INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

An Investigation On Ipomoea (Ipomoea Carnea) Concerning Its Availability And Bio-Energy Generation Potential In Assam

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Abstract:
Management and utilization of Ipomoea (Ipomoea spp.), a profusely grown wetland plant, have been under investigation in the regions of tropics including India. Uses of Ipomoea for bio-energy generation using modern biomass-to-energy conversion technologies have also been reported. Generally Ipomoea growth is considered undesirable as it causes problems. Profuse growth of this plant results covering of large patches of productive land. Moreover, it also blocks drainage system covering water body and canal thereby causing flood. Rapid growth of this plant is also noticed, especially in the wetlands of Assam. In this study, attempt has been made to assess potential of Ipomoea carnea ssp. fistulosa, the common Ipomoea species in wetland the wetlands of Assam, as bio-energy feedstock in. Spatial distribution of I.carnea in the wetlands of Assam is assessed. Further, energy potential of distributed I.carnea biomass is also estimated using standard procedure. About 244 kilotonne (equivalent energy: 3885 tera Joule) of dry Ipomoea feedstock could be available in different districts of Assam per annum even if 0.5% of wetland area is considered for Ipomoea growth. District level decentralized power production potentiality is also assessed for the state of Assam based on the available wetland statistics and Ipomoea biomass production rate. Overall, 44.4 MW electrical power unit could be expected using the thermo-chemical route of energy conversion of dry Ipomoea biomass. With 4.8 MW power unit, Sonitpur is the most potential district amongst the 23 undivided Districts of Assam followed by Dibrugarh (4.2 MW), Barpeta (3.4 MW), Dhubri (3.2 MW). If it is planned to increase the area of coverage of Ipomoea in the wetlands, this cumulative power generation potential can go up to 266 MW in the whole state. In all the districts biopower availability in unit area has a range between 0.08 kW/sq km (NC Hills) to 1.24kW/sq km (Dibrugarh). However there are some issues requiring attention in planning and management before, such as collection & transportation of biomass, suitable location of plant, economic feasibility. It could be expected that utilization of this undesirable plant, largely available in the wetlands of Assam, as biomass feedstock could provide much needed energy for overall development.

***Keywords**: Ipomoea, Wetland, Bio-energy, Gasification.*

Introduction

Today the world is facing crisis due to the increase in energy demand with diminishing availability of conventional energy sources. Limited availability and the environmental concern pertaining to conventional energy resources have compelled the mankind to search for suitable alternative. Biomass has always been a major source of renewable energy for mankind and is presently estimated to contribute of the order 10–14% of the world's energy supply (Periyasamy, 2011)). The biomass energy sources hold a great promise for several reasons viz., availability, carbon neutrality, capability to link with social welfare programme etc. Biomass can be of different types: woody, agro residue, homestead garden, forest etc. There are many competitive uses of these biomasses hence the availability is limited. The woody biomasses are used for thermal energy generation, in some countries it is used for electric power generation. Agro residues have competitive uses including animal feed, domestic fuel, building material. Overall, uncertainty arises as far as availability of land based biomass is concerned. In this context the biomass generated in the waste land could be made available for energy purpose provided their characteristics are known and availability is confirmed. Again, the biomass resources are spatially distributed over a large area sometimes with uneven abundance which necessitates assessment of spatial distribution for proper energy planning.

Ipomoea is an aquatic plant found in the wetlands of India as well as the tropical countries which grows profusely. Ipomoea can also be a potential source of bio-energy. In India, Ipomoea is a common amphibious weed occurring in fields, ponds, riversides and wet places (Deshmukh, 2012). Generally Ipomoea growth is considered unwanted as it causes problems like covering of large patches of productive land, and thereby creates impenetrable masses of tangled vegetation in water body, canal thereby obstructing water flow in drainage causing flood. It also infests water body displacing native plants, creates dense canopies creating stagnant water conditions facilitating parasite breeding. Management and utilization of the weed is under investigation for long in India and other regions of tropical world. Attempts made for management and control include as livestock feed, building material, paper pulp, source of drugs, and fuel etc. (Abbasi and Ramasamy, 1999). The physical removal is also difficult and remains un-economical, if productive utilization cannot be achieved.

