Nepal Journal of Science and Technology Vol. 14, No. 1 (2013) 109-114

Briquette Fuel - An Option for Management of *Mikania micrantha*

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Abstract

Mikania micrantha (mile- a-minute in English) is assessed as one of the six high risks posed IAS in terrestrial ecosystem in Nepal and is as a considered second biggest threat after deforestation to biodiversity conservation. It is becoming pervasive and estimated to have covered over 20% of the Chitwan National Park. A survey was conducted jointly with NTNC, TCN and NAST to establish the estimates of available *Mikania* biomass raw material. After being cut, it can even regenerate by old rootstocks, runners and suckers. It does not have much use after manual removal. So, using dried biomass for briquetting to get fuel may be an option for its utilization. Different types of briquettes using biomass as well as char were made from its raw materials. Various physical and fuel characteristics of the briquette fuels and combustion tests were performed and studied as an alternative fuel. Different test results show that the use of this weed to produce briquette fuel will generate a potential source of alternative energy and will also help in conserving biodiversity in long run.

Key words: *Mikania micrantha,* biomass briquetting, carbonization

Introduction

Biological invasion and climate change are the two hottest topics of ecology these days. *Mikania micranth*a (Mile-a-minute in English), one of the worst invasive weeds in the world, is a plant of Neotropical origin and threatening to the ecosystem of most countries within the moist tropical zones of South-East Asia (Sapkota 2006). *M. micrantha*, the name of this weed honors the Czech botanist Johann Christian Mikan. A native plant of Central and South America, *M. micrantha* was introduced into India after the Second World War to camouflage airfields and into Nepal through Ilam from Kajiranga National Park in Assam.

The *M. micrantha* is a fast growing plant, capable of climbing over other plants to gain more sunshine. It is also known as plant killer as it spreads appallingly fast, blocking sun light for other plants and strangles many plants, which wither as a result. Its shoot has been reported to grow 27mm a day. It is also reported that a single plant may cover over 25 m^2 within a few months. A single plant releases over 40,000 viable seeds every year (www. issg.org). This weed has reduced food availability of wildlife species found in Koshi Tappu and Parsa Wildlife Reserve and Chitwan National Park areas. It is threatening the rhino-habitat including the grassland. Its present infestation is estimated to have over 30 % of the entire Chitwan national park area (Yadav 2010). If it is spread widely it will reduce the productivity, destroy regeneration and degrade the forest condition. It is neither a good feed for the animals nor does it have any other value of biomass. *M. micrantha* is not a good feed for the cattle as it reduces milk of cow/buffalo and causes abdominal disorder to them (Siwakoti 2007). Due to its spatial spread from east to west, it now occurs in some 15 eastern and central lowland Terai districts of Nepal between 72 - 1200 m altitudinal ranges (Tiwari 2005).

Manual uprooting of this weed is the most feasible method but is possible only in the early stage. Burning is not viable as it is fairly deep rooted and is almost impossible to burn out the roots to exterminate the plant and prevent it from regenerating. Well established areas pose serious problems because new plants can grow even from the tiniest stem fragments (IUCN 2005). Mechanical methods are expensive, labour intensive and provide only short term control.

Herbicides like glycophosphate and 2, 4-D are used before flowering while contact herbicides such as paraquat is used in seedling stage. Chemical methods are expensive, environmentally damaging and is not in practice in Nepal. As the plant does not have any economic value or food value for herbivores, using this biomass for production of fuel briquettes could be one alternative method to manage the proliferation problem and also to reduce dependency on fuel wood and deforestation.

