ROLE OF COIR WASTE IN BIODEGRADATION

APARNA SAINI
RESEARCH SCHOLAR, HIMALAYAN UNIVERSITY
Supervisor Name: Dr. Sadhana Singh
ASST. PROFESSOR

ABSTRACT

Selected physical and chemical properties of thirteen coconut coir wastes (pith plus short-to medium-length fibres) commercially produced in six countries from Africa, America and Asia, were evaluated as growing media or growing media constituents for containerised plants. Coir waste was evaluated as a lightweight material and showed a high total porosity, over 94% (vol). It exhibited a very high air content together with fairly low easily-available water. Total water-holding capacity in coir waste was lower than peat. pH was slightly acidic and salinity varied between 0.4 and 6.0 dS m⁻¹. Cation exchange capacity ranged from 32 to 95 m.e./100 g and C/N ratios averaged. Coir waste contained more lignin and cellulose, but less hemicellulose when compared with peat. The amount of naturally-occurring available nutrients was low, especially mineral nitrogen, calcium and magnesium. On the other hand, indigenous phosphorus and potassium contents in coir waste were extremely high. Remarkable differences were observed between sources with respect to physical and chemical properties. Two individual coir waste samples from Mexico and Sri Lanka were manipulated in order to prepare suitable coir waste-based container media for growing Calendula officinalis and Coleus blumei. The removal of excess salts by controlled leaching did not improve plant growth and development in comparison with unleached coir waste. No N immobilisation was found in coir waste-based media with a conventional fertilisation programme. As a consequence of the particular chemical properties of coir waste, nutritional regimes may need to be adjusted on a crop-by-crop basis. The two plant species tested grew equally well or better in the best coir waste media than in the control mix composed of Sphagnum peat and vermiculite.

KEYWORDS: Coir Waste, Biodegradation, physical and chemical properties

INTRODUCTION

Coir, or coconut fibre, is a natural fibre extracted from the husk of coconut and used in products such as floor mats, doormats, brushes and mattresses. Coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut. Other uses of brown coir (made from ripe coconut) are in upholstery padding, sacking and horticulture. White coir, harvested from unripe coconuts, is used for making finer brushes, string, rope and fishing nets.² It has the advantage of not sinking, so can be used in long lengths on deep water without the added weight dragging down boats and buoys. The thickest and most resistant of all commercial natural fibres, coir is a coarse, short fibre extracted from the outer shell of coconuts.

Its low decomposition rate means is a key advantage for making durable geo-textiles.

The plant

Coir is extracted from the tissues surrounding the seed of the coconut palm (Cocosnucifera),
which is grown on 10 million ha of land throughout the tropics.

**The fibre**

Coir fibres measure up to 35 cm in length with a diameter of 12-25 microns. A coconut harvest occurs once in 45 days. From 1000 coconuts it would be possible to extract 10 kgs of coir. Among vegetable fibres, coir has one of the highest concentrations of lignin, making it stronger but less flexible than cotton and unsuitable for dyeing. The tensile strength of coir is low compared to abaca, but it has good resistance to microbial action and salt water damage and needs no chemical treatment.

There are two types of coir: the more commonly used brown fibre, which is obtained from mature coconuts, and finer white fibre, which is extracted from immature green coconuts after soaking for up to 10 months. Mature coir fibres contain more lignin, a complex woody chemical, and less cellulose than fibres such as flax or cotton.

**Environmental benefits**

Coir is a material which is widely used to overcome the problem of erosion. When woven into geotextiles and placed on areas in need of erosion control it promotes new vegetation by absorbing water and preventing top soil from drying out. Coir geotextiles have a natural ability to retain moisture and protect from the suns radiation just like natural soil, and unlike geo-synthetic materials, it provides good soil support for up to three years, allowing natural vegetation to become established.

**Uses of coir**

Traditionally the coconuts were left to cure in water for several months (or in brine for a longer period for white fibres) then the coir was extracted. However with technology there is an increased use of coconut husk defibering machines.

