Print-ISSN-2320-5504
Online-E-ISSN-2347-4793

ASIA PACIFIC JOURNAL OF RESEARCH

A Peer Reviewed International Journal

Dr.G.Shankar Government Women's First Grade College and P.G Study Centre,
Ajjarkadu, Udupi - 576 101

Date:
24/08/2022

Venue:
UG AV Hall

National Conference on

"RECENT ADVANCES IN SCIENCE AND TECHNOLOGY"

Organised by:

FACULTY OF SCIENCES

Dr.G.Shankar Government Women's First Grade College and P.G Study Centre,
Ajjarkadu, Udupi - 576 101

Vol-1, Special Issue, August 2022

Conference Patron:

Dr. S.Bhaskar Shetty
Principal

Advisory Committee:

Dr. G.Shankar
Chief patron of the college

Prof. B.S.Sherigara
Former, Vice Chancellor,
Kuvempu University

Prof.A.P.Bhat Retd.,
Principal, Poornaprjna College,
Udupi

Dr. Chandru Hegde
Chairman,
Department of Mathematics,
Mangalore University

Dr. Chandru Hegde
Chairman,
Department of Mathematics,
Mangalore University

Dr. Pankaj Koparde,
Assistant Professor,
MIT World Peace University,
Pune

Sri K.Raghupathi Bhat,
MLA & President CDC

Prof. Rangappa.K.S
Former, Vice Chancellor,
Mysore University

Prof. H.L.Shashirekha,
Professor and Chairperson, Department of
Computer Science Mangalore University

Dr. Umesh Maiya
Dr.Associate Professor,
Department of Commerce

Dr. G.Shankar
Govt. Women's First Grade College &
Post Graduate Study Centre,
Ajjarkadu, Udupi -576101

Dr. Kumaraswamy Udupa E.S
Professor, SJCBM College,
Sringeri.

Conference Director:

Sri Ramachandra Adiga.G

Conference Convener:

Sri Keshava Murthy.M.V

Organizing Committee:

Dr. Shridhara Prasad.K

Dr. Sujatha V.Shet

Dr. Chandrashekhara.B.M

Dr. Ravisha.M

Smt. Shubha.B.S

Sri H Ramakantha Puranik

Dr. Manibhushan D.Souza

Smt. Tija P.Thomas

Sri Jayalingamurthy

About the Conference

The aim of this conference is to bring together scientists, academicians, research scholars and students to present their recent research and share new ideas, experiences, practical challenges faced and the solutions implemented in all aspects concerning the field of basic sciences and technology. The conference will provide the opportunity for interaction with academicians from various institutions of higher academic standards. It is expected that researchers will bring new prospects (dimensions/avenues) for collaboration across disciplines and gain ideas facilitating novel concepts. The theme of this conference will motivate the researchers to adapt the outcome for implementation. The conference has the focus on the prime issues in the field of Science and Technology.

National Conference being organized under the broad theme "Recent Advances in Science and Technology" to bring researchers from all fields of sciences, including chemical, biological, computer and mathematical sciences to a common platform and facilitate the exchange of research ideas. Sessions under the broad fields will be organized parallelly and have keynote lectures from leading scientists related to specific themes of the sessions, followed by selected oral presentations.

About Faculty of Sciences

Aiming to provide science education to students from low-income rural households, science departments of our college were established. Begun with a BSc programme in 2003, the faculty now offers four bachelor courses (three BSc and one BCA) as well as two P G courses (M Sc Mathematics and Chemistry). All science disciplines have a well-established, fully equipped laboratories to meet the demands of the students.

Print-ISSN-2320-5504

E-ISSN-2347-4793

Asia Pacific Journal of Research

A peer reviewed international Journal

IMPACT FACTOR : 6.58

Print -ISSN -2320 - 5504
Online-E-ISSN - 2347 - 4793

Vol: I. Special Issue XVI, August 2022

Monthly Journal with Impact Factor: 6.58

Published By: Asia Pacific Publishing, Bangalore, India

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Asia Pacific Journal of Research
A peer reviewed international Journal
IMPACT FACTOR : 6.58
Print -ISSN -2320 - 5504
Online-E-ISSN - 2347 - 4793

VARIATIONS IN PHOTOSYNTHETIC PIGMENTS OF YOUNG AND ADULT LEAVES OF SOME SELECTED PLANTS SPECIES

Bindu[1#], Aparna[1], Anitha Nagaraju[2] and Siddaraju M N[1*]

[1]Department of Botany, University College Mangalore, Mangalore, Karnataka, India
[2]Department of Biochemistry, Mangalore University, Mangalore, Karnataka, India

**Corresponding Author: siddumn@gmail.com*

ABSTRACT

Photosynthetic pigments are the pigments that have the ability to absorb energy from sunlight and make it available to the photosynthetic apparatus. There are six main pigments present in plant species namely Chlorophyll a, Chlorophyll b, Phaeophytin a, Phaeophytin b, Xanthophyll and Carotene. Chlorophyll a is the most common pigment in every plant that performs photosynthesis. Each pigment absorbs light efficiently in a different part of the electromagnetic spectrum. These pigments serve as an indicator of photosynthetic activity, growth, development, production as well as biochemical aspects of plant species. It also provides valuable information about the physiological status of plants. The present study was conducted to measure the Chlorophyll content in young and adult leaves of Codiaeum variegatum and Psidium guajava. The age of the of leaves results revealed that older leaves depicted higher amount of chlorophyll a, chlorophyll b and total chlorophyll compared to younger leaves. The pigments vary with the age of leaf and plant growth.

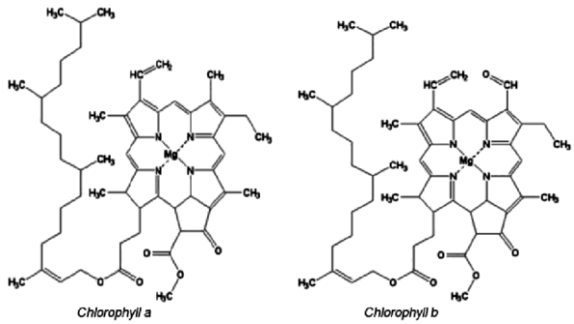
Keywords: *Chlorophyll a, Chlorophyll b, Pigment, Photosynthesis, Plants, Adult leaf*

1. INTRODUCTION

Photosynthetic pigments are located in the chloroplasts of the leaf a plant species. They capture energy from the visible light spectrum, which is used to synthesize carbohydrates from inorganic matter. There are many types of photosynthetic pigments, but the two main groups are chlorophylls and carotenoids. Carotenoids are classified into two classes, carotenes and xanthophylls [1]. Each pigment absorbs a different wavelength, so that together they capture more light. The ability of chlorophyll and carotenoid molecules to absorb the energy of light and use it effectively is related to their molecular structure and to their organization within the cell. Chlorophylls are the pigments primarily responsible for photosynthesis. They absorb red and blue light, and reflect green light. Carotenoids, on the other hand, reflect yellow, orange and red. During fall, chlorophyll breaks down so the carotenoid pigments become visible. Carotenoids assist with photosynthesis by absorbing wavelengths of light that chlorophylls cannot absorb [2]. They transfer energy to chlorophyll molecules and also help to protect the leaf from excess light – they absorb surplus light energy and dissipate it as heat to prevent it from damaging the leaf. Other non-photosynthetic pigments, such as anthocyanins or other flavonoids, determine the colour of flowers, so their absorption spectra vary. The function of these pigments is to attract insects or birds for pollination.

Chlorophyll, a principal photoreceptor in the process of photosynthesis, it absorbs sunlight energy in the form of electromagnetic radiations especially blue and red wavelengths of the spectrum to synthesize carbohydrates and oxygen from CO_2 and water. Chlorophyll a and b are two types of chlorophyll pigments present in plants which act as photoreceptors in the process of photosynthesis. Generally, a chlorophyll molecule consists of a tetra-pyrrole ring having magnesium ion in the center and a long hydrophobic phytol chain. Chlorophyll a consist a methyl group and chlorophyll b has a formyl group. The ratio of chlorophyll a to chlorophyll b is approximately 3:1 in higher plants. Chlorophyll serves as an indicator of photosynthetic activity, growth and development of a plant species. The amount of chlorophyll depends on many factors. It varies with change in season, temperature, precipitation and sunlight [3].

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793



The present study is to show that the age of the leaf is also a primary factor in deciding the chlorophyll content in plant species. *Codiaeum variegatum* (Garden croton) and *Psidium guajava* (Guava) are the two plants selected for the determination of chlorophyll content in young and older leaves in the present study.

2. Materials and Methods:

2.1 Study Area and plant material

The present study was conducted in Mangalore coastal ecosystem located between the geographical co-ordinates of 12.9141° N and 74.8560° E and at an elevation of 22 m above mean sea level (a.m.s.l) in Dakshina Kannada District of the state of Karnataka. The young and adult leaves from *Codiaeum variegatum* and *Psidium guajava* plants were collected on same day. The harvested leaves were transported to the laboratory immediately in air tight polyethylene bags. Leaves of these fresh plants were incised and washed thoroughly. The material was drained of excess moisture before carrying out the required procedure for the determination of chlorophyll [4].

2.2. Extraction and estimation of chlorophyll

One gram of leaf samples was finely cut and gently mixed with a clean pestle and mortar. The homogenized leaf material was added with 20ml of 80% acetone and 0.5gm $MgCO_3$ powder. The materials were further grind gently. The sample was then put into a refrigerator at 4^oC for 4 hours. Thereafter, the sample was centrifuged at 500 rpm for 5 minutes. The supernatant was transferred to 100 ml volumetric flak. The final volume was made up to 100 ml with addition of 80% acetone [5, 6]. The color absorbance of the solution was estimated by a spectrophotometer using 645 and 663nm wavelength against the solvent. Acetone (80%) was used as a blank (APHA, 1989). The samples were taken in triplicates and the results expressed as mg/ml.

2.3. Determination of Rf value by chromatography

The leaf extracts were spotted drop by drop on a designated chromatography paper using a capillary tube and dried immediately. The well dried chromatography papers were placed in chromatography chamber filled with 1:10 Acetone and Petroleum ether solution. The level of the solvent is maintained below the spot on a paper chromatogram. The movement of solvent and pigment up the chromatography paper was monitored till the solvent "front" reaches the edge of the paper and then removed. Location of the colored pigments were marked on the paper using a pencil. and used for RF value calculation [7]. The distance travelled by solvent and the pigments was used to calculate the retardation factor (Rf) using the following equation:

Rf = (distance travelled by pigment) / (distance travelled by solvent). Table 1 shows the Rf value calculation in a representative plant.

Table 1. Rf value calculation in young leaves of Guava

Pigments	Solvent front (cm)	Solute front (cm)	Rf value
Chorophyll b	13	5.8	0.45
Chorophyll a	13	8	0.62
Xanthophyll	13	9.2	0.71
Carotene	13	11.9	0.92

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

3. RESULTS AND DISCUSSION

Green plants have different pigments like chlorophyll, carotenoids and water content which together constitute the spectral characters of a plant body [8]. Chlorophyll concentration in leaf is an important parameter that is regularly measured as an indicator of chloroplast content, photosynthetic mechanism and of plant metabolism [9].

3.1 Chlorophyll content in leaves

P. guajava and *C. variegatum* are the two representative plants selected for estimation of chlorophyll content in young and adult leaves. The reason behind selecting these plants is, guava is a tree and is not much watered. It can stay healthy even in poor supply of water. It also represents a fully green coloured leaf. In other hand, Garden croton is a garden plant which needs daily dose of water and will start to wilt if not watered. It also has leaves with yellow spots all over the lamina which may represent the presence of various pigments. Chlorophyll-a (Chl. a), Chlorophyll-b (Chl. b) and total chlorophyll (T. Chl.) in young and adult leaf of both the plant species were determined. The result depicts significant differences in Chlorophyll content between the young and adult leaves of plants species (Table 2). Total Chlorophyll content in *P. guajava* showed considerable variations recording highest value of 19.5 ± 1.8 mg/ml in adult leaves and 11.6 ± 1.1 mg/ml in young leaves. Similarly, Total Chlorophyll registered in adult leaf of *C. variegatum* is 7.8 ± 0.5 mg/ml against the minimum value of 6.6 ± 0.5 mg/ml in young leaves.