Methodology

1. *M. micrantha* was collected from the Chitwan National park (CNP) and used as the raw material for this research work. The stem, leaves, branches and tendrils of the plant were collected three times in the months of July, August and October, respectively from the buffer zone area of Chitwan National Park. The material was first sun dried and part of it was used to make charcoal and the rest was ground in a grinder to get powder form for making direct biomass briquettes.
2. During the research period, a study for the estimation of *M. micrantha* biomass in Chitwan National Park was carried out jointly with National Trust for Nature Conservation (NTNC), Timber Corporation of Nepal (TCN) and Nepal Academy of Science and Technology (NAST) with the researchers to establish the amount of Mikania biomass, which could be available for briquetting.
3. Proximate analysis and calorific values were determined using Bomb calorimeter for both the biomass and charcoal using Japanese Industrial Standards (JIS) 8813 and 8814. The charred material was used to make beehive briquettes using an ordinary manual mold with 19 holes, whereas the biomass was used in a screw extruder machine Bangladeshi type in NAST to obtain biomass briquettes.
4. The briquette fuels (both biomass and charred briquettes) were then tested using the standard water boiling tests for their performance as fuel. Water Boiling Test was performed as per Apprevecho methodology with some modification.
5. Also the smoke emission from the briquettes during combustion was tested using the Bacharach Smoke Scale which lies within 0 to 9. Scale reading zero means no smoke and 9 means maximum smoke. Normally the range 0-3 is acceptable and considered safe. Low value of smoke emission signifies the fuel is burning without smoke and little pollution. The smoke test was carried out with the Bacharach Smoke Index Pump. This method conforms to ASTM D 2156-63 and used to evaluate the air pollution from smoke coming from different fuels.

Results and Discussion

Mikania biomass estimation in Chitwan National Park (CNP)

A study for the estimation of *M. micrantha* biomass in CNP was carried out in June, 2010 jointly with NTNC, TCN and NAST to establish the amount of Mikania biomass in Chitwan National Park, which could be available for briquetting (see figures1-3). The results of the joint survey are presented in Table 1.

Table 1. Estimates of *Mikania* as raw material for briquetting

No	Parameter	Amount	Unit
1	Average fresh weight of Mikania from a plot	30.39 kg/25m^2	
2	Total area of Chitwan national park	932 km^2	
3	Mikania coverage**	30%	
4	Effective Mikania coverage with reference to row no 3	279.6 km^2	
5	Total weight of Mikania biomass in 279.6 Km^2	339881760 kg	
6	No of times Mikania can be collected in a year	2	
7	Total biomass yield from 2 collection phases in a year	679763520 kg	
8	Moisture content with reference to thesis***	86.6%	
9	Recovery of dried Mikania for direct densification	91088312 kg	~91088 tons
10	Recovery of Mikania after charring***	34158117 kg	
11	Recovery of Mikania for charcoal briquetting	34158.117	~34158tons

Source: Field Survey June 2010, ** As per the information of NTNC of Chitwan National Park
*** With reference to thesis work (37.5%) (Poudel 2010)

It was projected that 339881.8 mt of fresh *M. micrantha* could be harvested annually from the total area of the park. The survey conducted has shown that 91,088 mt of dried *Mikania* or 34,158 mt of charcoal from *Mikania*, respectively, is available for briquetting purpose, annually.

Mikania has infested many other places such as the Koshi Tappu, Parsa Wildlife Reserve, etc. It has been established that more than 20 districts in the Terai region have been infested with *Mikania* (Sapkota, 2007). Therefore, the potentials of *Mikania* as a raw material for briquetting in these areas are quite large.

Fig. 1. Collection of *Mikania*

Fig. 2. Weighing the biomass

Fig. 3. NTNC, TCN & NAST team

Briquette production

The dried *Mikania* biomass was ground to powder form in a disc mill and was then run through a screw extruder briquetting machine at 300°C die temperature to obtain log type briquettes. Some portion of the powder was compressed in a tablet making machine to obtain biomass pellets as well. Other remaining biomass was charred in a charring drum to obtain charcoal which, after grinding, was mixed with 30% clay binder and water to obtain a thick paste, which was then molded into a manual beehive briquette mold to obtain circular cylindrical briquettes with 19 holes. Some hand pressed pellets were also made for some tests. Some photos of different briquettes from Mikania are shown in Figures 4-6 below.

Fig. 4. Long type briquettes

Fig. 5. Beehive briquettes

Fig. 6. Charcoal pellets

Proximate analysis

The highest moisture content (14.77 %) was found in char sample while *M. micrantha* biomass was 6.8 %. Similarly, moisture content of beehive briquette (BHB) was found 5.26 %. The highest moisture content in the char (drum) may be due to humid weather during the day of testing. Normally, charcoal when standing has the tendency to absorb a lot of moisture. Water from the water seal in the charring drum sometimes gets sucked into the drum when low pressure is created during the cooling process of the charcoal in the drum. The high moisture content could result from both reasons. Moisture content should be as low as possible, generally in the range of 10-15 percent. High moisture content will pose problems in grinding and require additional energy for drying (Grover & Mishra 1996). Before briquetting all the materials are sun dried.

