ANIMAL DUNG AS A SOURCE OF ENERGY IN REMOTE AREAS OF INDIAN HIMALAYAS

VAŇKÁT A.[1], KREPL V.[1], KÁRA J.[2]

[1]*Institute of Tropics and Subtropics, Czech University of Life Sciences Prague, Czech Republic*
[2]*Faculty of Engineering, Czech University of Life Sciences Prague, Czech Republic*

Abstract

This paper summarizes a small research that was conducted in Indian Himalayas, Zanskar Range, during the summer 2009. The subsequent experiments that were carried out in the Czech Republic are included as well.
In order to acquire data on the dung-as-a-fuel usage, one of the most remote villages in Indian Himalayas (the co-operation with Czech people had already been well established in advance) was visited. The inhabitants were asked questions related to the only resource of heat energy that is widely utilized here – the dried excrements of domestic animals. The focus was to the techniques of collection, storage, properties of the stoves and to the qualities of the different types of dung. The amounts of dung burned daily were measured as well. The data obtained were used to estimate the total amount of dung used per capita. Supposing the energetic value and the efficiency of energy transformation to the usable form is known, the total amount of energy needs for cooking and heating may be quantified. A few samples of the different types of dung were brought to the Czech Republic in order to conduct different experiments. These included the analysis of the fuel properties (calorific value, volatile combustible, ash properties, basic elements analysis) and the biodigestion experiments which showed the fuel potential for the usage with the usage of biodigestion technology. The results of biodigestion experiments are not involved in this paper.

Key words: biomass, fuel dung, burning, combustion, energetic needs, yak, high altitude, Himalayas, cooking, stove, heating, Kargyak

INTRODUCTION

There are many areas in the world which are characterized by very harsh natural conditions including drought, extreme temperatures and so on. One kind of these territories comprises the high-altitude arid areas.
Despite the fact that these places may be considered as unsuitable for human livelihood, there are many inhabitants living here – mostly in a very modest and therefore the most "sustainable" way of life that we can find among the human population.
But why can we call their way of life "sustainable" while ours may be considered as the opposite? It is the great shortage of energy resources which determines their usage only for the basic human needs (preparation of food and heating of houses during the winter). The resulting small scale energy consumption causes obviously very little global pollution, and may be therefore called "sustainable".
The energetic resources available here may be all classified as "renewable". The primary and the greatest source is of course the solar energy (Váňa, 2007). It enables the plants to grow – these are consequently eat-en by the domestic animals and by human. The animals are the only source of draught power and of the dung – the only fuel available, which is therefore very valuable. Other great source of energy is the energy of water – not only it is the medium that brings nutrients to the plants, it also moves the watermills which crush the dried barley into the popular tsampa. The circulation of energy is closed by the human beings who carry out most of the work with their hands and feet and whose excrements are brought out of the composting toilets to fertilize the fields.

Objective

Let us have a closer look at the biomass source of energy that is used so widely in the arid areas. How is the fuel gathered and stored? What quantities are needed to support human livelihood? What are the basic fuel properties of the dung of domestic animals? And finally – how much energy for cooking and heating is needed by the inhabitants?

MATERIAL AND METHODS

A remote Himalayan village named Kargyak (4 200 m alt.) was visited. 14 families were asked questions regarding their fuel gathering, storage and usage. The volume

of dung combusted annually was calculated on the basis of daily fuel usage during summer/winter time. The daily fuel usage was both measured and questioned. Two families of different wealth (number of livestock, size of the house) were provided with a fuel-sack. They were asked to use only the fuel from this sack. The sack was weighted and filled up every day at the same time. The experiment lasted for 7 days showing the mean daily fuel consumption of "wealthy"/"poor" family during the summer time. The volume of dung that was taken out of the sheep and goat stables was estimated on the basis of average yearly manure production of sheep and goat as stated in the literature (Andre de Paula, 2008). The assumption is that the whole year production of sheep and goat dung is utilized in the next season. The total energy usage was calculated by multiplying the volume of fuel combusted, its lower calorific value and the stove efficiency of 25.5% (Kandpal, 1995).
A few samples of different kind of dung were brought to the Czech Republic. The analysis of the fuel properties was carried out. The parameters observed were: water content, volatile combustible matter, non-volatile combustible matter, ash content, basic elements – C, H, N, S, O, Cl, lower and higher calorific value, and the ash properties – temperature of softening, melting and the flow point. The values of the Himalayan dung were compared with the values of dung of animals obtained in the ZOOs of the Czech Republic.

RESULTS AND DISCUSSION

Fuel gathering and storage

The dung is collected mostly by women and old people. The most common answer to the question "How much dung do you collect daily?" is 1–2 basket (1 basket = approx. 13 kg) per day. In addition most of the villagers bring some fuel from "docsa". Docsa is a place of temporary pastures. It is equipped with tents, the dairy products and the dung is gathered here. The docsa changes its location about three times during the short vegetation period of about 4 months – according to the villagers.
Another source of fuel is the sheep and goats which stay inside the house during the winter time. The manure is brought out 2–3 times during the winter. It is literally cut into cubes and placed on the roof. When it dries completely, it may be burned.
The fuel is stored on the roofs and in the rooms. The rooms are used especially in winter time when the dwellers move to the ground-floor storey, while the upper storey is filled up with the dung, thus protecting it from snow, making it accessible and serving probably as heat insulation.