Table 2: Variation in chlorophyll a, chlorophyll b and total chlorophyll content (µg ml^{-1}) in Young and adult leaves of plants (**Week 1**)

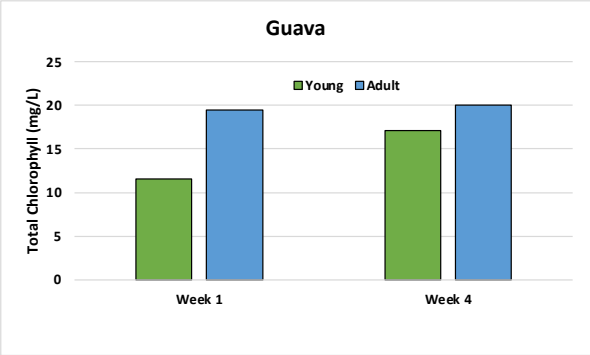
Plant species	Pigments	Young leaf (mg/L)	Adult leaf (mg/L)
Gavua *(Psidium guajava)*	Chl. A	8.4 ± 0.3	12.3 ± 1.2
	Chl. b	5.2 ± 0.8	7.2 ± 0.6
	Total Chl.	**11.6 ± 1.1**	**19.5 ± 1.8**
Garden Croton *(Codiaeum variegatum L.)*	Chl. a	3.8 ± 0.3	4.2 ± 0.2
	Chl. b	2.8 ± 0.2	3.6 ± 0.3
	Total Chl.	**6.6 ± 0.5**	**7.8 ± 0.5**

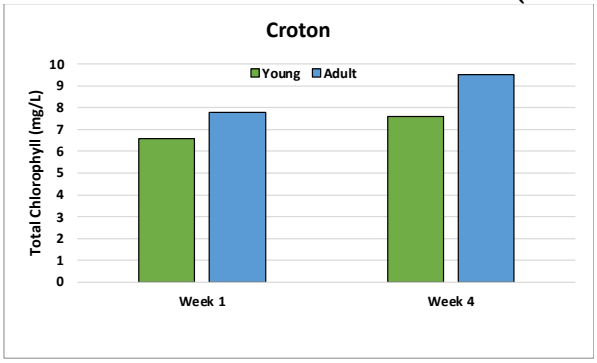
The chlorophyll content was measured again after four weeks to see whether the one month old leaves matches the adult leaves. There was 1.1 fold increase of Total chlorophyll content in adult leaves compared to young leaves of guava plant. In the case of Garden croton, it was 1.25 fold increase in total chlorophyll content of adult leaves compared to young leaves (Table 3). The increase in chlorophyll content in adult leaves is may be due to the increased mesophyll cells that contain more chloroplasts compared to that of young leaves. The developing cells in young leaves are in constant growth and multiplication and the formation and maturation of chloroplasts will be lesser compared to adult leaves.

Table 3: Variation in chlorophyll a, chlorophyll b and total chlorophyll content (µg ml^{-1}) in Young and adult leaves of plants (**Week 4**)

Plant species	Pigments	Young leaf (mg/L)	Adult leaf (mg/L)
Gavua *(Psidium guajava)*	Chl. A	9.8 ± 0.5	14.6 ± 1.2
	Chl. b	7.3 ± 0.6	5.4 ± 0.6
	Total Chl.	**17.1 ± 1.1**	**20.0 ± 1.8**
Garden Croton *(Codiaeum variegatum L.)*	Chl. a	4.2 ± 0.4	5.8 ± 0.3
	Chl. b	3.2 ± 0.2	3.7 ± 0.4
	Total Chl.	**7.6 ± 0.6**	**9.5 ± 0.7**

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793





3.2 Rf values of photosynthetic pigments in leaves

Paper chromatographic study revealed the presence of various pigments in leaves. The Rf values of paper chromatography for both *P. guajava* and *C. variegatum* is shown in Table 4. The values were similar to that of standard values published elsewhere [9].

Table 4. Rf value of photosynthetic pigments of plants

Pigments	Rf value			
	Guava young leaves	Guava old leaves	Croton young leaves	Croton old leaves
Chorophyll b	0.45	0.49	0.45	0.44
Chorophyll a	0.62	0.64	0.60	0.58
Xanthophyll	0.71	0.69	0.67	0.68
Carotene	0.92	0.97	0.88	0.96

4. CONCLUSION

The present study was conducted with an aim to determine the Chlorophyll content in young and adult leaves of plant species such as *P. guajava* and *C. variegatum.* Since, chlorophyll content is the best indicator of photosynthesis activity, stress conditions, measure of the crop response tonitrogen application and many other plant biochemical aspects. Variations in pigment content may provide valuable information about the physiological status of plants [10, 11]. The results revealed that adult constitute higher amount of chlorophyll a, chlorophyll b and total chlorophyll compared to that of young leaves. Rf values of photosynthetic pigments were determined using paper chromatography and it was in accordance with the standard values.

5. REFERENCES

[1] Khaleghi E, Arzani K, Moallemi N, Barzegar M. Evaluation of chlorophyll content and chlorophyll fluorescence parameters and relationships between chlorophyll a, b and chlorophyll content index under water stress in Olea europaea cv. Dezful. World Acad Sci Eng Technol, 2012, 68: 1154-1157.

*[2] Mishra SS, Mishra KN, Mahananda MR. Chlorophyll content studies from inception of leaf buds to leaf-fall stages of teak (Tectona grandis) of Kapilash Forest Division, Dhenkanal, Odisha. J Glob Biosci, **2013**, 2: 26-30.*

[3] Angela G, Usha Shri P. A study on variation in pigment content in plants under air pollution stress. International Conference on Recent Innovations in Sciences, management and Technology, 2016, 483-487.

*[4] Rajalakshmi K, Banu N. Extraction and estimation of chlorophyll from medicinal plants. Int J Sci Res, **2015**, 4: 209-212.*

[5] Strain HH, Cope BT, Svec WA. Analytical procedures for the isolation, identification, estimation and investigation of the chlorophylls. Methods Enzymol, 1971, 23: 452–476.

[6] F. Johan, M. Z. Jafri, H. S. Lim and W. O. Wan Maznah, "Laboratory measurement: Chlorophyll-a concentration measurement with acetone method using spectrophotometer," 2014 IEEE International Conference on Industrial Engineering and Engineering Management, 2014, pp. 744-748, doi: 10.1109/IEEM.2014.7058737.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

[7] Singh S, Bothara SB, Singh SB, Patel R, Ughreja R, et al. Preliminary Pharmaceutical Characterization of Some Flowers as Natural Indicators. The Pharma Research. 2011; 5(2): 213-220.

[8] Kupiec JA, Curran PJ. Decoupling effect of the canopy and foliar biochemicals in AVIRIS spectra. Int J Remote Sens, 1995,16: 1731-1739.

[9] Pramod N. Kamble, Sanjay P. Giri, Ranjeet S. et al. Estimation of Chlorophyll Content in Young and Adult Leaves of Some Selected Plants. Univ J Environ Res Tech. 2015 Volume 5, Issue 6: 306-310

[10] Sari M, Sonmez NK, Karaca M. Relationship between chlorophyll content and canopy reflectance in Washington navel orange trees (Citrus sinensis (L.) Osbeck). Pak J Bot, 2005, 37: 1093-1102.

[11] Kershaw KA, Webber MR. Seasonal changes in the chlorophyll content and quantum efficiency of the moss Brachythecium rutabulum. J Bryol, 1986, 14: 151-158.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Asia Pacific Journal of Research
A peer reviewed international Journal
IMPACT FACTOR : 6.58
Print -ISSN -2320 - 5504
Online-E-ISSN - 2347 - 4793

ROLE OF BITTER GOURD SEED PROTEASE ON BLOOD HEMOSTASIS SPECIFICALLY ON PLATELETS FUNCTION.

Bhagyalakshmi Manjappa*[a] and Devaraja Sannaningaiah[b]

[a] Department of Biochemistry, UCST, Tumkur University, Tumkur, Karnataka, India

[b] Department of Studies and Research in Biochemistry and Centre for Bioscience and Innovation, Tumkur University, Tumkur, Karnataka, India.

*Corresponding address**

Bhagyalakshmi Manjappa, PhD,

Assistant Professor,

Department of Biochemistry

University College of Science

BH Road, Tumkur University,

Tumkur-572103, India

Tel: +91 9481343477; fax: +91 816 2270719;

E-mail: bhagyaayanur@gmail.com

ABSTRACT

In Ayurveda, unani, homeopathic and folk medicine system, Momordica charantia known as Bitter gourd was extensively using to cure many diseases and disorders since from olden days. Hence bitter gourd was taken to study its effect on blood hemostasis .serine protease was isolated and purified from seed. Purified MCase found to exhibit anticoagulant activity and furthermore, MCase interfered in platelet function. Platelet aggregation was analyzed using agonists such as, ADP and epinephrine using platelet-rich plasma and ADP, Arachidonic acid, thrombin and epinephrine for washed platelets. MCase inhibited the agonists such as collagen, ADP and epinephrine induced platelet aggregation of about 45 % , 94% in PRP and in washed platelets 45 %, 65 %, 87 % and 90 % respectively at the concentration of 15µg. MCase hydrolysed fibrinogen but did not hydrolyze other plasma proteins. Interestingly, MCase was nontoxic to experimental mice as it did not cause hemolysis, hemorrhage and edema.

Keywords: *MCase, blood hemostasis, platelet-rich plasma and platelet aggregation.*

Introduction

Medicinal plants and their products continue to be an important therapeutic aid for alleviating the ailments of human kind [1]. Many traditional medicines systems derived organic and inorganic compounds from medicinal plants. The world health organization (WHO) has listed more than 21000 medicinal have using around the world and more than 150 plant based dugs have been commercially using in huge scale [2]. One such plant is Bitter gourd, Bitter gourd also known as Bitter melon/balsam pear/*Momordica charantia*. Bitter gourd is a medicinally important plant, belongs to the family of *Cucurbitaceous* and grows in tropical region. Many researchers identified different functional compounds in bitter gourd seeds with strong health benefit [3]. Hence in our study bitter gourd seed extract was screened for anticoagulant and antiplatelet activities and seed protease was identified and purified.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Materials

ADP type-I, ADP, epinephrine, collagen were purchased from Sigma Chemicals Company, St. Louis, USA. UNIPLASTIN, LIQUICELIN-E and FIBROQUANT were purchased from Tulip Diagnostics Pvt. Ltd., Goa, India. All chemicals and reagents used were analytical grade. Fresh blood sample was collected from healthy human donors. Swiss Wister albino mice weighing 20–25g from the central animal house facility, were procured from Liveon Bio Labs, Limited, Institutional Animal Ethical Committee (Tumkur, India) and kept in polypropylene cages for acclimatization for 6 d in groups. Animal care and handling complied with the National Regulation for Animal Research.

Momordica Charantia seed and Preparation of Momordica Charantia seed extract

Momordica charantia (bitter gourd) fruits were purchased from the local market of Tumkur and the seeds were collected from the fruit. Seeds were crush homogenized using double distilled water centrifuged, supernatant was collected and protein estimation was carried to confirm protein using bovine serum albumin (BSA) as standards[4]. Isolated sample was stored at -20^{0}C for further studies.

Isolation and Purification of protease

DEAE Cellulose column chromatography was used for gel filtration of protein using NaCl -tris buffer with different molarities . Ten peaks were obtained , out of ten peak II exhibited proteolytic activity , further Peak II fraction was recovered (20mg in 1mL of 0.1M NaCl) and loaded on to a pre-equilibrated Sephadex G-75 column with 0.1M NaCl (1 x 90cm).Fractions exhibited positive results were pooled and concentrated. The purified fraction of protein obtained from Sephadex G-75 column chromatography was subjected for RP-HPLC using shimadzu LC20AD prominence HPLC with PDA detector. The protein was eluted at a flow rate 0.5 mL/min and it was monitored at 280nm. Protein estimation , SDS PAGE[5] , proteolytic activity[6] with inhibitors and anticoagulant assay[7] were confirmed the presence of serine protease . protease was named as MCase.

Preparation of platelet rich plasma (PRP)

The platelet rich plasma was prepared [8]. Nine volumes of human blood from healthy donors (who were nonsmokers and non-medicated at least for the previous 15days) in to one volume of acid citrate dextrose (93mM sodium citrate, 7mM citric acid and 140mM glucose pH 6.5) followed by centrifugation at 90g for 10min at room temperature. The supernatant was called platelet rich plasma (PRP). The remaining blood was centrifuged at 500g for 15min and the supernatant obtained was the platelet poor plasma (PPP). The platelet concentration of PRP was adjusted to 3.1 x 108 platelets/ml with PPP and maintained at 37^{0}C was used within 2h. All the above preparations were carried out using plastic (polypropylene tubes) wares or siliconized glassware.

Preparation of washed platelets

Washed platelets were prepared [9]. Blood was drained from antecubital vein of healthy drug-free human volunteers (non-smokers). The collected blood was immediately mixed with acid citrate dextrose (ACD) anticoagulant (85mM sodium citrate, 78mM citric acid and 110mM D-glucose) in the ratio 6:1 [blood: ACD (v/v)]. The anticoagulated whole blood was then centrifuged at 90x*g* for 15min to obtain platelet rich plasma (PRP). The PRP was centrifuged at 1700x*g* for 10min and the platelet pellet obtained was suspended in Tyrode's albumin buffer (145mM NaCl, 5mM KCl, 10mM HEPES, 0.5mM Na2HPO4, 1mM MgCl2, 6mM glucose, and 0.3 % bovine serum albumin, BSA) pH 6.5 and washed thereafter at 1700x*g* for 10min. The previous washing step was repeated once more and finally the platelets were suspended in Tyrode's albumin buffer, pH7.45. The cell count was determined using a Neubauer chamber and adjusted to 5 x 108cells/mL in the final suspension using Tyrode's albumin buffer, pH 7.45.