The highest ash content (44.7 %) was found in *M. micrantha* BHB sample, which is expected as clay binder up to 30 % by weight is added during briquetting. Similarly char and *M. micrantha* biomass had 28.69 % and 15.61 % ash respectively. Normally, the ash content of ordinary biomass such as saw dust and Banmara are below 5 % and for rice husk it is over 15 %. *M. micrantha* biomass has ash content similar to that of rice husk. The higher ash content in biomass may create problem during briquetting such as wearing of screw in screw extruder. Biomass residues normally have much lower ash content, below 5%, except for some, like rice husk, banana waste, water hyacinth, etc. which have values above 15%; but their ashes have a higher percentage of alkaline minerals, especially, potash that is good for the soil.

Table 2. Results of proximate analysis and calorific values of biomass, char and beehive briquette

No	Sample / Property	Mikania biomass	Mikania char	Mikania BHB
1	Moisture content	13.82	14.77	5.26%
2	Ash content	15.61	28.68	44.70%
3	Volatile matter	57.69	21.10	24.60%
4	Fixed carbon	12.9	35.45	25.44%
5	Calorific value MJ/kg, (kcal/kg)	15.88 (3781)	18.43 (4388)	-

The volatile matter content in *M. micrantha* biomass was 57.69 %, while in its char and BHB was found to be 21.10 % and 24.6 %, respectively. As most biomass had high volatile matter and their char as well as the BHB had lower values (Singh 2011), these values can be considered to be normal for *M. micrantha* too.

The fixed carbon contents in *M. micrantha* biomass were found to be 12.90 %, its char 35.45 % and BHB 25.44 %. Since the volatile matter and ash content are high for *M. micrantha* biomass, the fixed carbon content is slightly lower than that of Banmara biomass (17.22 %) and Banmara charcoal (37.07 %). The carbon content of the BHB made from charcoal of *M. micrantha* is 25.44 %, which is good as charcoal for making the briquettes. The calorific value of *M. micrantha* biomass sample was 15.88 MJ/kg and its char had value of 18.43MJ/kg (Table 2).

Water boiling test

The water boiling test was conducted using the standard procedure with some modification for briquette fuels with different briquettes from biomass and charred biomass in bucket stove which was available at NAST Biomass laboratory. The thermal efficiencies for differerent fuels are given in Table 3.

Table 3. Water boiling test

Fuel used	Amount of Fuel (gm)	Amount of Water evaporated (gm)	Thermal Efficiency (%)
Biomass pellets	250	380	34.93
BHB	570	804	29.97
Screw extruder briquettes	414	774	40.22

From the table it can be seen that the thermal efficiencies are very high (above 25 %). The values are much higher than for the traditional stoves (10-12 %) and above 25 % which are characteristics values for improved cook stoves.

Temperature charactersitics for different fuels

The ignition temperature of *M. micrantha* biomass and its char were 254.9 °C and more than 350 °C respectively. Normally, biomass fuels contain higher volatile matter (57.68 % for *M. micrantha* biomass) and are easier to ignite and have lower ignition temperature. Charcoal has less volatile matter (21.10 %), hence it is difficult to ignite.

During the combustion tests the maximum temperatures of the flame and the boiling water were registered using a data logger Fluke 54 II. The total time of combustion was also noted. The results of these tests are given in Table 4.