Typically, white coir spun into yarn is used in the manufacture of rope and, thanks to its strong resistance to salt water, in fishing nets. Brown coir is stronger and more widely used than white coir. Applications include sacking, brushes, doormats, rugs, mattresses, insulation panels and packaging.

**Geotextiles**

Recognition of coir for sustainable vegetation and erosion control arises from the fact that it is an abundant, renewable natural resource with an extremely low decomposition rate and a high strength compared to other natural fibers. Coir is woven into thick textiles which are applied like blankets on the ground in erosion prone areas. Geotextiles made from coir are durable, absorb water, resist sunlight, facilitate seed germination, and are 100% biodegradable. These blankets have high strength retention and a slow rate of degradation meaning they last for several years in field applications.

Coir is widely used in the upholstery industry, and it is a healthy substitute for processed synthetic rubber. It is also used as a combination with natural rubber and is used for filling up mattresses, automobile seats, sofas, settees, and seating systems. European automobile producers upholster cars with pads of brown coir bonded with rubber latex. Coir is used for insulation and finds application in panels, cold storages, food industry, etc.

**Coir Ply**

A substitute to plywood, coir ply is an innovative product that when is added together with resin and limited pre-treated timber veneers. In India the product has been well
accepted by the market as an alternative to plywood. Substituting coir for other timber products could also save a substantial amount of tropical trees being logged for this purpose.

Coir ply has all the properties of phenol-bonded ply with the added strength of fibre reinforced phenol bonding. It has high degrees of surface abrasion resistance and resists contraction/ expansion due to variations in temperatures.

By products

The waste product from milling the coir is peat or pith which makes for high quality mulch and fertilizer. Coir peat compost developed from coir waste is an excellent organic manure and soil conditioner applicable to agricultural crops.

Production and trade

The coir industry is fully developed only in India and Sri Lanka, but economically important in Brazil, Indonesia, the Philippines and Vietnam. Coconuts are typically grown by small-scale farmers, who use local mills for fibre extraction.

Globally around 650 000 tonnes of coir are produced annually, mainly in India and Sri Lanka. India and Sri Lanka are also the main exporters, followed by Thailand, Indonesia, Malaysia, Vietnam, and the Philippines. Around 80 percent of the coir produced is exported in the form of raw fibre. Smaller quantities are exported as yarn, mats, matting and rugs.

Market outlook

India has made considerable efforts to promote coir industry including establishing an annual International Coir Festival. The efforts support the market expansion for coir and India hopes to further increase production by streamlining the fibre collection process to meet demand. Research and development efforts are continuing to focus on the use of coir in geotextiles and other new applications as the market shows promising prospects. Coconuts are grown in more than 93 countries in the world and therefore there is considerable scope to develop coir industry in further countries.

Coir Developments

Much of coir production is done by small holders meaning production is scattered and at small volumes. Integrated farm level processing as a community/cooperative approach would help to facilitate greater availability of technology to process the husk and extract the fibre in volumes needed for industrial buyers. Since many of the developing countries growing coconuts are not utilizing coconut husk to produce value added products, providing such facilities can go along way to provide employment, increase the income of coconut farmers and reduce poverty and provide environmental benefits associated with use of the nutrient rich waste product.

A Common Fund for Commodities (CFC) funded project in Sri Lanka established a R & D and Training Center in a rural area to demonstrate best practices in coir processing. Improved production (increased quantities and higher quality) is to be matched with improvements in the working conditions and production environment currently prevalent, ultimately resulting in higher levels of profitability at the bottom-end of the coir production chain.

The name coir comes from kayar, a Dravidian word for cord, used in
both Malayalam and Tamil, with neither language clearly proven to be the origin.\[3]\[4] Ropes and cordage have been made from coconut fibre since ancient times. Indian navigators who sailed the seas to Malaya, Java, China, and the Gulf of Arabia centuries ago used coir for their ship ropes. Arab writers of the 11th century AD referred to the extensive use of coir for ship ropes and rigging.\[5]

A coir industry in the UK was recorded before the second half of the 19th century. During 1840, Captain Widely, in co-operation with Captain Logan and Mr. Thomas Treloar,\[6] founded the known carpet firms of Treloar and Sons in Ludgate Hill, England, for the manufacture of coir into various fabrics suitable for floor coverings.