Platelet aggregation

Platelet aggregation was done [10]. Aliquots of PRP were pre-incubated with various concentrations of MCase (0-6µg) in 0.25ml reaction volume. The aggregation was initiated independently by the addition of agonists, such as collagen, ADP and epinephrine and followed for 6min. As platelets aggregate in response to an added agonist, light transmission decreases progressively producing an aggregation trace on the recorder. The aggregation trace was the plot of light transmission between platelet rich plasma (PRP) and platelet poor plasma (PPP) base line, which represent 0 % and 100 % aggregation respectively.

Degradation of human plasma proteins

Degradation of human plasma protein was assayed [11]. MCase (0-10µg) was incubated with the 100µg of plasma proteins for 12 h at 37^{0}C. The reaction was terminated by the addition of 20µl denaturing buffer containing 4 % SDS and boiled for 5min and analyzed on 7.5 % SDS-PAGE under non-reduced condition.

Indirect hemolytic activity

Indirect hemolytic activity was determined [12] using washed human erythrocytes in presence of 0-50µg of MCase. The amount of hemoglobin released in the supernatant was measured at 540nm.

Edema inducing activity

Edema inducing activity was performed. The groups of five mice were injected separately in to the right foot pads with different doses 0-50µg of MCase in 20µl saline and 20µl saline alone served as controls. The left foot pads received 20µl saline alone

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

served as controls. After 1h, the mice were anesthetized by diethyl ether inhalation. The hind limbs were removed at the ankle joint and weighed. Weight increased was calculated as the edema ratio, which equals the weight of edematous leg x100/weight of normal leg. Minimum edema dose (MED) was defined as the amount of protein required to cause an edema ratio of 120%.

Hemorrhagic activity

Hemorrhagic activity was assayed [13]. A different concentration of MCase(0-50µg) was injected (intradermal) independently into the groups of five mice in 30µl saline. The groups receiving saline alone served as a negative control and the group receiving Daboia resselli venom (2MHD) served as the positive control. After 3h, the mice were anesthetized by diethyl ether inhalation. A dorsal patch of the skin surface was carefully removed and observed for hemorrhage against saline-injected control mice. The diameter of the hemorrhagic spot on the inner surface of the skin was measured. MHD was defined as the amount of the protein producing 10mm of hemorrhage in diameter.

Statistical Analysis

The data are presented as mean± SD. Statistical analyses were performed by Student's t test. A significant difference between the groups was considered if P value was less than 0.01.

Results and Discussion

Antiplatelet activity of MCase

In figure 1 plasma protein degradation assay, MCase hydrolyzed only fibrinogen and other plasma proteins are not affected in figure 11. The fibrinogen protein band intensity was progressively decreased with increased concentration MCase (0-20µg) as compared to positive control fibrinogen alone.

Furthermore, MCase interestingly caused platelet aggregation inhibition in both in platelet rich plasma and washed platelets, the aggregation was analyzed using agonists such as collagen, ADP and epinephrine using platelet-rich plasma and ADP, Arachidonic acid, thrombin and epinephrine for washed platelets. MCase inhibited the agonists such as collagen, ADP and epinephrine induced platelet aggregation of about 95 % in figure 2,45 % in figure 3 and 94% in figure 4 in PRP and in washed platelets figure 5 -90 %, figure 6-65 % and 68% in figure 7 respectively, further for Thrombin 75%in figure 8 and for Arachidonic acid 90% in figure 9 respectively at the concentration of 15µg.

Non-toxic properties of MCase

Furthermore, MCase was found to interfere in the platelet function of both platelet rich plasma and washed human platelets. Platelets are vital components of normal haemostasis, platelet activation and aggregation plays an important role in the formation of clots at site of injury. Agonists, receptors, and effectors systems participating in platelet activation and its regulation [14].Uncontrolled progression of platelets aggregation, may induces the cardiovascular and thrombotic disorder. In addition, it also associated with complications in diabetes [15]. In order to treat these pathological conditions antiplatelet agents such as aspirin, Dipyridamole, Clopidogrel, Eptifibatide Vorapaxar and thienopyridines have been using extensively [16,17]. While, antiplatelet therapy considered to be more elusive due to life threatening side effects associated with them, thus there has been an increasing rate of morbidity and mortality [18,19]. Crinumin, a serine protease from *Crinum asiaticum* reported to inhibits platelet aggregation [20]. Meanwhile, MCase was nontoxic in nature that was confirmed in RBC lysis assay , non-hemorrhage and non edematic to in experimental mice also supports its non-toxic nature.

MCase did not destroy red blood cell membrane, in addition, it did not cause hemorrhage and edema in experimental mice up to the concentration of 50µg, while positive control daboia russelli venom induced hemorrhage and edema in experimental mice was confirmed in figure10.

Conclusion

In conclusion, serine protease of Bitter gourd was purified and characterized form crude aqueous extract of seed. It delay plasma coagulation time and showed strong antiplatelet activities. Hence therapeutic applications of MCase for preventing and/or treating thrombotic cardiovascular disorders found to be promising.

Acknowledgements

Authors acknowledge the Vision Group on Science and Technology, Government of Karnataka, Bangalore, and UGC, New Delhi for financial assistance.

Conflicts of interest
The authors declared no potential conflict of interest with respect to the authorship and publication.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Reference

1. *Arjun Ram, Duraisamy Arul Joseph, Selvakumar Balachandar, Vijay Pal Singh. Medicinal plants from Siddha system of medicine useful for treating respiratory diseases . International Journal of Pharmaceuticals Analysis, ISSN: 0975-3079, Volume 1, Issue 2, 2009, pp-20-30 .*
2. *Ghosh P, Chakraborty P and Ghosh GB et al.: Antibacterial, antifungal and phytotoxic screening of some prepared pyrazine derivatives in comparison to their respective α- diketo precursors. Int J Pharmaceu Sci Res 2(7): 2011;1687-1692.*
3. *Cragg GM1, Newman DJ.Natural products: a continuing source of novel drug leads. Biochim Biophys Acta. 2013 Jun;1830(6):3670-95. doi: 10.1016/j.bbagen.2013.02.008. Epub 2013 Feb 18.*
4. *Laemmli UK. Cleavage of structural proteins during the assembly of the head of bacteriophage T4. Nature 1970; 227:680–685.*
5. *Leach BS, Collawn JF, Fish WW. Behavior of glycopolypeptides with empirical molecular weight estimation methods in sodium dodecyl sulfate. Biochemistry 1980; 9:5734–5741.*
6. *Quick AJ, Stanley-Brown M, Bancroft FW. A study of the coagulation defect in hemophilia and in jaundice. Am J Med Sci 1935; 190:501–511.*
7. *Denis C, Methia N, Frenette PS. A mouse model of severe von Willebrand disease: defects in hemostasis and thrombosis. Proc Natl Acad Sci USA 1998; 95:9524–9529.*
8. *Ardlie NG, Han P. Enzymatic basis for platelet aggregation and release: The significance of the'platelet atmosphere' and the relationship between platelet function and blood coagulation. Journal of Haematology, 1974. 26:331-56.*
9. *Born GV. Aggregation of blood platelets by adenosine diphosphate and its reversal. Nature 1962, 194:927-9.*
10. *John W. Weisel and Rustem I. Litvinov. Fibrin Formation, Structure and Properties. Subcell Biochem. 2017 ; 82: 405–456.*
11. *Kumar MS, Devaraj VR, Vishwanath BS, Kemparaju K. Anticoagulant activity of a metalloprotease: further characterization from the Indian cobra (Naja naja) venom. J Thromb Thrombolysis 2010; 29:340–348.*
12. *Kondo H, Kondo S, Itezawa H, Murata R, Ohasaka A. A study on the quantitative method from determination of hemorrhagic activity of Habu snake venom. Jpn J Med Sci Biol 1969; 13:43–51.*
13. *Sannanaik Vishwanath B, Manjunatha Kini R, Veerabasappa Gowda T. Characterization of three edema-inducing phospholipase A2 enzymes from habu (Trimeresurus flavoviridis) venom and their interaction with the alkaloid aristolochic acid. Toxicon 1987; **25**(5): 501-515.*
14. *Kondo H, Kondo S, Itezawa H, Murata R, Ohasaka A. A study on the quantitative method from determination of hemorrhagic activity of Habu snake venom. Jpn J Med Sci Biol 1969; 13:43–51.*
15. *Santilli F, Rocca B, De Cristofaro R, Lattanzio S, Pietrangelo L, Habib A, Pettinella C, Recchiuti A, Ferrante E, Ciabattoni G, Davı` G, Patrono C. Platelet cyclooxygenase inhibition by low-dose aspirin is not reflected consistently by platelet function assays. J Am CollCardiol 2009; 53:667–677.*
16. *Hollopeter G, Jantzen HM, Vincent D, Li G, England L, Ramakrishnan V, Yang RB, Nurden P, Nurden A, Julius D, Conley PB. Identification of the platelet ADP receptor targeted by antithrombotic drugs. Nature 2001;409:202–207.*
17. *Moscucci M, Fox KA, Cannon CP, Klein W, Lo´pez-Sendo´n J, Montalescot G, White K, Goldberg RJ. Predictors of major bleeding in acute coronary syndromes. Eur Heart J 2003;24:1815–1823. 65.*
18. *Eikelboom JW, Mehta SR, Anand SS, Xie C, Fox KA, Yusuf S. Adverse impact of bleeding on prognosis in patients with acute coronary syndromes. Circulation 2006;114:774–782.*
19. *Asadi H, Yan B, Dowling R, Wong S, Mitchell P. Advances in medical revascularization treatments in acute ischemic stroke. Thrombosis 2014.*
20. *Sowmyashree Gangaraju, Bhagyalakshmi Manjappa, Girish Kesturu subbaiah, Kemparaju kempaiah, Manohar shinde, Devaraja Sannaningaiah. Anticoagulant and anti platelet activities of jackfruit (Artocarpus heterophyllus) seed extract. International Journal of Pharmacy and Pharmaceutical Sciences ISSN- 0975-1491 2015; 7(Supple 1).*

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Figure legends:

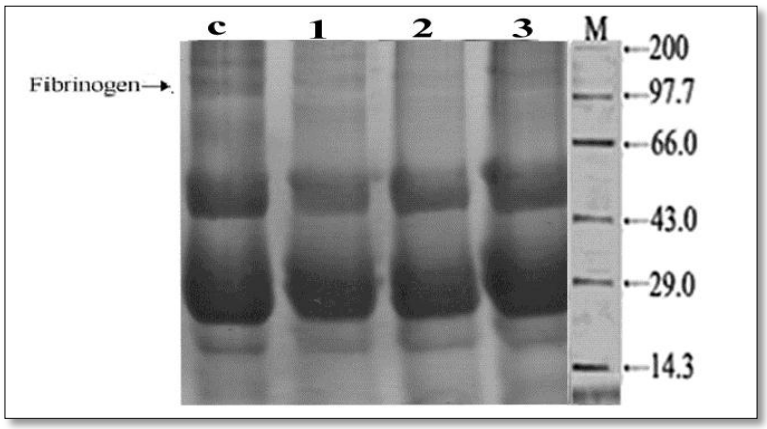


Figure 1 Degradation of plasma proteins: Plasma protein (100µg) is incubated with MCase in 40µl of 10mM Tris-HCl buffer pH 7.4 at 37 ^{0}C and then analyzed on 7.5 % SDS-PAGE under non-reduced condition. Plasma protein (100µg) alone (c), plasma protein treated with 5µg (1), 10µg (2), 20µg (3)for 12h. M represents the molecular weight markers.