Fuel analysis

The fuel analysis was conducted for the following samples of animal dung (Table 1).
The calorific values of the dung obtained in the Czech Republic are significantly higher than those of the fuel obtained in Himalayas. They are even comparable to the calorific value of wood – 16.2 ± 1.7 MJ/kg (Habib, 2004). The lower content of volatile combustible matter, higher content of ashes and subsequent lower calorific value of the fuel obtained in Himalayas is more close to the values indicated by Habib (2004) – 11.8 ± 2 MJ/kg. The differences in results may be explained by different qualities of the dung tested. The Czech samples were dried only

Tab. 1: Fuel parameters of excrements of different animal species

Animal	Yak	Yak	Sheep and Goat	Kiang	Kiang
Place of origin	Vyškov	Himalaya	Himalaya	Chomutov	Prague
Water content (%)	2.6	4.36	5.17	4.86	4.62
Volatile combustible matter (%)	67.17	52.8	50.77	61.89	67.32
Non-volatile combustible matter (%)	18.61	11.68	11.87	11.57	7.99
Ashes	11.62	31.16	32.19	21.68	20.07
C (%)	42.87	32.52	29.89	39.79	41.14
H (%)	5.69	3.85	3.43	5.48	4.97
N (%)	1.6	1.84	2.21	1.13	0.9
S (%)	0.18	0.18	0.2	0.13	0.19
O (%)	35.44	26.09	26.91	26.93	28.11
Cl (%)	0.14	0.2	0.27	0.1	0.14
Higher calorific value (MJ/kg)	17.59	13.41	11.95	15.72	16.31
Lower calorific value (MJ/kg)	16.29	12.47	11.08	14.41	15.12
Ash:					
Temperature of softening (°C)	1 110	1 120	1 130	1 170	1 120
Temperature of melting (°C)	1 160	1 130	1 150	1 200	1 160
Temperature of flow (°C)	1 210	1 140	1 160	1 230	1 170

Tab. 2: Average fuel usage

Fuel usage per household/year (kg)	Fuel usage per capita/year (kg)	Fuel usage per capita/day (kg)	Energy usage per household/year (MJ)	Energy usage per capita/year (MJ)	Energy usage per capita/day (MJ)
7 771.81 ± 2 713.68	1 411.15 ± 492.11	3.87 ± 1.35	24 598.93 ± 8 646.15	4 466.21 ± 1 568.36	12.24 ± 4.3

Tab. 3: Average fuel usage per day in summer time

	Household/day (kg)	Capita/day (kg)	Family members
Wealthy family (20 yaks)	11.29	1.13	10
Average family (5 yaks)	6.93	1.38	5

for a few months on a roofed place, while the Himalayan samples spent uncertain period of time exposed to the natural elements. These conditions resulted in a stone – like outlook of the fuel. Nevertheless this is the fuel that the villagers use on a regular basis, its calorific value may be therefore used for further calculations.

Fuel usage

The fuel usage and consequential energetic needs for cooking and heating were quantified. Following the methods of calculation described in the part "Material a Methods", the results that were obtained – Table 2.

The significant differences in the amounts of fuel used per household may be explained by many household specific factors which include: the number of family members, the social situation of the family, the heated room insulation etc. The practical measurement showed that a wealthy family (owing biggest house in the village, 20 yaks etc.) burns much more fuel per day than a family with significantly more modest propriety. Nevertheless – after dividing the amount of fuel utilized by the number of family members, we may see, that the wealthier – but more numerous family is in fact more effective in terms of per capita fuel consumption.

The daily fuel usage values were confirmed by a practical experiment (methods described above), the results observed in Table 3.

The results achieved were in accordance with results obtained by researches in other areas (Rhode, 2007).

CONCLUSION

Three sources of fuel-dung in the Kargyak village were identified: yak and horse dung collected on daily basis in the vicinity of the village, yak and horse dung gathered at docsa and sheep and goat manure that is gathered in the stables during the winter time.

The calorific values and other fuel properties were determined. The dung brought from Himalayas proved to be less valuable fuel than the dung obtained in the Czech Republic.

The fuel and energetic needs of inhabitants of Kargyak for heating and cooking were quantified as 1 411.15 kg per capita/year, 3.87 kg per capita/day, and 4 466.21 MJ per capita/year and 12.24 MJ per capita/day.

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Corresponding author:

Ing. Adam Vaňkát
Czech University of Life Sciences Prague, Institute of Tropics and Subtropics
Kamýcká 129, 165 21 Prague 6, Czech Republic
e-mail: vankadam@seznam.cz