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PINE NEEDLES FOR BIOFUEL PRODUCTION TO MANAGE FOREST FIRE AND ENVIRONMENT CONSERVATION IN HIMACHAL PRADESH

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ABSTRACT

In Himachal Pradesh, chirpine forests are found in ten districts out of 12 districts. The total amount of needle litter falling in pine forests is around 6.3t/ha per year depending on the density and maturity of the crop. In summer pine needles burn in no time and fires spread fast to large swathes of the forest. All this not only damages the natural resource pool in the area but also adversely affects the local livelihood, besides the release of carbon dioxide and other pollutants, responsible for the enhanced green house effect. Briquettes prepared from pine needles have a calorific value of 4727 kcal/kg suitable for heating in industries. The strategy and tools to collect pine needles have been presented in the present study.

INTRODUCTION

In Himachal Pradesh, chirpine forests occupy an area of 1346 km^2 in ten districts out of 12 districts. The chirpine tree is rich in resin content making it a species of economic importance and is a major source of revenue generation for the states. The pine needles are acidic and have been put to limited use (mulching) in the hills. Chirpine needles create a slippery dry carpet on the forest floor which causes the depletion of groundwater by reducing water infiltration and inhibits the growth of grass and other underground flora by acting like a carpet on the forest bed. The needles are not edible; the tree does not produce anything that herbivores can eat. The expansion of this species thus affects the availability of food for wild animals too. But today this valuable native species has become invasive and a major cause of forest fires hampering the ecological cycle of the entire Himalayan region which has become a major concern for environmentalists and forest departments. The total amount of needle litter falling in pine forests is around 6.3t/ha per year depending on the density and maturity of the crop (Bhagat et al, 2009).

The spread of pine needles on the surface of the forest limits the growth of grass, herbs, and other vegetation. The leaves are needle-like, in fascicles of three, and range from 20–35 cm long, which provides large surface-to-volume ratios and low surface fuel bulk densities that readily support surface fire. Due to high resin content decomposition is low and because of their flammable nature catches fire

and resulting in the loss of forest wealth and creating air pollution. The low bulk density of pine needles makes their transportation difficult, therefore these are not collected from the forest.

INTENSITY OF FOREST FIRES

About 6.3 tonnes per hectare or 0.63kg/m^2 of pine needles fall in pine forests during the summer season in India. Within India, much of the research and activity aimed at commercially exploiting pine needles is concentrated in northern Himachal Pradesh state which has nearly 3,300 square kilometers of pine forests, shedding some 1,300 metric tonnes of pine needles annually or 3900kg/km^2. The average pine needle yield is 1.2 kg/ha/yr. According to the Himachal Pradesh government, an average of 2,000 forest fires are reported in the state each year (Kashyap, A., 2020). Between 2001 and 2021, Himachal Pradesh lost more than 900 hectares of tree cover from fires. The most severe losses were in 2004, when 150 hectares were destroyed, according to Global Forest Watch data.

In summer pine needles burn in no time and fires spread fast to large swathes of the forest. These frequent forest fires cause a huge impact on biodiversity such as change in species composition, loss of microflora and fauna, loss of regeneration/plantation areas, damage to seeds, damage to soil health, damage to vegetation cover, loss of wildlife habitat, loss of biodiversity, increased spread of invasion weeds and change in microclimate resulting in change in floral and faunal patterns. All this not only damages the natural resource pool in the area but also adversely affects the local livelihood, besides the release of Carbon dioxide and other pollutants, responsible for the enhanced Green House Effect. About 8961.7 ha of the area was affected by the forest fire during 2019-20 in HP out of which 4952.63 ha natural, 1659.04 ha plantation and 2350.04 ha other (Rajput et al, 2024). As per traditional forest management, control burning of the pine needle is carried out just before the summer months. The huge pine needle biomass (organic resource) instead of controlled burning needs to be utilized on a sustainable basis. That will generate employment and income for the local people and involve their effective participation in forest fire prevention and control.

The fuel-wood collection from the forests for domestic consumption is a factor for deforestation and degradation. The Himachal Pradesh State Forest Corporation (HPSFDCL) supplies fuelwood to tribal areas, including Kinnaur, through depots maintained by the H.P. Forest Department. In November 2023, the government announced that it would provide a subsidy of about Rs 500/quintal to the HPSFDCL, bringing the price of firewood to Rs 805/quintal. Briquette (biofuel) can used as an alternative to forest-based fuel wood because of its durability. The systematic use of pine needles as Pine Needle Briquettes can help control forest fires, save biodiversity and at the same time can be utilized as a fuel for domestic as well as industrial use.