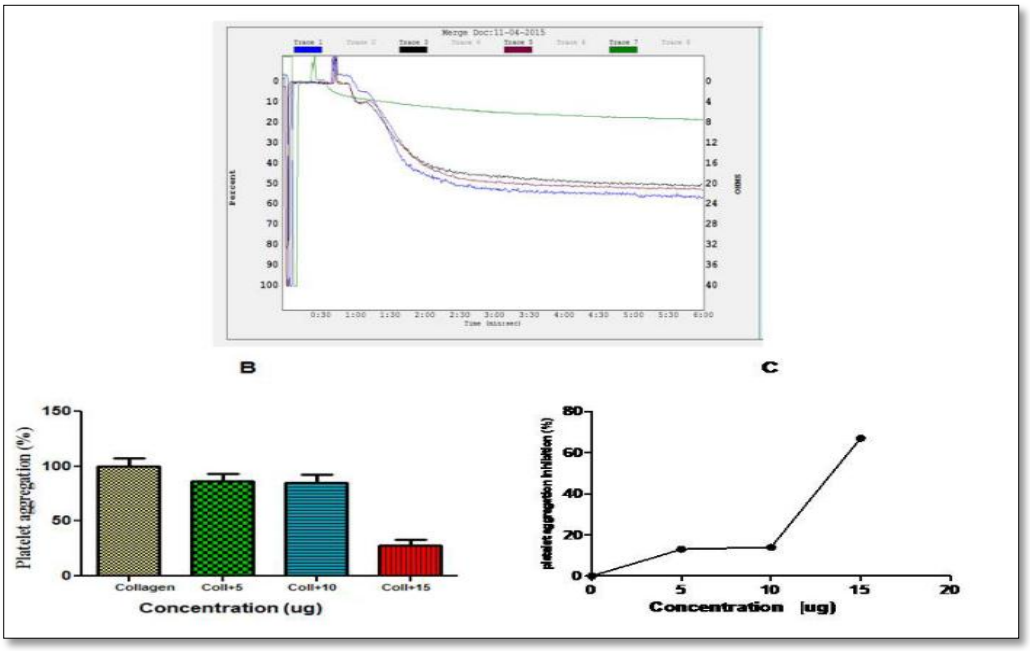


Figure 2 Effect of MCase on collagen induced platelet aggregation. (**A) Aggregation trace:** Trace 1 (Collagen 10µM); Trace 2 (Collagen 10µM +5µg of MCase);); Trace 3 (collagen 10µM +10µg of MCase);); Trace 4 (collagen 10µM +15µg of MCase);), The values represent ± SD of three independent experiments , . **(B) Dose dependent platelet aggregation %. (C) Dose dependent platelet aggregation inhibition %.**

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

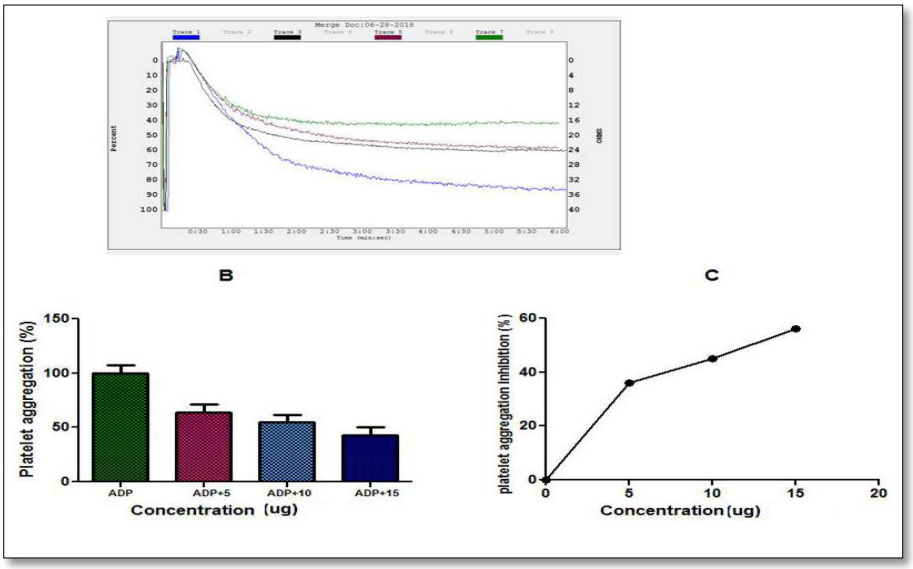


Figure 3 Effect of MCase on ADP induced platelet aggregation.(A)Traces of platelet aggregation: Trace 1 (ADP 10µM); Trace 2 (ADP 10µM +5µg of MCase); Trace 3 (ADP 10µM + 10µg of MCase); Trace 4 (ADP 10µM +15µg of MCase). The values represent ± SD of three independent experiments. **(B) Dose dependent platelet aggregation %. (C) Dose dependent platelet aggregation inhibition %.**

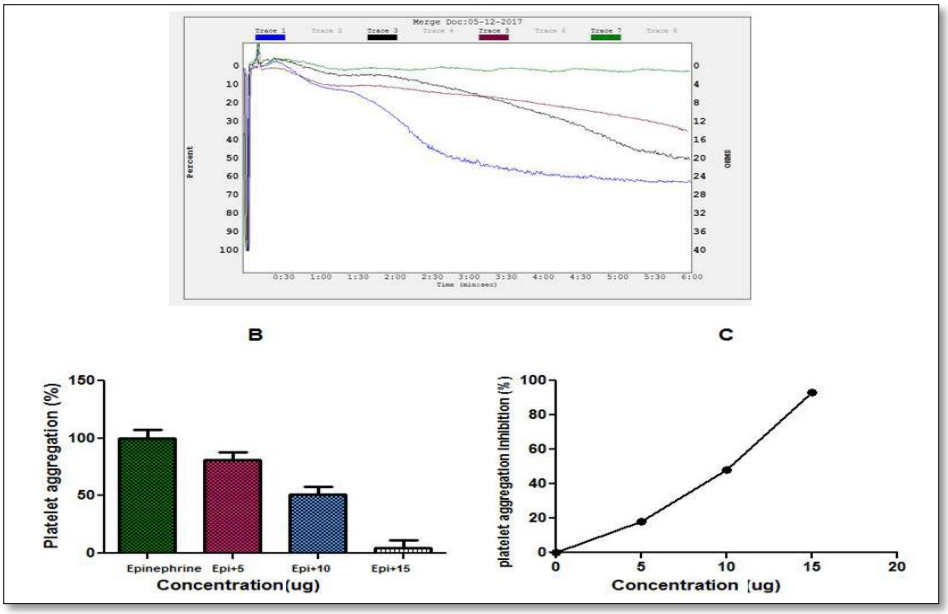


Figure 4 Effect of MCase on Epinephrine induced platelet aggregation. Trace 1 (Epinephrine 5µM); Trace 2 (Epinephrine 5µM+5µg of MCase); Trace 3 (Epinephrine 5µM+ 10µg of MCase); Trace 4 (Epinephrine 5µM+15µg MCase). The values represent ± SD of three independent experiments. **(B) Dose dependent platelet aggregation %. (C) Dose dependent platelet aggregation inhibition %.**

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

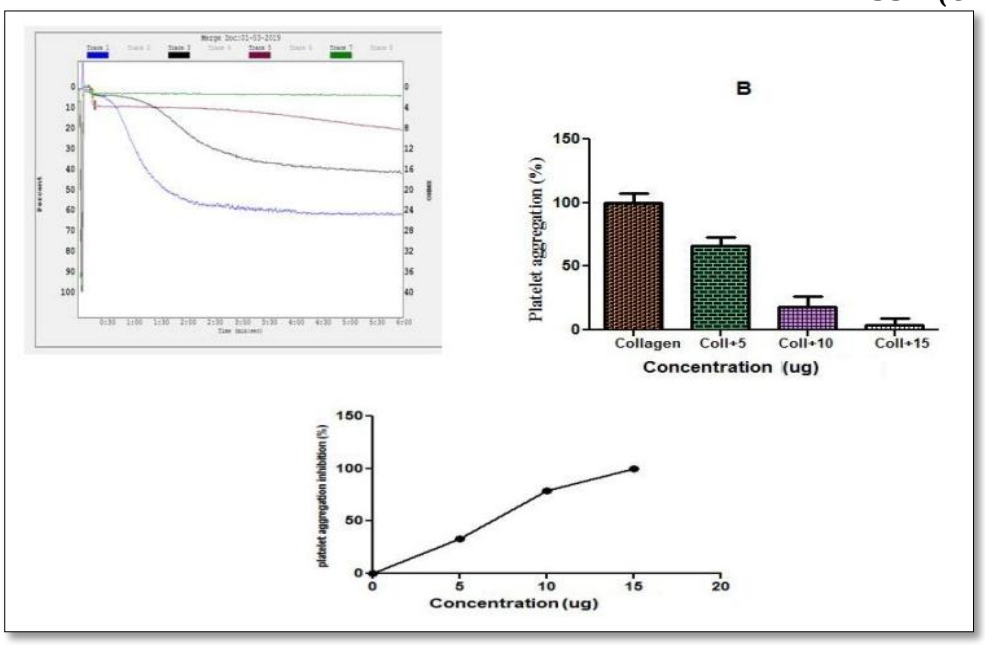


Figure 5 Platelet Aggregation was initiated by adding Collagen as an agonist washed platelets. (A) Aggregation trace: Trace 1 (Collagen 10µM); Trace 2 (Collagen 10µM +5µg of MCase);); Trace 3 (collagen 10µM +10µg of MCase);); Trace 4 (collagen 10µM +15µg of MCase);), The values represent ± SD of three independent experiments , . **(B) Dose dependent platelet aggregation %. (C) Dose dependent platelet aggregation inhibition %.**

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

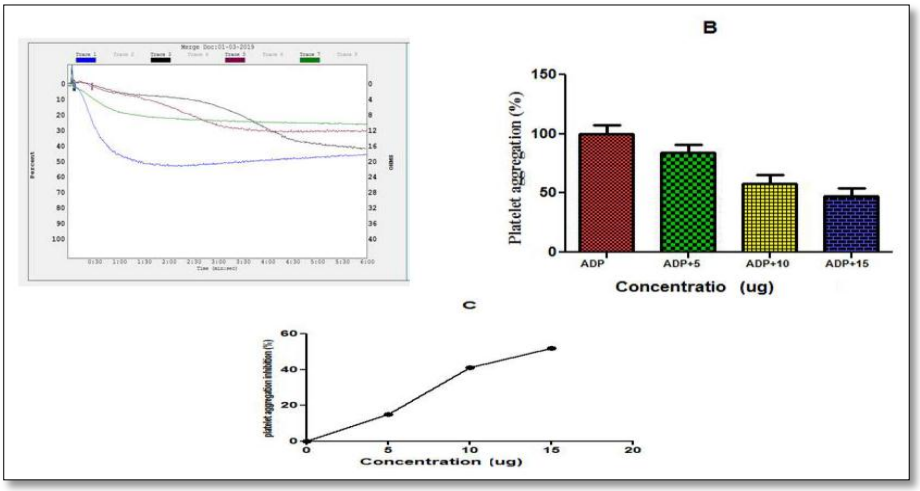


Figure 6 Platelet aggregation was initiated by adding ADP as an agonist using washed platelets. **(A)Traces of platelet aggregation:** Trace 1 (ADP 10µM); Trace 2 (ADP 10µM + 5µg of MCase); Trace 3 (ADP 10µM + 10µg of MCase); Trace 4 (ADP 10µM + 15µg of MCase). The values represent ± SD of three independent experiments. **(B) Dose dependent platelet aggregation %. (C) Dose dependent platelet aggregation inhibition %.**

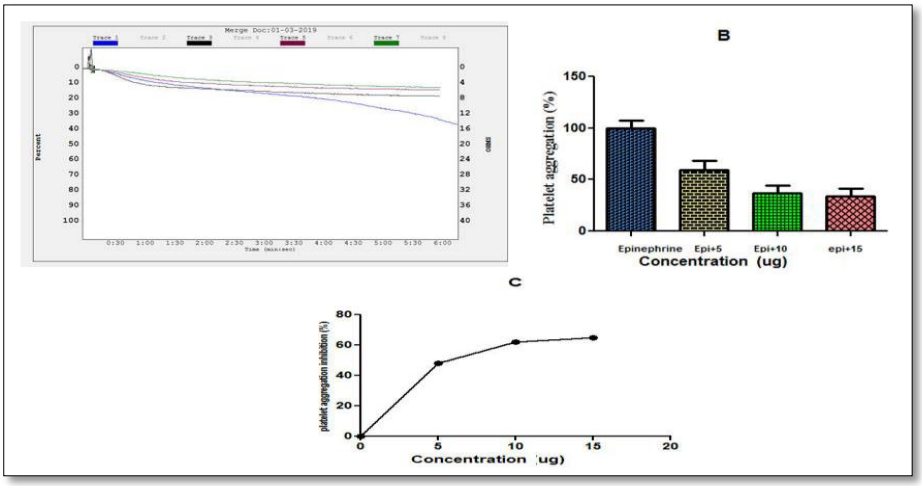
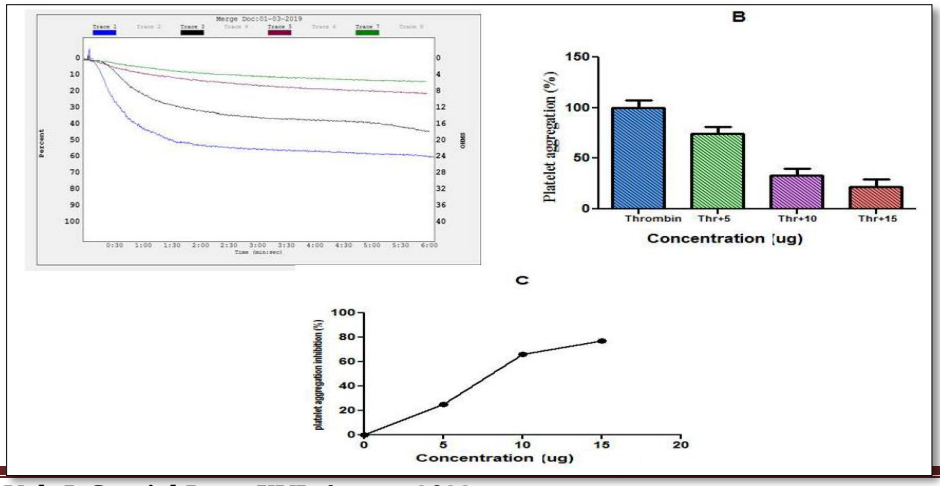