Table 4. Temperature characteristics of different fuels

Fuel used	Amount of Fuel (gm)	Total combustion time (min)	Max temp of flame (oC)	Max Temp of Water Attained°C
Biomass pellets	250	48	889	94.8
BHB	570	122	782	92.8
Screw extruder briquettes	414	127	701	92.8

The beehive briquette of 570 g weight burnt for 122 minutes and the maximum temperature of boiling water was found to be 92.8 ÚC while that of fuel was 782 ÚC. The biomass pellets of 250 g burnt for 48 minutes and the maximum temperature of boiling water was found to be 94.8 ÚC while that of fuel was 889.3ÚC . The cylindrical (screw extruder) briquette of 414 g weight burnt for 127 minutes registering the maximum temperature of boiling water at 95.2 ÚC while that of fuel was 701 ÚC. The higher the volatile matter of the fuel, the faster is the combustion and hence the temperature of the flame as well as the water seems to be higher. Mikania biomass therefore burns quickly and gives higher flame tempaerture in comparison to other briquettes. Also probably the densities are higher for other screw extruder briquettes so they burn for a longer duration (Singh & Kim 2006).

Smoke index test

The smoke emitted by biomass pellets during initial ignition period was No 2-3 in the Bacharach oil burner smoke scale which later decreased to No. 0-1. The smoke index of BHB during initial ignition period was No 1 and later came down to No 0. The smoke index result showed that the smoke emission for the briquettes was minumum in the context of indoor air pollution from smoke (Table 5).

Table 5. Smoke index of different fuels

S.N	Fuels used	Igniting condition	Checking time	Smoke index	Remarks
1.	Mikania pellets	Initial ignition period	Between first 5 minutes	2-3	The smoke produced during the firing of pellets.
		Burning of pellets	After subsiding of visible smoke	0-1	There is hardlysmoke formed i.e. pellets are smoothlyburning.
2	Mikana BHB	Initial ignition period	Between first 5 minutes	1	The smoke produced during the firing of BHB.
		Burning of BHB	After subsiding of visible smoke	0	There is no smoke formed i.e. BHB is burning with blue falme.
3*	CC Briquettes	Initial period	Between 1-5 min	5-6	The smoke produced during the firing of CCB.
		Burning of CCB	After 5 min	2-3	There is very little smoke once briquette are ignited
4*	Beehive briquette	Initial peroid	Up to 3 min	5-6	The smoke produced during lighting of briquette
		Burning of BHB	After 3 min burning of BHB	< 2	There is very little smoke after the briquette is ignited
5*	Fuel wood (Matribhumi chulo)	Burning of fuel wood	Upto combustion period of 10mins	4-6	Smoke does not subside

Source: 3*,4* and 5* NAST test reports of compressed coal briquettes (CCB), beehive briquette and fuel wood in Matribhumi chulo

Results and Discussion

Different types of briquettes were prepared from the *M. micrantha* biomass in the Biomass laboratory of NAST and various tests were conducted *M. micrantha* biomass after manual removal does not have use. So, study for identification of possibility to use *M. micrantha* as a raw material in briquetting was done. Some of the conclusions drawn from this study are given below:

- Survey results show that 339881.8 metric tons of fresh *M. micrantha* could be harvested annually from the total area of Chitwan National Park and 91,088 tons of dried Mikania or 34,158 tons of Charcoal from Mikania, respectively is available for briquetting purposes annually.
- Proximate analysis (moisture content, ash content, volatile matter and fixed carbon) of *M. micrantha* was that of a typical biomass except that the ash content (>15%) was in the range of rice husk. The calorific values of biomass and char of *Mikania* also have similar values and can be used for making briquette fuels.
- Briquette formation using biomass and char of *Mikania* with the common briquetting methods showed that stable briquettes having adequate strength can be formed to conduct all the combustion and water boiling tests.

- Water boiling tests and combustion tests showed that briquettes from *Mikania micrantha* have good combustion as well as fuel properties and can be used as substitute for fuel wood or an alternative fuel in rural areas. This research work showed that *M. micrantha*, a problematic biomass in the Chitwan National Park, could be utilized for producing biomass as well as char briquettes, which serve as a management solution to the proliferation problems from this invasive weed.

Acknowledgements

The authors are very thankful to the Biomass Laboratory of Nepal Academy of Science and Technology for allowing us to do this research work for the M.Sc. thesis of M.S. Poudel. Special thanks go to the survey team members of TCN, NTNC and Chitwan National park for their kind support and cooperation during the survey of M. *macrantha* in Chitwan National Park. Thanks are also due to Alternative Energy Promotion Centre for the photographs of the survey.

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