PROPERTIES AND ENERGY POTENTIAL OF PINE NEEDLES

Pine needles have good energy potential for exploitation through pyrolysis and gasification. The pine needles can be converted into high-density fuel briquettes for getting renewable energy as volatile matter, ash content and fixed carbon are found to be 71.23 wt%, 3.11 wt% and 19.90 wt%, respectively thus, a suitable material for thermochemical conversion (Verma and Monda).

Briquettes have a high specific density (1200 kg/m^3) and bulk density (800 kg/m^3) compared to 60 to 180 kg/m^3 of loose biomass and a calorific value of 4727 kcal/kg. Because of their low volume loading/unloading and transportation costs and storage requirements are drastically reduced. Briquettes give higher boiler efficiency as compared to firewood or loose biomass because of low moisture and higher density.

Environmentally, the use of biomass briquettes produces much fewer greenhouse gases, specifically, 13.8% to 41.7% CO_2 and NO_X. There is also a reduction from 11.1% to 38.5% in SO_2 emissions when compared to coal. Briquetting gasification to heat water reduces 74% of GHG emissions, increases the thermal efficiency by 30%, and reduces pollutant emissions of CO, CH_4, and $PM_{2.5}$, NMHC, EC, and OC by 50% to 75% compared to a three-stone fire. The use of briquettes on the improved stove showed energy savings of 12% and a 36% reduction in CO_2 compared to the “U” type open fire. Pine needle briquettes reduce $PM_{2.5}$ concentration by nearly 73%.

CASE STUDY

Selection of forest area: - The approachable dense forest areas of 34 ha and moderate forest area of 10 ha were selected which were most prone to fire. The selected area catches fire approximately 2-3 times annually.

Collection Strategies: - Three kinds of strategies were adopted for the collection of pine needles

1. Hiring personal labour
2. Local community and relatives
3. Involving self-help groups and social workers

Since SHGs and the local community do not have as much effective participation as there is of personal labour. Collection with the help of labour is taken into account along with the payment of daily wages to them at the rate of Rs. 600/day (8 hours)/person and Rs. 50 for extra hours and shifts. The local community and SHGs were reluctant to collect the pine needles as they could not collect as many pine needles to get a minimum daily wage of Rs. 300/-

Machinery and equipment used for collection: - As the collection of pine needles from such a vast area is a hectic process in terms of cost and time, to make it financially viable, equipment was developed according to the demand for raw materials and area. The main tools used are

1. Rake for collection
2. Balers for compression

Rake: - The market size of the rake is not as per field requirement so the size of the rake was modified as per convenience with 5-7 inches long needles and a 1.5 ft area. The market price of rake is around Rs. 500-600/- but indigenously developed rake costs Rs. 300/- only which is economically viable and according to requirements.

Baler: - It plays a very important role in compressing lightweight needles. When pine needles get dry, they are comparable to cotton in terms of weight and volume. The baler is designed as per the requirements and to make the collection economically sound. By doing so, the cost of transportation is also reduced.

Rack

Baler

Permission is required from the forest department to collect the pine needles with a nominal charge of Rs.5/quintal. After obtaining the permission, labourers were deployed in the forest with equipment and other useful things such as gloves, water, food, a first aid kit in case of any injuries, baler, rakes, rope and jumbo bags.

Collection centers: - The collected pine needles are compressed with the help of a baler. Then these bales are shifted to the collection center which was made near the road. In these collection centers a tall heap was created with bales. These bales are transported to the pellet and briquette manufacturing industries.

Collection and transportation of pine needles

In the year 2023, 40000 kg of pine needles were sent to the Rajpura (industry for making Pellets and briquettes). 20 persons got employment for 2 to 3 months. Approximately 9,000-10,000 trees were saved. The grass fields are also improved with healthy cattle feed.

Challenges: - As pine needles are present in forests, collecting them from the forests is a challenging task. A few challenges are Scorpion stings, Snakebites, Wild animal attacks, slippery surfaces, Labour injuries, Interference by local communities, Fire hazards and Risk of theft.

CONCLUSION

The proliferation of chirpine forests in Himachal Pradesh has led to numerous ecological challenges, primarily due to the accumulation of pine needles, exacerbating forest fires and disrupting the local ecosystem. These fires not only pose threats to biodiversity but also have far-reaching consequences for soil health, vegetation cover, and air quality. Addressing this issue requires innovative solutions that harness the potential of pine needles as a sustainable resource. Utilizing pine needles to produce briquettes offers a promising avenue to mitigate forest fires, reduce greenhouse gas emissions, and generate economic opportunities for local communities. Despite the challenges involved in collection and processing, the adoption of efficient strategies and equipment can facilitate the sustainable utilization of pine needles, thereby promoting forest conservation and livelihood enhancement.

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