.32

3.6 Power Generation Potential from Surplus Animal Dung

To convert the surplus animal dung into power generation potential the appropriate values of all parameters of the recommended model are must. The power generation from surplus animal dung with different conversion efficiencies is shown.

Table 8: Power Generation Potential

Conversion efficiency η (% age)	Power Generation Potential per Day (GWH)	Power Generation Potential per Month (GWH)	Power Generation Potential per Year (GWH)
25	.754	22.6	274.9
35	1.05	31.7	384.8
40	1.3	36.2	439.8

3.7 Conclusions

The district Bathinda of Punjab state has a large livestock population and the animal dung of this livestock can be utilized for production of electrical power. A case study has been conducted for estimation of total large animal waste based biomass potential for meeting the growing power demand of the state and also making the state as power surplus state. During study it has been observed that district Bathinda has animal population (large animals) of 423375 and potential of animal dung is 1385247 GJ per year. The electrical energy that can be produced from surplus animal dung with conversion efficiency 35% is 384.8 GWH per year. The production of electrical energy by use of dung is reducing GHG emission, meeting rising power demand, appropriate use of surplus animal dung and renewable energy production.

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