In Assam, National Wetland Atlas (2010) mapped 5097 wetlands with a total estimated wetland area of 764372 ha (9.74% of the geographic area). These wetlands are covered with large vegetation throughout the year. Among these vegetations, Ipomoea carnea ssp. fistulosa (Common name: Amar lota, Fig 1) is the common species (Sharma, 2010) and is under investigation for the purpose of energy generation. With a view to utilize this harmful weed for fuel purposes, Konwar et al. (2007) tried to convert its woody stems first to charcoal through the process of pyrolysis and then the charcoal produced was converted to solid fuel. Revealing its wide ecological amplitude, systematic study was undertaken by Deshmukh et al. (2012) to examine the biomethanogenic potential alone and in combination with distillery waste. During the last two or three decades, this weed has been spreading rapidly in many low-lying areas of northeast India (Konwer, 2007). Considering the widespread and uneven distribution of Ipomoea carnea in the state of Assam, its bio-energy potential and available technology for biomass to energy conversion, the study investigates spatial availability of Ipomoea biomass feedstock, energy availability as well as power generation potential at district levels in Assam.

Material & Method

Plant Profile

The genus Ipomoea occurs throughout the tropical and subtropical regions of the world with more than 500 species (Mabberley, 2008. The amphibious weed Ipomoea carnea is one of the most productive perennial shrubs vine growing profusely on water bodies and adjoining marshy lands, often jostling out most other plant species (Ganesh, 2008). I. carnea plant is 4 to 16 feet tall; leaves hairy underside with Pink flowers. The Hierarchical classification of the plant is given in Table 1.

Kingdom	Plantae
Division	Tracheophyta
subdivision	Spermatophytina
Class	Magnoliopsida
Order	Solanales
Family	Convolvulaceae
Genus	Ipomoea (morning glory)
Species	carnea ssp. fistulosa

Table 1: Classification of Ipomoea

Figure 1: Ipomoea carnea ssp. Fistulosa

Estimation Procedure

The present investigation aims to assess the spatial availability of *I.carnea* district wise and thereby the potential power generation capacity from these feedstock. Considering its habitat (marshy areas, peat, bog etc.), to estimate *I.carnea* distribution hence feedstock availability, district wise area under wetland in Assam is first assessed using standard data of National wetland Atlas: Assam (2010) prepared by Ministry of Environment & forest. Further, considering three scenarios i.e. 0.5, 1 & 3 % area of a wetland will be occupied by Ipomoea vegetation (distribution percentage), district wise area under Ipomoea vegetation is estimated for the three cases. This will help to avoid overestimation of available potential energy and to estimate possible range of available energy and the corresponding power with minimum and maximum coverage of Ipomoea.

It is reported that, the yield of green Ipomoea feedstock in Indian condition is 160 tonne per ha (Bio-energy India, 2010). Using this yield data, district wise yield of green feedstock of Ipomoea is estimated for the state of Assam. Further it has been also reported that 160 tonne of green Ipomoea is equivalent to 64 tonnes of dry feedstock for gasification (Bio-energy India, 2010). District wise availability of dry feedstock of Ipomoea is estimated using this reported data.

Clean energy has a high demand and good market value over the globe and widespread availability of agriculture wastage, fuel wood, animal dung, dry leaves, plant weed etc make biofuel and biomass based energy appealing, with biomass gasification representing one of the most clean and promising small-scale energy and power generating technologies. The dry feedstock available from Ipomoea could be successfully utilized as biomass gasification feedstock (Bio-energy India, 2010*)*. The estimated dry feedstock of Ipomoea available in each district is then used to estimate their energy potential to generate producer gas considering gasification as the conversion technology. Taking the calorific value (CV) of Ipomoea as 15584 MJ/tonne (3,800 kcal/kg) (Bio-energy India, 2010) gross energy yield from these feedstock in each district is estimated using the following equation (Eq 1)

$$\text{Gross energy (TJ)} = \frac{\text{CV of ipomoea} \times \text{Tonnes of ipomoea available in the district}}{1000000} \quad (1)$$

Generally, conversion efficiency of a feedstock in power plant is a function of technology, fuel characteristics and plant size, which is expected to increase with technological upgradation. Yang et al. (2007) have reported efficiency of a 38 MW straw fired power plant above 32% where wheat straw was used as primary fuel. There are also reports of plants operating at as low as 20% overall conversion efficiency. So to estimate the net energy that could be available from I.carnea and to avoid probable overestimation, a conservative figure of conversion efficiency of 30% is taken for all the Ipomoea fired power plants in the present study and the net energy is estimated by Eq. (2)

$$\text{Net energy (TJ)} = \text{Gross energy} \times 0.03 \quad (2)$$

Then to find the power potential from the available net energy the equation 3 is used. Spatial variation of power plant operational time is also ignored and uniform continuous plant operation of 20 hours is considered for power generation.

$$\text{BP (MW)} = \frac{\text{Net energy from (TJ)} \times 1000000}{\text{T (sec)}} \quad (3)$$

Where BP is biomass power in Megawatt, T is operating time of the gasification unit in seconds per annum.