Figure 7 Platelet aggregation was initiated by adding epinephrine as an agonist using washed platelets. (A)Traces of platelet aggregation: Trace 1 (epinephrine 5µM); Trace 2 (epinephrine 5µM + 5µg of MCase); Trace 3 (epinephrine 5 µM + 10µg of MCase); Trace 4 (epinephrine 5µM + 15µg of MCase) The values represent ± SD of three independent experiments. **(B) Dose dependent platelet aggregation %. (C) Dose dependent platelet aggregation inhibition %.**

Figure 8 Platelet aggregation was initiated by adding thrombin as an agonist using washed platelets. (A) Traces of platelet



ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

aggregation: Trace1 (thrombin 1U); Trace 2 (thrombin 1U + 5µg of MCase); Trace 3 (thrombin 1U + 10µg of MCase); Trace 4 (thrombin 1U + 15µg of MCase). The values represent ± SD of three independent experiments. **(B) Dose dependent platelet aggregation %. (C) Dose dependent platelet aggregation inhibition %.**

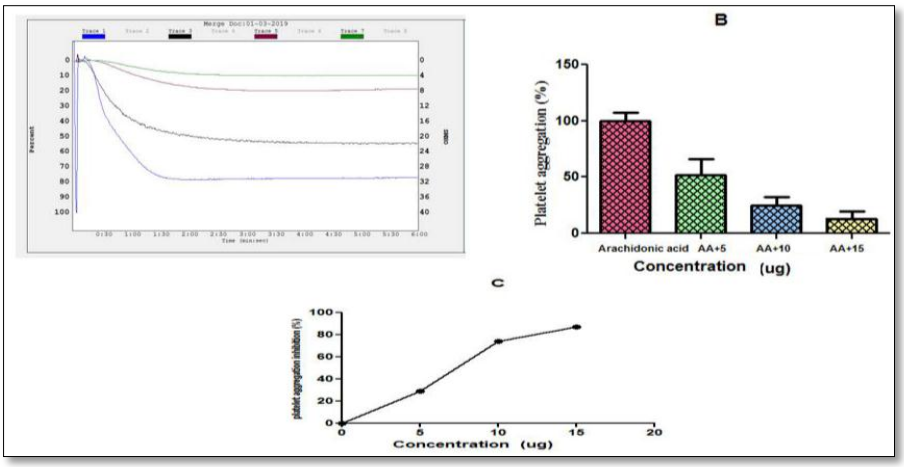


Figure 9 Platelet aggregation was initiated by adding Arachidonic acid (AA) as an agonist using washed platelets. (A)Traces of platelet aggregation: Trace 1 (AA 0.25mM); Trace 2 (AA 0.25mM + 5µg of MCase); Trace 3 (AA 0.25mM + 10µg of MCase); Trace 4 (AA 0.25mM + 15µg of MCase). The values represent ± SD of three independent experiments. **(B) Dose dependent platelet aggregation %.(C) Dose dependent platelet aggregation inhibition %.**

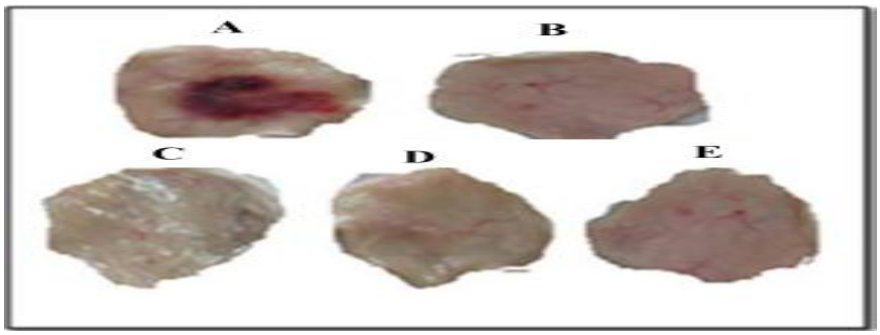


Figure 10 Dose dependent hemorrhagic activity of MCase. A: positive control 2 MDH venom, B: saline C: 25µg, D: 50µg and E: 75µg of MCase was injected independently in to mice in a total volume of 50µlintradermally.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Asia Pacific Journal of Research
A peer reviewed international Journal
IMPACT FACTOR : 6.58
Print -ISSN -2320 - 5504
Online-E-ISSN - 2347 - 4793

INVESTIGATING MECHANICAL AND ACOUSTICAL PROPERTIES OF PVA-NATURAL DERIVATIVE COMPOSITES

Mubarak Khan Pastoni[1], Chethan G.[2], Disha G. Shetty[1], M.R. Maddani[3], Y. Narayana*.[4]

[1]Student, Department of studies in Physics, Mangalore University, Mangalagangothri, Mangalore 574199
[2]Research scholar, Department of Studies in Physics, Mangalore University, Mangalagangothri, Mangalore 574199
[3]Assistant Professor, Department of studies in Physics, Mangalore University, Mangalagangothri, Mangalore 574199
[4]Professor, Department of studies in Physics, Mangalore University, Mangalagangothri, Mangalore 574199

**Corresponding author. Email: narayanay@yahoo.com*

ABSTRACT

In recent days, replacement of synthetic fibres by natural derivatives such as natural fibres in polymeric composites have gained great interest among researchers to manufacture sustainable products. Following this, in present study, Polyvinyl Alcohol (PVA) composites of Coconut Shell Powder (CSP), Areca Husk Fibre (AHF) and Biochar have been synthesised with ratio of 1:10 wt%. The polymer films were prepared using solution casting technique and investigated the mechanical and acoustical properties. The results of tensile test revealed that PVA composites exhibits good tensile strength and acoustical properties of composites of CSP and biochar had good performance above 1000Hz while PVA and composite of AHF had good results below 1000Hz.

Keywords: *Natural derivatives, Polyvinyl Alcohol, Tensile Strength, Acoustics absorber.*

1 Introduction

Over the years, there have been significant developments in the materials that can be utilised for effective sound absorption. However, materials which are inexpensive and light-weight are the most desirable, thereby reducing the structure weight. Amongst them, polymeric composites are seen as potential candidates for sound absortion (Gibson, 2010; Kuang et al., 2017). Moreover, these materials have already found their place in several applications which includes automotive, aerospace, marine, sports, electrical and electronic industries. Researchers are now interested in developing polymer composites of natural derivatives, specifically natural fibres, due to its tremendous environmental benefits (Thakur & Thakur, 2014). The polymer composites of bamboo (Jindal, 1986), coir fibre (Varma et al., 1985), banana (Venkateshwaran & Elayaperumal, 2010) and sisal (Paramasivam & Abdul Kalam, 1974) have been developed earlier and they are enormous applications in many sectors. In addition, studies have been reported on the performance of natural fibres as acoustic absorbers. The coir fibre and oil palm fibre demonstrated good acoustic absorption at higher frequencies rather than at low frequencies (Ayub et al., 2009; Mwaikambo & Ansell, 1999; Ren & Jacobsen, 1993). The sound absorption properties of jute fibre and polypropylene composite were studied which revealed that increase in fiber content favours increase in sound absorption (Shen et al., 2021). Acoustical properties of bamboo fibre have been explored and found to have identical retention with the glass wool (Koizumi et al., 2002). The tea- leaf fibre, produced as an industrial waste, was also investigated for its sound absorption properties (Ersoy & Küçük, 2009).

The present work aims to understand sound absorption and mechanical properties of materials, derived from natural sources, that are largely considered to be agricultural waste. The materials used for the study are coconut shell, areca husk and acacia leaves which are widely abundant in the coastal parts of Karnataka and biochar was obtained from acacia leaves through pyrolysis. Polyvinyl alcohol is used as polymer matrix due to its excellent adhesive properties, water solubility and bio-degradability. The composites were prepared by solution casting method. Later, the mechanical and acoustical properties were measured according to relevant standards.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

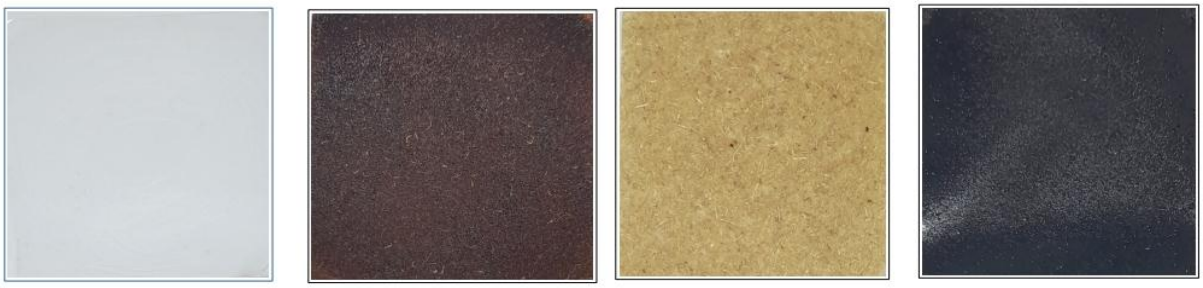
2 Materials and Methods

2.1 Materials

Materials incorporated in this study are polyvinyl alcohol (PVA) solution, Coconut Shell Powder (CSP), Areca Husk Fibres (AHF), Acacia Biochar and distilled water. Dried coconut shells were collected from Udupi, Karnataka. The shells were first cleaned and later ground into fine powder. The powder sieved through a mesh of 0.5mm was used for the study. Fruits of areca were procured from Thirtahalli, Karnataka. The nut and husk were separated by the hand striping method. For the extraction of the fibres, retting process was used (G. Chethan et al., 2022; Nayak & Mohanty, 2019; Sampathkumar et al., 2014). For 140 hours, the collected areca husks were soaked in water after separating from the impurities. The soaking process loosens the fiber from the husks and were extracted manually. After washing through running water, the extracted AHF were kept to dry at 70^{o}C for 24 hours. Later it was cut into small pieces for composite preparation. Acacia leaves are fetched from the local area. Leaves are chopped, demoisturized in hot air oven then heated in muffle furnace at 300^{o}C for 90 minutes. Biochar obtained was ground into fine powder. All the materials (CSP, AHF and biochar) are stored in sealed covers to avoid moisture absorption.

2.2 Preparation of composites

10ml of distilled water is added to clear and viscous solution of PVA and mixed using magnetic stirrer. 1:10 wt% of natural derivatives were added to the solution and stirring continued for another 2 h. The viscous polymer solution was cast into a Petridish and kept in oven for 12 h at 40^{o}C. In addition to three polymer composite films, pure PVA film was also prepared similarly. Figure 1 presents the prepared specimens: PVA, Coco-PVA, AHF-PVA and Biochar-PVA.



a) b) c) d)

2.3 Mechanical test

The PVA composites are tested for their tensile properties with a ZWICK ROELL Z020 Universal testing machine of LOADCELL 100N with the test speed of 10mm/min.

2.4 Sound absorption test

To study the sound absorbing properties of the composites are carried out in a two-microphone impedance tube analyser with ASTM E1050-10 standard. The tests are conducted for a frequency range from 100Hz-2000Hz. The sound absorption coefficient (α) gives the performance of sound absorbing material.

$$\alpha = |1-R^2| \quad (1)$$

$$R = B/A \quad (2)$$

where, α is the sound absorption coefficient, A and B are the reflection and incident amplitudes respectively.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