**Structure**

Various forms in which coir fibre can appear

Coir fibres are found between the hard, internal shell and the outer coat of a coconut. The individual fibre cells are narrow and hollow, with thick walls made of cellulose. They are pale when immature, but later become hardened and yellowed as a layer of lignin is deposited on their walls. Each cell is about 1 mm (0.04 in) long and 10 to 20 μm (0.0004 to 0.0008 in) in diameter.\[7] Fibres are typically 10 to 30 centimetres (4 to 12 in) long.\[8] The two varieties of coir are brown and white. Brown coir harvested from fully ripened coconuts is thick, strong and has high abrasion resistance. It is typically used in mats, brushes and sacking. Mature brown coir fibres contain more lignin and less cellulose than fibres such as flax and cotton, so are stronger but less flexible. White coir fibres harvested from coconuts before they are ripe are white or light brown in color and are smoother and finer, but also weaker. They are generally spun to make yarn used in mats or rope.

The coir fibre is relatively waterproof, and is one of the few natural fibres resistant to damage by saltwater. Fresh water is used to process brown coir, while seawater and fresh water are both used in the production of white coir. It must not be confused with coir pith, or formerly cocopeat, which is the powdery material resulting from the processing of the coir fibre. Coir fibre is locally named 'coprah' in some countries, adding to confusion.\[8]

**Processing**

Green coconuts, harvested after about six to 12 months on the palm, contain pliable white fibres. Brown fibre is obtained by harvesting
fully mature coconuts when the nutritious layer surrounding the seed is ready to be processed into copra and desiccated coconut. The fibrous layer of the fruit is then separated from the hard shell (manually) by driving the fruit down onto a spike to split it (dehusking). A well-seasoned husker can manually separate 2,000 coconuts per day. Machines are now available which crush the whole fruit to give the loose fibres. These machines can process up to 2,000 coconuts per hour.

**Brown fibre**

The fibrous husks are soaked in pits or in nets in a slow-moving body of water to swell and soften the fibres. The long bristle fibres are separated from the shorter mattress fibres underneath the skin of the nut, a process known as wet-milling. The mattress fibres are sifted to remove dirt and other rubbish, dried in the sun and packed into bales. Some mattress fibre is allowed to retain more moisture so it retains its elasticity for twisted fibre production. The coir fibre is elastic enough to twist without breaking and it holds a curl as though permanently waved. Twisting is done by simply making a rope of the hank of fibre and twisting it using a machine or by hand. The longer bristle fibre is washed in clean water and then dried before being tied into bundles or hanks. It may then be cleaned and 'hackled' by steel combs to straighten the fibres and remove any shorter fibre pieces. Coir bristle fibre can also be bleached and dyed to obtain hanks of different colours.

**White fibre**

The immature husks are suspended in a river or water-filled pit for up to ten months. During this time, micro-organisms break down the plant tissues surrounding the fibres to loosen them — a process known as retting. The Segments of the husk are then beaten with iron rods to separate out the long fibres which are subsequently dried and cleaned. Cleaned fibre is ready for spinning into yarn using a simple one-handed system or a spinning wheel.

Researchers at CSIR's National Institute for Interdisciplinary Science and Technology in Thiruvananthapuram have developed a biological process for the extraction of coir fibre from coconut husk without polluting the environment. The technology uses enzymes to separate the fibres by converting and solubilizing plant compounds to curb the pollution of waters caused by retting of husks.[9]

**Buffering**

Because coir pith is high in sodium and potassium, it is treated before use as a growth medium for plants or fungi by soaking in a calcium buffering solution; most coir sold for growing purposes is said to be pre-treated.[10] Once any remaining salts have been leached out of the coir pith, it and the cocochips become suitable substrates for cultivating fungi. Coir is naturally rich in potassium, which can lead to magnesium and calcium deficiencies in soilless horticultural media. Coir fiber is rarely used as a potting material, except for orchids, and does not need buffering, as it has a very low cation-exchange capacity (CEC) capacity, hence not retaining salts.