Results & Discussion

District wise I.carnea (Green as well as dry feedstock) availability is presented in Table 2. Considering a minimum of 0.5% of total wetland area of each district occupied by Ipomoea vegetation, the total area under Ipomoea in Assam is about 3,822 ha. This will give rise to about 611,498 tonnes of green Ipomoea feedstock and 244,599 tonnes of dry Ipomoea feedstock for bioenergy generation in the state. At individual district level, Sonitpur has the highest potential for Ipomoea biomass feedstock (66742 tonnes and 26,697 tonnes green and dry feedstock respectively) while Hailakandi has the least potential (2080 tonnes and 832 tonnes green and dry feedstock respectively). From energy perspective, dry feedstock available in the Sonitpur district is equivalent to 424 TJ of gross energy (Net energy 127 TJ) which is highest among all the districts in the state followed by Dibrugarh, Barpeta, Dhubri and for Hailakandi it is 13 TJ (Net energy 4 TJ) of gross energy, being the lowest. For the state of Assam the total dry feedstock of Ipomoea is found to be equivalent to gross energy of 3885 TJ from which 1165 TJ of net energy can be made available.

District	Total Wetland area (ha)	Area under Ipomoea, (ha)	Green Ipomoea (tonne)	Dry Ipomoea (tonne)	Gross energy, TJ	Net energy, TJ
Kokrajhar	24833	124	19866	7947	126	37
Dhubri	56538	283	45230	18092	287	86
Goalpara	33221	166	26577	10631	168	50
Bongaigaon	22149	111	17719	7088	112	33
Barpeta	59038	295	47230	18892	300	90
Kamrup	43655	218	34924	13970	221	66
Nalbari	20140	101	16112	6445	102	30
Darrang	48983	245	39186	15675	248	74
Marigaon	28737	144	22990	9196	146	43
Nagaon	35695	178	28556	11422	181	54
Sonitpur	83427	417	66742	26697	424	127
Lakhimpur	27307	137	21846	8738	138	41
Dhemaji	33468	167	26774	10710	170	51
Tinsukia	40626	203	32501	13000	206	61
Dibrugarh	72461	362	57969	23188	368	110
Sibsagar	12582	63	10066	4026	63	19
Jorhat	45979	230	36783	14713	233	70
Golaghat	43635	218	34908	13963	221	66
KarbiAnglong	5810	29	4648	1859	29	8
NC Hills	6619	33	5295	2118	33	10
Cachar	10419	52	8335	3334	52	15
Karimganj	6450	32	5160	2064	32	9
Hailakandi	2600	13	2080	832	13	3
Total	764372	3822	611498	244599	3885	1165

Table 2: District wise availability of I.carnea

Note: New districts (Udalguri, Baksa, Dima Hasao, Kamrup metro, Chirang) are not shown separately.

The electricity demand in most Indian villages lies between 20kW to 100kW and the locally available surplus biomass is often sufficient to meet these power requirements (Bharadwaj and Tongia, 2003). The use of biomass gasification technology for rural electrification still remains limited, though with large potential across India (Kishore et al. 2004; Ravindranath et al. 2005). Under the existing state of affairs, additional generation of electricity is imperative to support sustainable rural development in India. So considering gasification technology for electricity production with plant efficiency of 30%, cumulative biopower generation capacity can be made up to 44 MW (with 0.5% of wetland under Ipomoea) in the whole state if period of generation is planned for 20 hour per day for the plant instead of continuous generation. This shows that even if Ipomoea covers a 0.5% area of total wetland in a district then also a minimum amount of 44MW energy would remain available to the state of Assam. With this much vegetation, district wise power potential can vary between 0.2 to 4.8 MW. With a growth area of 1 % of wetland, Ipomoea can hold a potential to provide upto 88 MW of power which can go upto 266 MW if 3% growth area of wetland is ensured under Ipomoea. The power availability may be higher as field verification is not covered in the present study. Table 3 shows the district wise variation of power potential considering 0.5%, 1% and 3% coverage of wetland by Ipomoea vegetation.

Further discussion is based on the scenario of 0.5% coverage of Ipomoea (bio power 44.4 MW). The districts are ranked as low, medium and high biopower potential districts, considering the range of 0-1 MW, 1-2.5 MW, >2.5 MW for low, medium and high power potential respectively (Table 3, 0.5% Ipomoea coverage). Then the districts are mapped using spatial analysis (Fig 2). This consideration shows that the bank of river Brahamaputra (Kamrup, Darrang, Sonitpur, Golaghat, Dhubri) has the maximum potential for power generation using *I.carnea* as feedstock grown in the wetlands of this area. The reason behind this is abundant number of wetlands largely distributed in both the banks of river Brahmaputra that supports luxuriant growth of vegetation with Ipomoea as a common species. The Southern Assam districts e.g. Karbi Aanglong, NC Hills, Karimganj, Hailakandi are shown to be less potent in extracting energy thereby power from these Ipomoea. This variation in power potential could be attributed to the topography of these areas as these regions are covered by branches of the ranges like Barail range, Khasi garo Hill which are eroded and dissected parts of the South Indian Plateau system. The hilly terrain supports less number of wetlands. Map shows that Nalbari, Bongaigaon, Kokrajahar etc are medium potential districts.