3. Results and discussion

3.1 Mechanical properties

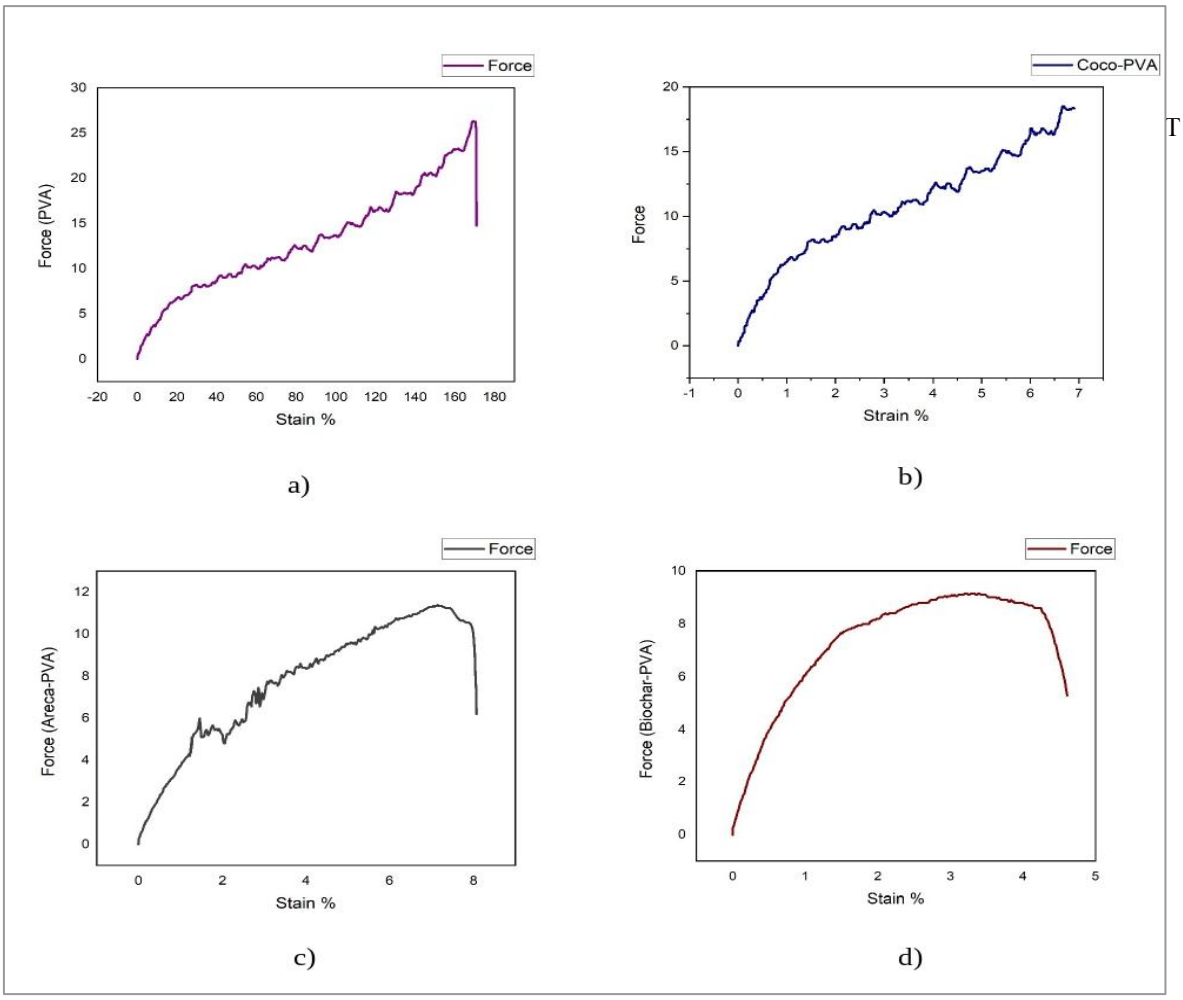


Figure 2: Force (N) vs. Strain curve of the prepared composites, a) PVA, b) Coco-PVA, c) AHF-PVA, d) Biochar- PVA

T

he tensile strength of the prepared specimens is represented in Figure 2. Compared with pure PVA, it can be observed that tensile strength of the composites: coco-PVA, AHF-PVA and biochar-PVA have shown significant decline in the graph. The composites also had lower values of elongation at break than pure PVA. There are various factors that determine the mechanical properties of polymeric composites such as adhesion between fillers and polymer matrix, distribution and dispersion of reinforcing material in the matrix and orientation of filler (Al-Saleh & Sundararaj, 2011). Thus, the decrease in tensile strength could be attributed to the lack of adhesion between fillers and matrix, in addition to the size of filler particles used. Table 1 presents the Young's modulus and tensile strength of the specimens. The Young's modulus of Biochar-PVA composite is greater than other composites indicating that it is stiffer than other specimens. As compared to pure PVA, composites of natural derivative are more stiffer thus rough films are formed.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Table 1. Young's Modulus and Tensile strength of PVA-Composites.

Specimen Name	Young's Modulus	Tensile Strength
PVA	0.341 Pa	32.812 MPa
Coco-PVA	6.880 Pa	16.435 MPa
AHF-PVA	3.321 Pa	14.187 MPa
Biochar-PVA	7.723 Pa	11.437 MPa

The addition of biochar might have resulted in greater disruption of the polymer cross-linking network than the other fillers. In addition, due to hydrophilic nature the biochar the surface became stiff. For the enhancement of mechanical properties, the fillers can be chemically treated to improve adhesion between matrix and fillers (Nayak & Mohanty, 2019; Ramaraj & Poomalai, 2006).

3.2 Acoustic properties

Figure 3 represents the plot of sound absorption coefficient vs. frequency for PVA and its composites of CSP, AHF and biochar. From the figure 3, it is clear that PVA composites of CSP and biochar show better absorption for the frequency greater than 1000Hz. Whilst, pure PVA and composite of AHF show good absorption coefficient below 1000Hz, with absorption coefficient in the range of 0.3 to 0.7 for AHF. Thus, in the lower frequency range (100 Hz-1000 Hz) PVA and PVA-AHF exhibits excellent sound energy absorption when compared to prepared composites of CSP and biochar which gave satisfying results in the higher frequency range (1000 Hz-2000 Hz).

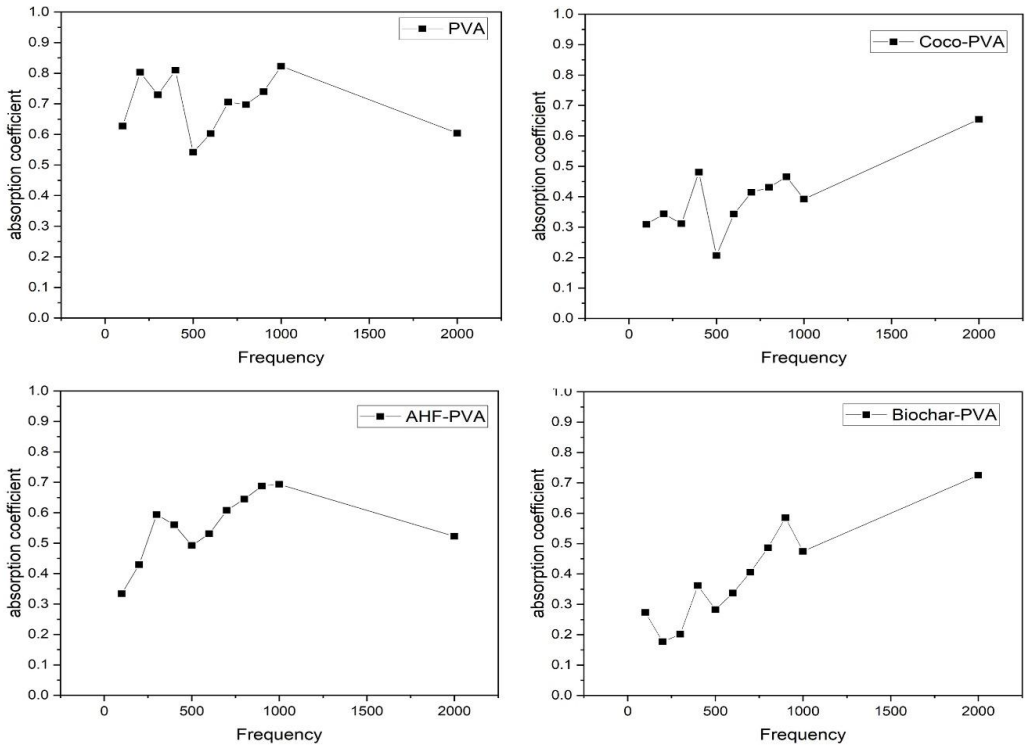


Figure 3: Sound absorption coefficient of prepared specimens

In addition to these results, the PVA-natural derivative composite films shows good mechanical property. However, the Biochar-PVA composite is a stiffer film and AHF-PVA composite shows good elasticity. These composite films can be used as a secondary layer for acoustical absorber to absorb the sound energies.

4 Conclusion

In this study, PVA composites of CSP, AHF, biochar and pure PVA film were manufactured using solution casting technique. The prepared specimens were tested to measure the mechanical and acoustical properties. The addition of natural derivatives has increased the stiffness of the film when compared to pure PVA. Acoustical analysis revealed that the AHF-PVA composite is suitable for lower frequencies (<1000Hz) and composite of CSP and biochar are good for frequencies greater than 1000 Hz.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Acknowledgements

The author gratefully acknowledges KSTePs, VGST, Government of Karnataka for financial support through CISEE scheme.The author acknowledges Dr. Vishwanath T., Department of Material Science, Mangalore University for carrying out tensile test for the prepared specimens.

References

1. *Al-Saleh, M. H., & Sundararaj, U. (2011). Review of the mechanical properties of carbon nanofiber/polymer composites. Composites Part A: Applied Science and Manufacturing, 42(12), 2126–2142. https://doi.org/10.1016/j.compositesa.2011.08.005*
2. *Ayub, M., Nor, M., Amin, N., Zulkifli, R., Hosseini Fouladi, M., & Ismail, A. (2009). Analysis on sound absorption of natural coir fiber using Delany-Bazley model. International Conference on Mechanical Engineering (ICME2009) (26 Dec 2009 - 28 Dec 2009 : Dhaka, Bangladesh), 1–6.*
3. *Ersoy, S., & Küçük, H. (2009). Investigation of industrial tea-leaf-fibre waste material for its sound absorption properties. Applied Acoustics, 70(1), 215–220. https://doi.org/10.1016/j.apacoust.2007.12.005*
4. *G, C., K C, S., & Narayana, Y. (2022). Development and characterization of low thermal conductivity material from reinforced Areca husk fibre composite. Composites: Mechanics, Computations, Applications: An International Journal. https://doi.org/10.1615/CompMechComputApplIntJ.2022043114*
5. *Gibson, R. F. (2010). A review of recent research on mechanics of multifunctional composite materials and structures. Composite Structures, 92(12), 2793–2810. https://doi.org/10.1016/j.compstruct.2010.05.003*
6. *Jindal, U. C. (1986). Development and Testing of Bamboo-Fibres Reinforced Plastic Composites. Journal of Composite Materials, 20(1), 19–29. https://doi.org/10.1177/002199838602000102*
7. *Koizumi, T., Tsujiuchi, N., & Adachi, A. (2002). The development of sound absorbing materials using natural bamboo fibers. High Performance Structures and Materials, 4, 157–166.*
8. *Kuang, T., Chen, F., Chang, L., Zhao, Y., Fu, D., Gong, X., & Peng, X. (2017). Facile preparation of open-cellular porous poly (l-lactic acid) scaffold by supercritical carbon dioxide foaming for potential tissue engineering applications. Chemical Engineering Journal, 307, 1017–1025. https://doi.org/10.1016/j.cej.2016.09.023*
9. *Mwaikambo, L. Y., & Ansell, M. P. (1999). The effect of chemical treatment on the properties of hemp, sisal, jute and kapok for composite reinforcement. Die Angewandte Makromolekulare Chemie, 272(1), 108–116. https://doi.org/10.1002/(SICI)1522-9505(19991201)272:1<108::AID-APMC108>3.0.CO;2-9*
10. *Nan, N., DeVallance, D. B., Xie, X., & Wang, J. (2016). The effect of bio-carbon addition on the electrical, mechanical, and thermal properties of polyvinyl alcohol/biochar composites. Journal of Composite Materials, 50(9), 1161–1168. https://doi.org/10.1177/0021998315589770*
11. *Nayak, S., & Mohanty, J. R. (2019). Influence of chemical treatment on tensile strength, water absorption, surface morphology, and thermal analysis of areca sheath fibers. Journal of Natural Fibers, 16(4), 589–599. https://doi.org/10.1080/15440478.2018.1430650*
12. *Paramasivam, T., & Abdul Kalam, A. P. J. (1974). On the study of indigenous natural-fibre composites. Fibre Science and Technology, 7(2), 85–88. https://doi.org/10.1016/0015-0568(74)90020-7*
13. *Ramaraj, B., & Poomalai, P. (2006). Ecofriendly poly(vinyl alcohol) and coconut shell powder composite films: Physico-mechanical, thermal properties, and swelling studies. Journal of Applied Polymer Science, 102(4), 3862–3867. https://doi.org/10.1002/app.23913*
14. *Ren, M., & Jacobsen, F. (1993). A method of measuring the dynamic flow resistance and reactance of porous materials. Applied Acoustics, 39(4), 265–276. https://doi.org/10.1016/0003-682X(93)90010-4*
15. *Sampathkumar, D., Punyamurthy, R., Bennehalli, B., Patel Ranganagowda, R., & Venkateshappa, S. C. V. (2014). Natural areca fiber: Surface modification and spectral studies. J. Adv. Chem, 10(1).*
16. *Shen, J., Li, X., & Yan, X. (2021). Mechanical and Acoustic Properties of Jute Fiber-Reinforced Polypropylene Composites. ACS Omega, 6(46), 31154–31160. https://doi.org/10.1021/acsomega.1c04605*
17. *Thakur, V. K., & Thakur, M. K. (2014). Processing and characterization of natural cellulose fibers/thermoset polymer composites. Carbohydrate Polymers, 109, 102–117. https://doi.org/10.1016/j.carbpol.2014.03.039*
18. *Varma, D. S., Varma, M., & Varma, I. K. (1985). Coir Fibres II: Evaluation as a Reinforcement in Unsaturated Polyester Resin Composites. Journal of Reinforced Plastics and Composites, 4(4), 419–431. https://doi.org/10.1177/073168448500400406*
19. *Venkateshwaran, N., & Elayaperumal, A. (2010). Banana Fiber Reinforced Polymer Composites - A Review. Journal of Reinforced Plastics and Composites, 29(15), 2387–2396. https://doi.org/10.1177/0731684409360578*

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Asia Pacific Journal of Research
A peer reviewed international Journal
IMPACT FACTOR : 6.58
Print -ISSN -2320 - 5504
Online-E-ISSN - 2347 - 4793

STUDY ON OPTIMIZATION OF PYROLYSIS TEMPERATURE: UTILIZING ACACIA AURICULIFORMIS PHYLLODES AS BIOCHAR.