Coir does provide a suitable substrate for horticultural use as a soilless potting medium. The material's high lignin content is longer-lasting, holds more water, and does not shrink off the sides of the pot when dry allowing for easier rewetting. This light media has advantages and disadvantages that can be corrected with the addition of the proper amendment such as coarse sand for weight in interior plants like Draceana. Nutritive
amendments should also be considered. Calcium and magnesium will be lacking in coir potting mixes, so a naturally good source of these nutrients is dolomitic lime which contains both. pH is of utmost importance as coir pith tends to have a high pH after some months of use, resulting in plant stunting and multiple deficiencies. Coir has as well the disadvantage of being extremely sensitive to the Leucocoprinus greenhouse fungus. The additions of beneficial microbes to the coir media have been successful in tropical greenhouse conditions and interior spaces as well. However, it is important to note that the microbes will engage in growth and reproduction under moist atmospheres producing fruiting bodies (mushrooms).

Bristle coir

Bristle coir is the longest variety of coir fibre. It is manufactured from retted coconut husks through a process called defibrining. The coir fibre thus extracted is then combed using steel combs to make the fibre clean and to remove short fibres. Bristle coir fibre is used as bristles in brushes for domestic and industrial applications.

Uses

Cordage, packaging, bedding, flooring, and others

Making coir rope in Kerala, India

Red coir is used in floor mats and doormats, brushes, mattresses, floor tiles and sacking. A small amount is also made into twine. Pads of curled brown coir fibre, made by needle-felting (a machine technique that matts the fibres together), are shaped and cut to fill mattresses and for use in erosion control on river banks and hillsides. A major proportion of brown coir pads are sprayed with rubber latex which bonds the fibres together (rubberised coir) to be used as upholstery padding for the automobile industry in Europe. The material is also used for insulation and packaging.

The major use of white coir is in rope manufacture. Mats of woven coir fibre are made from the finer grades of bristle and white fibre using hand or mechanical looms.
White coir also is used to make fishing nets due to its strong resistance to saltwater.

**Agricultural and horticultural uses**

In agriculture and horticulture, coir is a substitute for sphagnum (peat moss) and peat because it is widely available and environmentally friendly. Many sources of coir however are heavily contaminated with pathogenic fungi, and the choice of the source is important. Coir is also useful to deter snails from delicate plantings, and as a growing medium in intensive glasshouse (greenhouse) horticulture.\(^{[11]}\)

Coconut coir from Mexico has been found to contain large numbers of colonies of the beneficial fungus *Aspergillusterreus*, which acts as a biological control against plant pathogenic fungi.\(^{[12]}\)

Coconut coir or identified with the term plantation waste *cocopeat* is abundant in oil-producing areas, crops still aren or Arecaceae family, all parts have great benefits for humans. If the coconut water has important advantages as the manufacture of liquid **organic fertilizer**, as well as fiber wrapped around coconuts can be processed into solid organic fertilizer.

In the world of organic farming-based, utilizing **coconut husk** as solid manure has an important role for the fertility of agricultural land. the solid organic manure, cocopeat / coconut coir function as bio-pores to the soil, with the cavity - the cavity in the ground can improve air circulation carries oxygen needed by plants.

In addition to improving soil aeration on agriculture, other **benefits of coconut fiber** has the ability to store water is 6 times more than its volume. In other words, if the weight of coco 1 kg of water, the power savings can reach 60 kg of water, of course, use coconut fiber as the base material of organic fertilizer is the right solution for the area is minimal rainfall.

**Nutrient content of Coconut Fiber**

Actually the coconut husk which though not yet in cocopeat, cocopeat itself is a waste coconut coir processing in the capture of fiber or fiber. Cocopeat is fine grains or powders of coconut fiber, whatever the term used to call it
is not a problem, which is the subject of the benefits of coconut husk is very large for agriculture. The nutrient content owned coconuts husk either macro or micro-turns are needed by plants.