District	0.5%	1%	3%
Kokrajhar	1.4	2.9	8.6
Dhubri	3.3	6.6	19.7
Goalpara	1.9	3.9	11.6
Bongaigaon	1.3	2.6	7.7
Barpeta	3.4	6.9	20.6
Kamrup	2.5	5.1	15.2
Nalbari	1.2	2.3	7.0
Darrang	2.8	5.7	17.1
Marigaon	1.7	3.3	10.0
Nagaon	2.1	4.1	12.4
Sonitpur	4.8	9.7	29.0
Lakhimpur	1.6	3.2	9.5
Dhemaji	1.9	3.9	11.7
Tinsukia	2.4	4.7	14.1
Dibrugarh	4.2	8.4	25.2
Sibsagar	0.7	1.5	4.4
Jorhat	2.7	5.3	16.0
Golaghat	2.5	5.1	15.2
KarbiAnglong	0.3	0.7	2.0
NC Hills	0.4	0.8	2.3
Cachar	0.6	1.2	3.6
Karimganj	0.4	0.7	2.2
Hailakandi	0.2	0.3	0.9
Total	**44.4**	**88.7**	**266.1**

Table 3: District wise available Biopower potential with different coverage area of I.carnea (MW)

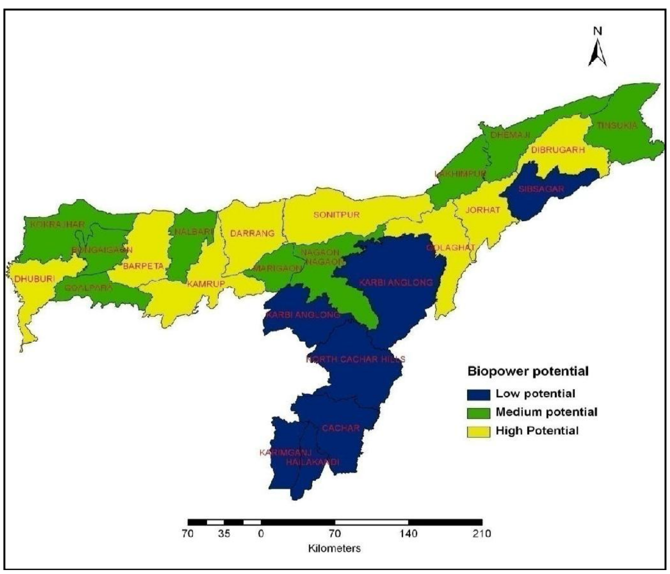

Figure 3: District wise bio power potential from *I.carnea*

In case of biomass, it is spatially distributed with uneven distribution unlike the fossil fuel sources like coal seam, petroleum reserves etc where the sources are confined to specific location spread over few kilometers. To know bio-energy potential it is necessary to estimate the availability in unit area. In all the districts power availability per unit area using I.carnea is determined considering the total area of the districts. This shows that the districts have a range between 0.08 kW/sq km to 1.24kW/sq km of biopower availability. For Assam the average biopower potential of Ipomoea available per sq. km is 0.63 kW. Dibrugarh and Dhubri have the highest power potential available in unit area with 1.24kW/sq km and 1.18 kW/sq km.

Based upon the availability of Ipomoea resources and power demand of a place, decentralized power generation plant could be planned at distinct levels. This spatial variation of Ipomoea and expected power generation potential can help in deciding the suitable location of power plant taking into consideration shortest collection route, collection method etc. Utilization of this unused weed for energy feedstock could supplement energy demand to some extent and would generate employment opportunity. Further investigation concerning the characteristics of load and associated factors will be required to decide the size and mode of operation of power plant.

Conclusion

The present study shows that the vast availability of I.carnea plant can positively supplement use of fossil fuel at the cost of no environmental harm. Being a renewable energy Ipomoea can be an added potent source of energy that will get renewed at regular interval, making sure of minimum energy remain available always. Considering minimum resource availability and power potential also, it can supplement to the total energy demand of the state with a contribution of 44 MW and holds a maximum expected potential of 266 MW. The study demands more focus on suitable method of conversion technology for maximum energy extraction and setting up of this conversion unit in suitable places as a future scope of work with minimum economic and environmental impact.

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