K S Ashadevi[1], Chethan G[2], M Sahana Rai[3], Yerol Narayana[*4]

[1] Student,Department of studies in Physics, Mangalore University, Mangalagangothri, Mangalore 574199

[2] Research scholar,Department of Studies in Physics, Mangalore University, Mangalagangothri, Mangalore 574199

[3] Student,Department of Studies in Physics, Mangalore University, Mangalagangothri, Mangalore 574199

[4] Professor, Department of Studies in Physics, Mangalore University, Mangalagangothri, Mangalore 574199

**Corresponding author : narayanay@yahoo.com*

ABSTRACT

This paper deals with the optimization of pyrolysis temperature to synthesis biochar from Acacia auriculiformis phyllodes. Acacia auriculiformis is one of the plantational crops which grows extensively to get the quality wood for commercial and domestic fuel purposes . Unlikely, the phyllodes have not been used as much and a slow degradation rate turns it as a biomass. Hence, the pyrolysis process is opted which converts these phyllodes as biochar. In this study, pyrolysis temperature is optimized through Thermogravimetric Analysis (TGA). The crystallinity, chemical composition and variation of pH of synthezised biochar are characterized through X-Ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR) and digital pH meter respectively. The study provides much clearer vision to use Acacia auriculiformis phyllodes biochar in agriculture, super capacitors, semiconductor and waste water treatment applications.

Keywords: *Biochar, Acacia auriculiformis, Pyrolysis, Variation in pH, Phyllodes bochar.*

Introduction:

Amidst 1970-80 Acacia auriculiformis , a plant native to Australia, Indonesia and Papua New Guinea was introduced to India for commercial usage in timber industry, paper industry, furniture manufacturing and as domestic fuel. The species being introduced as a solution for deforestation in early 1970's , instead of a solving the problem, the same had been created a numerous problems . The tree trunk being major source of fuel wood, has high market demands. However, the Acacia auriculiformis phyllodes have no such value and being left out as plantation residue. Low water absorption capacity, slow degradation rate and thickness of the phyllodes causes several environmental problems. The accumulation of these phyllodes prevent the water from reaching the soil surface and over a time period results in reduction of underground water level. These phyllodes neither used in industries nor in household practice nor as compost fertilizer in agriculture sectors.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Figure 1: Deposition of Acacia auriculiformis phyllodes in plantations

The plantation residues are being managed using several methods. The compost method for Acacia auriculiformis phyllodes are not widely used due to their low degrading ability. Pyrolysis, hydrothermal carbonisation, gasification and torrefaction (Meyer, S at al.,2011) are some of the other methods. Out of these, pyrolysis is an accepted method by which the biomass can be converted into a black residue. The pyrolysis can either be slow pyrolysis or fast pyrolysis depending on the biochar requirements. Biochar produced is rich in carbon content (Ahmed Ashfaq et al,2018), with wider applications. Biochar is used in animal feeding (Schmidt H at al.,2019), in building sectors, as insulators due to its low thermal conductivity. It is also employed in decontamination and waste water treatment (Siipola Virpi et al,2020 ; Enaime Ghizlane at al., 2020). Biochar amends soil and enhance its fertility, quality and carbon sequestration (P R Yaashikaa at al.,2020). Since, physical properties of the biochar are directly depended on the pyrolysis temperature. The study optimizes the pyrolysis temperature through thermogravimetric analysis. The Acacia auriculiformis phyllodes are pyrolyzed to convert it as biochar and its crystallinity index, chemical compositions, density and pH variation are studied.

Materials and methods:

a)Materials:

The Acacia auriculiformis phyllodes are collected from Mangalore University, Mangalagangothri campus. The collected phyllodes are washed to remove the dust particle and other impurities followed by de-moisturized in a hot air oven for 24 hours at 110^0C..

Figure 2: Acacia auriculiformis phyllodes green (left) and demoisturized (right)

b) Thermogravimetric analysis (TGA) of Acacia auriculiformis phyllodes:

It is an eminent characterisation during the conversion of Acacia auriculiformis phyllodes into biochar. The Thermogravimetric analysis carried out through the SDT Q600 V20.9 Build instrument .

c) Pyrolysis of Acacia auriculiformis phyllode

Pyrolysis temperature have been optimized through TGA curve The finely cut de-moisturised Acacia auriculiformis phyllode placed inside a ceramic crucible muffle furnace for and placed inside the Muffle furnace for 90 minutes at 300^0C.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

d) Characterisation of Acacia auriculiformis phyllode biochar:

i)X-Ray Diffractometer (XRD):

A Rigaku Miniflex 600 X-Ray Powder Diffractometer with Cu K alpha source of wavelength 1.54A^0 is used to study the X-ray diffraction spectra. The crystallinity index is determined through Segal's method . The 2θ angles ranging from 10^0 to 80^0 is obtained from diffractogram. Segel's equation for crystallinity index is given by

$$\text{Crystallinity Index} = \frac{I_{200} - I_{am}}{I_{200}} \times 100. \qquad (1)$$

I_{002} is the intensity of the peak at 2θ ~22.5 and I_{am} is the intensity at 2θ~18^0 (Thorat N. Meghana & Dastager G. Syed,2018).

ii) Fourier Transform Infrared Spectrometer (FTIR) analysis:

The chemical composition analysis of Acacia auriculiformis phyllodes biochar is carried out using compact FTIR Bruker Alpha Spectrometer. The spectra are obtained for the wavenumber range from 4500cm^{-1} to 500 cm^{-1}.

iii)Density and pH Analysis:

The Acacia auriculiformis phyllode biochar prepared for different temperature is filled in 1750 ml capsule and weighed. The density is calculated using the formula,

$$\text{Density}(g/cm^3) = \frac{m_T - m_c}{V_c} \qquad (2)$$

m_T is the mass of container and biochar .
m_c is the mass of the empty container.
V_c is the volume of the container.

SYSTRONICS, a digital pH meter 335 instrument is used to analyse the pH of Acacia auriculiformis biochar. The instrument is calibrated using buffer solutions of pH 7 and pH 4 . 0.1g of biochar is dissolved in 10ml distilled water and sonicated for 6 minutes using ultra sonicater . The pH of 20 ml distilled water is recorded for every 1ml addition of the prepared solution.

RESULT AND DISCUSSION :

a) Thermogravimetric analysis (TGA) :

The figure 3 demonstrate TGA curve, the phase 1 weight loss occurs between 40.98^{0}C to 89.45^{0}C due to evaporation of moisture and volatile materials. The phase 2 decomposition due to the loss of hemicellulose and cellulose occur between 200^0 C to 600^0 C (Ahmad Ashfaq et al ,2021). The residue is the lignocellulosic components of Acacia auriculiformis

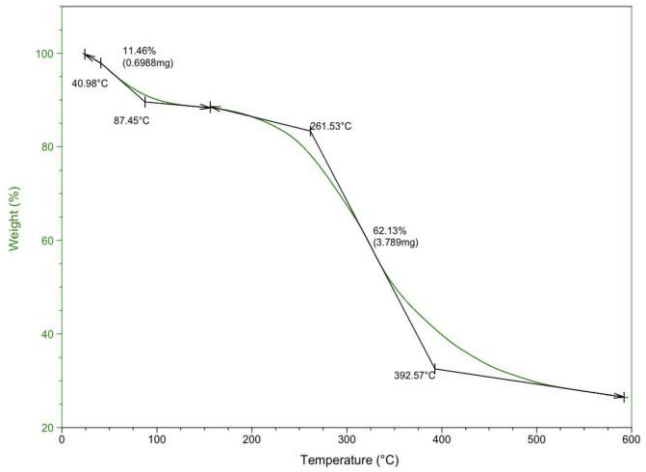


Figure 3: Thermogravimetric Analysis of Acacia auriculiformis phyllode

b) Pyrolysis of Acacia auriculiformis biochar :

According to the TGA analysis, after 330^{0}C the residue may contain mostly for lignin as major component. The Hemicellulose and cellulose components decomposes maximum at the second phase, the loss of cellulose will lead to more amorphous nature to the biochar. Hence, the temperature is restricted to 300^{0}C to control the cellulose decomposition. The pyrolysis of Acacia auriculiformis phyllodes are conducted for 90 minutes at this temperature in muffle furnace. The obtained biochar is grinded to get finer powder and used to analyse the pH and density.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

c) Crystallinity index :

The figure 4 shows X- Ray Diffractogram of pyrolyzed Acacia auriculiformis. The peak associated with cellulose crystalline structure is observed between 18^0 to 24^0. The trace of silicon dioxide is observed at 30^0, 40^0 and 57^0 (E.Rohaeti, Hikmawati , Irzaman , 2010), it may be due to the presence of sand particles in the raw sample. The crystallinity index of the biochar is calculated using Segal's formula and found to be 15.98%.

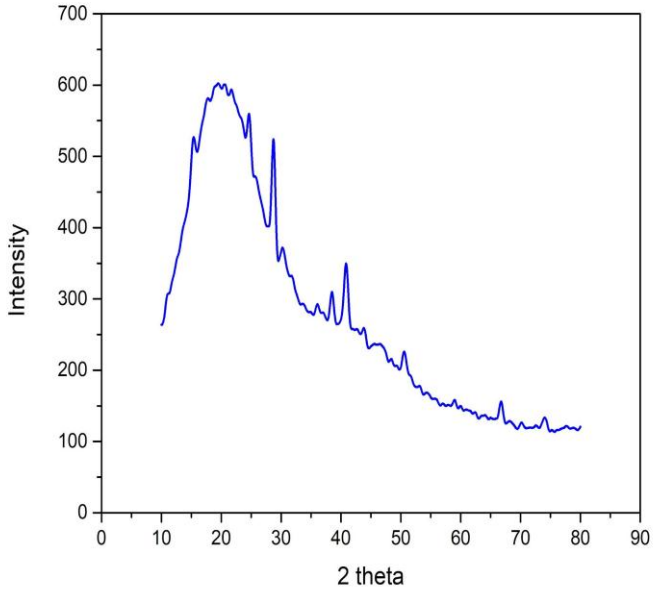


Figure 4: X-Ray Diffractogram of Acacia auriculiformis phyllode biochar

d) Fourier transform Infrared Spectrometer (FTIR) Analysis :

The Chemical composition of pyrolyzed Acacia auriculiformis is as shown in figure 5. The absorption peaks observed in the spectra at 3400cm^{-1} corresponds to O-H bond stretching of aliphatic and phenolic hydroxyl groups (Ahmad Y Elnour et al, 2019). Stretching vibrations of C-H in benzene ring is shown at 3000cm^{-1} and vibration of C-H in aromatic ring at 750cm^{-1}(Yong Cui et al, 2016). The peaks at 1564 cm^{-1}, 1450cm^{-1} , 1150cm^{-1} and 1040cm^{-1} represents C=C stretching of cyclic alkane, C-H bending in methyl group, aliphatic ether and anhydride compound respectively. The stretch from 2960cm^{-1} to 2850cm^{-1} indicates the presence of cellulose, hemicellulose and lignin in precursor. Peaks at 1610cm^{-1} to 1590cm^{-1} indicate C=C stretch in hemicellulose. C-H deformation in cellulose and hemicellulose are noticed from 1480cm^{-1} to 1410cm^{-1} (Md Sumon Reza et al, 2019).

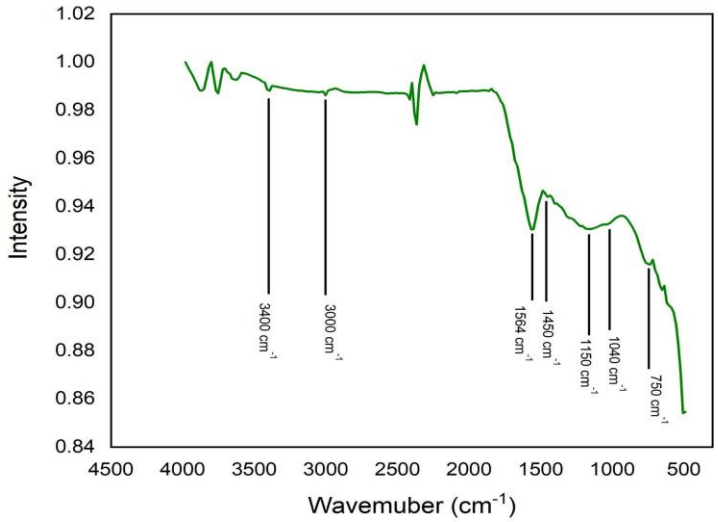


Figure 5 : FTIR spectra of pyrolyzed Acacia auriculiformis phyllode

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

e) Density and pH Analysis:
From equation (2) the calculated density of Acacia auriculiformis phyllode biochar at 300^0C is 0.0857g/cm^3. The figure 6 indicates the variation of pH with every 1ml addition of sonicated biochar solution.