The content of macro and micro nutrients contained in coconut fiber, among others (K) Potassium (P) phosphorus (Ca) Calcium, (Mg) Magnesium, (Na) Sodium and some other minerals. But of the many nutrient content owned cocopeat, it turns out the number of the most abundant is the element of K (potassium). As we all know that the content of (P) Phosphorus and (K) Potassium is needed by plants during the process of the formation of the fruit as well as an increased sense for any kind of fruit.

**Other Uses**

**Oil and Fluid Absorption**

Due to its superior absorption capabilities when compared to products made of clay, silica and diatomaceous earth-based absorbents, dry coconut coir pith is gaining popularity as an oil and fluid absorbent. Many other absorbents have to be mined, whereas coconut coir pith is a waste product in abundance in countries where coconut is a major agriculture product.

**Animal Bedding**

Coconut coir pith is also used as bedding in litter boxes, animal farms and pet houses to absorb animal waste.

**Biosecurity risks**

*Further information: Invasive species*

Coco fibre can harbour organisms that pose a threat to the biosecurity of countries into which it is imported. Coco peat has been imported into New Zealand since about 1989 with a marked increase since 2004. By 2009 a total of 25 new weed species have been found in imported coco peat. The regulations relating to importing coco peat into New Zealand have been amended to improve the biosecurity measures.

*Trichoderma* is a naturally occurring fungus in coco peat; it works in symbiosis with plant roots to protect them from pathogenic fungi such as *Pythium*. It is not present in sterilised coco peat.

**Major producers**

Total world coir fibre production is 250,000 tonnes (250,000 long tons; 280,000 short tons).

This industry is particularly important in some areas of the developing world. India, mainly in Pollachi and the coastal region of Kerala State, produces 60% of the total world supply of white coir fibre. Sri Lanka produces 36% of the total brown fibre output. Over 50% of the coir fibre produced annually throughout the world is consumed in the countries of origin, mainly India. Together, India and Sri Lanka produce 90% of the coir produced every year. Sri Lanka remains the world's largest exporter of coir fibre and coir fibre based products.

1. **Coir compost**

The largest by products of coconut is coconut husk from which coir fibre is extracted. This extraction process generates a large quantity of dusty material called coir dust or coir pith. Large quantity of coir waste of about 7.5 million tones is available annually form coir industries in India. In Tamil Nadu state alone 5 lakh tons of coir dust is available.

Coir pith has gained importance owing to its properties for use as a growth medium in Horticulture. Because of wider carbon and
nitrogen ratio and lower biodegradability due to high lignin content, coir pith is still not considered as a good carbon source for use in agriculture. Coir pith is composted to reduce the wider C:N ratio, reduce the lignin and cellulose content and also to increase the manorial value of pith. Composting of coir pith reduces its bulkiness and converts plant nutrients to the available form.

2. Coir pith composting technology

Collection of raw material

Coir pith heap

Coir pith is collected from the coir industry without any fiber. If fibrous materials are present, it is removed by sieving at the source itself. Otherwise, it has to be removed at the end of composting at the compost yard. These fibrous materials will not get composted and it will hinder with composting process. It is advisable to bring fibre free coir pith for composting.

Site selection for composting

A separate area should be earmarked for composting. It is better to have an elevated place for composting. In between coconut trees, shade under any tree is good for composting. The shady area conserve the moisture in the composting material. The floor of the compost making area should be levelled. If earthen floor is available the floor can be made to hard by hard pressing and also by applying cow dung slurry. Presence of roof over the composting material is advantageous, since it protects the material from rain and severe sunshine.

Coir pith compost heap

pleurotus
Coir pith is an aerobic composting. So it should be heaped above the soil. There is no need for pit or cement tub to make the compost. Coir pith should be spread to the length of 4 feet and breadth of 3 feet. Initially coir pith should be put up for 3 inch height and thoroughly moistened. After moistening, nitrogenous source material should be added. The nitrogenous source may be in the form of urea or fresh poultry litter. If urea is applied, it is recommended that 5 kg urea is required for one ton of coir pith. This 5 kg equally divided into five portions and in alternative layer of coir pith one kg of urea should be applied. If fresh poultry litter is applied, it is recommended @ 200 kg for one ton of coir pith.

One has to proportionally divide and put the required amount of poultry litter over the coir pith. For example if one ton coir pith is divided into 10 portion, in the first layer, 100 kg poultry litter is added. After adding, the nitrogen source, the microbial inoculums *Pleurotus* and TNAU biomineralizer (2%) are added over the material. Over this one portion of coir pith is added and the same input mentioned above should be added. It is advisable to make a heap up to minimum of 4 feet height. But beyond 5 feet, it requires machinery to handle the materials. The increase in height retains the temperature generated in the coir pith compost process. If the height is low, what ever the heat generated will be dissipated easily.

**Turing of material**

The compost heap should be turned once in 10 days to allow the stale air trapped inside the compost material to go out and fresh air will get in. The composting process is an aerobic one, the organism performing the composting require oxygen for its metabolic activity. This turning of material indirectly aeraates the substrate. The other way of giving aeration is inserting perforated unused PVC or iron pipe in the composting material both vertically and horizontally.

**Moisture maintenance**

Maintaining optimum moisture is the pre-requisite for uniform composting or waste material. Sixty percent moisture is to be maintained. 60 % moisture is, the compost material should be always wet. But excess water should not be drained form the waste material is to take a handful of composting material and put in between the palms and squeeze it. If no water is coming out of the material, that moisture status is ideal for composting.

**Compost maturity**

The period of composting vary from substrate to substrate. If all the above said conditions are maintained in the composting, it will take sixty days (60 days) for some of the physical parameters to be observed in the compost. First observation is volume reduction of waste material. When the waste material is composted, the compost heap height will be reduced by 30 %. The second observation is waste materials are turned to black in colour and the waste particle size is reduced. The third observation is that composted material emits earthy odour. The chemical observation for compost maturity is to be analysed in the laboratory. The chemical observations are narrower C:N ratio (20:1), less oxygen uptake, less number of microorganism, more amount of available nutrients and highly cation exchange capacity.

**Compost harvest**

The composted material which is obtained from sieving is ready for use. If the composition is not used immediately, it should
be stored in a open, cool place, to retain the moisture, so that the beneficial microorganism present in the compost will not die. Once in a month, water is sprinkled over the compost material to maintain the moisture.

CONCLUSION

The use of the studied organic by-products is possible in order to create substrates suitable for soilless plant cultivation but in many cases there are some limitations requiring a less applied percentage or a pre-treatment procedure, increasing the production costs. The suitability of marc may benefit from washing in order to reduce salt concentration and mixing with materials able to improve the physical characteristics. Green compost showed high heavy metals content limiting the application in soilless cultivations and strongly suggesting a better selection of source materials before the composting process. Also for coarse fraction of hemp, mixing with fine materials such as coir pith or peat could represent a way to increase the water retention that seems to be the main limiting factor. For this purpose, coir may improve the quality of alternative substrate mixes, thanks to the suitable pH and EC, the absence of phytotoxicity and the good physical characteristics, according to the proportion of pith and fiber. Results of this study will be helpful in the selection of proper materials to compose new growth substrates alternative to peat for plant cultivation. Peat is the main constituent for growing media but the high price of good quality peat and the availability in the near future due to environmental constraints are driving the study to investigate new alternative media. Recycled and reclaimed solid wastes and various organic residues generated by agriculture, industries and city are alternative source of materials for substrate production with the advantage of circular economy. This manuscript reports interesting and novel results about the characterization of new materials and by-products as suitable alternative media to peat for a proper use in soilless plant cultivation. A substantial part of the initial targets for the project to develop technologies to produce better quality and more attractive coir products with better consumer acceptance have been achieved. Although there is still work to be carried out as a follow up to the various project team activities, much more is now known of the chemical and biochemical aspects of wet processing of coir as the result of CFC/FAO project investments.

REFERENCES


[2]. How coir is made - material, making, history, used, processing, product, industry, machine, History Archived 2006-07-14 at the Wayback Machine


[6]. "Thomas Treloar 1818-1876". RootsWeb. Archived from the original on 2017-12-12.

[9]. "'Clean' technology for coir fibre extraction". The Hindu. 2009-04-30. Archived from the original on 2012-11-08.