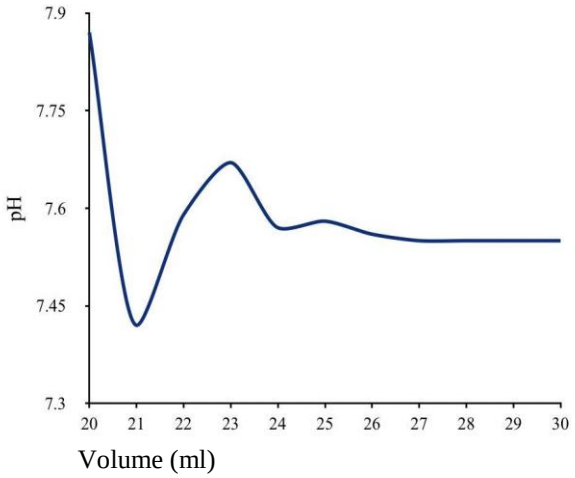


Figure 6: The plot of pH vs Volume(ml)

The pH of 20ml distilled water decreases with addition of 1ml of biochar solution. With further addition the pH varies and becomes saturated with 6ml of sonicated Acacia auriculiformis biochar in 10ml of distilled water. The biochar decreases the pH of the water used.

From the above results the biochar produced from Acacia auriculiformis phyllodes at 300^0C being amorphous in nature has potential application in field of agriculture for reducing green house gasses, mitigating contamination , for soil conditioning and enhancing the animal health. To regulate the humidity and for the reduction of damping in building ,the biochar is mixed with clay along with lime and cement mortar. It's also acts as barrier preventing the pesticides from entering the water surface (Schmidt H P,2012). The biochar also being used in supercapacitors (Qiu Zhipeng et al, 2018), batteries and also for metal reduction. The steps been taken towards the achievement of sustainable future in which biochar will play a major role. The currently applied chemical fertilisers in near future will be completely replaced by the low cost, nutrient enriching biochar. The chemical usage for different carbon based treatments will be reduced by opting the carbon rich biochar. The super capacitors developed using biochar will be used as commercial storage devices.

Conclusion:
This experimental work gives sufficient evidences for the approach taken to sustainably manage the Acacia auriculiformis phyllodes. By analyzing the thermogravimetric analysis, the pyrolysis temperature has been optimized to 300^oC. The pyrolyzed biochar, characterized to investigate the crystallinity, chemical composition and variation in pH concentration. The XRD peak shows the amorphous nature of the biochar with 15.98% crystallinity. The FTIR confirms the presence of lignin and cellulosic compositions in the biochar, the pH variation observed to know the saturation level for 20ml distilled water at pH 7.55.and the density is found to be 0.0854 g/cm^3. The conversion of Acacia Auriculiformis phyllodes into biochar has its potential application in agriculture, water treatment, super capacitors and soil amendment.

Acknowledgment:
With gratitude the author thanks Prof. S. M. Dharma Prakash, Department of studies in Physics, Mangalore University for support in XRD characterisation and Prof. Devendrappa, Department of studies in Physics, Mangalore University for his support in FTIR characterisation.

Reference:

1. *S.Meyer, B. Glaser, P. Quicker, (2011) . "Technical, economical, and climate-related aspects of biochar production technologies: A literature review". Environ. Sci. Technol. 45, 9473–9483.*
2. *Ahmed Ashfaq, Hidayat Syarif, Abu Bakar S. Muhammad, Azad K. Abdul, Sukri S. Rahayu & Phusunti Neeranuch.(2018). " Thermochemical characterisation of Acacia auriculiformis tree parts via proximate, ultimate , TGA, DTG,calorific value and FTIR spectroscopy analyses to evaluate their potential as biofuel resources, Biofuels,doi:10.1080/17597269.2018.1442663.*
3. *H. Schmidt, N. Hagemann , K. Draper , C. Kammann. (2019). " The use of biochar in animal feeding".ISSN:2167-8359.doi:10.7717/peers.7373.*
4. *Siipola Virpi, Pflugmacher Stephan,Romar Henrik, Wendling Laura and Koukkari Pertti,2020.Low- cost Biochar Adsorbents for Water Purification Including Microplastics Removal.doi:10.3390/app10030788.*

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

5. *Enaime Ghizlane , Bacaoui Abdelaziz, Yaacoubi Abdelrani & Lubken Manfred.(2020). " Biochar for Wastewater Treatment - Conversion Technologies and Application".https://www.mdpi.com/2076-3417/10/10/3492.ISSN:2076-3417. doi:10.3390/app10103492*
6. *P Yaashikaa, P Kumar, S Varjani, A Saravanan.(2020). "A critical review on the Biochar production techniques, characterization, stability and applications for circular bioeconomy".ISSN:2215017X. doi:10.1016/j.btre.2020.e00570.*
7. *Thorat N. Meghana & Dastager G. Syed.(2018).High yield production of cellulose by a Komagataeibacter rhaeticus PG2 strain isolated from pomegranate as a new host.doi:10.1039/c8ra05295f.*
8. *Ahmed A, Bakar M.S.A.,Razzaq A, Hidayat S, Jamil F,Amin M N, Suri R S, Shah N S, Park Y-K.2021.charectorization and Thermal Behaviour Study of Biomass from Invasive Acacia mangium Species in Brunei Preceding Thermochemical conversion. https://doi.org/10.3390/su13095249.*
9. *E. Rohaeti , Hikmawati, Irzaman.(2010). "Production of semiconductor materials silicon from silica rice husk waste as alternative silicon sources". https://www.researchgate.net/publication/294086109.*
10. *Elnour Y. Ahmed, Alghyamah A. Abdulaziz, Shaikh M. Hamid, Poulode M. Anesh, Al-Zahrani M. Saeed, Anis Arfat & Al-Wabel I. Mohammad.(2019).ISSN:20763417.doi:10.3390/app9061149.*
11. *Chi Yong, Chang Jianmin & Wang Wenliang.(2016). "Fabrication of Glass Fibre Reinforced Composites Based on Bio- oil Phenol Formaldehyde Resin.ISSN:19961944.doi:10.3390/ma9110886.*
12. *Reza Md. Sumon, Afroze Shammya, Bakar S. A. Muhammad, Saidur Rahman, Aslfattahi Navid, Taweekun Juntakan, Azad K. Abul.(2020). "Biochar Characterization of invasive Pennisetum purpureum grass: effect of Pyrolysis temperature". ISSN:2012909499.doi:10.1001/s42773-020-00048-0.*
13. *Schmidt H P.2012. 55 Uses of Biochar.Ithaca Journal 1/2012:286-289(2012).www.ithaka-journal.net*
14. *Qiu Zhipeng, Wang Yesheng, Bi Xu, Zhou Tong, Zhou Jin, Zahoor Jinping, Miao Zhichao, Yi Weiming, Fu Peng, Zhuo Shuping. 2018.Biochar based carbons with hierarchical micro-meso-macro porosity for high rate and long cycle life supercapacitors, Journal of power sources. Vol 376(2018), pages 82-90,ISSN 0378-7753, https://doi.org/10.1016/j.jpowsour.2017.11.077.*

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Asia Pacific Journal of Research
A peer reviewed international Journal
IMPACT FACTOR : 6.58
Print -ISSN -2320 - 5504
Online-E-ISSN - 2347 - 4793

CONVERSION OF AGRO-WASTE ARECA HUSK TO BIO-CHAR: AN OPTIMIZATION STUDY ON TEMPERATURE.

M. Sahana Rai[1], Chethan G.[2], K. S. Ashadevi[3], Y. Narayana*.[4]

[1]Student, Department of studies in Physics, Mangalore University, Mangalagangothri,Mangalore 574199.

[2]Research scholar, Department of Studies in Physics, Mangalore University, Mangalagangothri,Mangalore 574199.

[3]Student, Department of Studies in Physics, Mangalore University, Mangalagangothri,Mangalore 574199.

[4]Professor, Department of Studies in Physics, Mangalore University, Mangalagangothri,Mangalore 574199.

**Corresponding author. Email: narayanay@yahoo.com*

ABSTRACT

In recent days, the technology has been developing to reuse the disposed waste materials which can cause environmental pollution such as plastic, e-waste, biomass and agro-waste. Areca husk is one among the agro-waste with low decay rate. In this present study, pyrolysis temperature hasbeen optimized to convert areca husk as bio-char. Thermal decomposition characteristics of areca husk has been analyzed through Thermogravimetric analysis (TGA). The pyrolyzed areca husk have been characterized to study the surface morphology by FE-SEM imaging, elemental composition by EDAX, crystallinity index by Segal's method and functional group analysis was done with the help of Fourier Transform Infrared Spectrometer (FTIR). The results have shown that the pyrolysis temperature can be optimized to 250^{o}C and the produced bio-char shows 13.5% crystallinity and 75% carbon deposition. In conclusion, the areca husk bio-char can be used as the carbon source in agriculture sector, super-capacitors and in water treatment.

Keywords: *Areca Husk, Pyrolysis, Bio-char, Biomass, Surface morphology.*

Introduction

Now a days, Science and technology is developing innovative ideas to promote the use of renewable energy and sustainable environment. The waste management is one such field whichis adopting the innovation to resolve the issues regarding disposal and decay. Although, the scientific developments and innovations are yet to be adopted in traditional practices in agriculture and plantation crops. The agriculture biomass or agro-waste management is one such unsolved problem caused either from unscientific agricultural practice or harvesting techniques. Discarded biomass can have a negative impact on nature because when decomposed it releases greenhouse gases like Carbon Dioxide (CO_2), Methane (CH_4), etc. for which proper disposal methods need to be designed. (Tripathi N et. Al., 2019). However, most of the agricultural byproducts are used as a source of fuel and animal feeder. Unlikely, areca husk is beingdiscarded because of its slow degradation rate and wetness. The areca husk constitutes about 60- 80% total weight and volume of the fresh fruit. Ripe, unripe and dry areca fruits are processed according to different cultivation practices of different regions. Mostly dry husk separated from the dried areca fruit is used as a burning fuel. The unmanaged wet husk left in the plantation decomposes very slowly due to high lignin-cellulose composition of areca husk fiber (AHF) and hence causes bad odor and other decay related problems (Srinivasa C.V. et Al., 2011). Several studies on sustainable use of areca husk have been conducted and areca husk finds place in preparations of hard boards, paperboards and cushions (Sheeka Subramani B., et Al., 2019). Despite all these applications, it is not able to utilize the potential of areca husk biomass due to lack of infrastructure and low

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

market demands. Studies show potential utilization of areca husks through thermo-chemical conversion. One such treatment is the pyrolysis method. (Gogoi D., et Al., 2017)

Pyrolysis process is one of the important methods through which can convert areca husk into bio-char. Bio-char is a low cost, carbon rich material which emerges as a carbon material with high potential of application in different fields (Kyu T. T., et Al., 2020). The applications of bio- char include flue gas cleaning, metallurgical applications, heat and power production and gas and water purification. Bio-char has also been used as a soil amendment to improve soil fertility. (Weber K., et Al., 2018). In this study, the pyrolysis temperature for areca husk was optimized through thermogravimetric analysis. The areca husk has been pyrolyzed to obtain bio-char and characterized to investigate the crystallinity and chemical composition analysis of pyrolyzed areca husk was studied using X-ray diffractometer and Fourier transform Infra-red spectrometer. The morphology and elementary analysis of the same was performed by Field effect scanning electron microscope.

Materials and Methods

(a) Materials

The areca husk was collected from GRS farm, Thirthahalli, one of the major areca cultivating areas in the western ghat section of Karnataka, India. The wet husk was washed thoroughly by running water and separated from impurities. The washed husk was placed inside a hot-air oven for 24 hours at 105^0C to remove the moisture content.

(b) Thermogravimetric analysis (TGA) of AHF

TGA is an important characterization in order to obtain the optimization temperature for pyrolysis process. TGA was performed on the SDT Q600 V20.9 Build 20 instrument. Fibers are tested at a rate of 10^0C/min from ambient temperature to 8000C, with a constant nitrogen supply of 100 ml/min.

(c) Pyrolysis of Areca Husk

As per TGA analysis, with the optimum pyrolytic temperature, the pyrolysis treatment was done for two hours at a muffle furnace (Tripathi M., et Al., 2015). The synthesized bio-char was grinded to fine powder and were used to determine its morphology, elementary composition, FTIR and crystallinity.

(1) Study of surface morphology and elemental composition

Field emission scanning electron microscope (FE-SEM) instrument The Carl Zeiss-Sigma IGMA Oxford was used to capture the surface images of the areca husk bio-char. The bio-char is fixed on aluminum stubs by steel tape and coated with gold to make the surfaces conductive, so as to avoid electron charge gathering. The study on elemental composition of pyrolyzed areca husk was carried out through Energy dispersive X-Ray analysis (EDAX).

(3) X-Ray Diffraction of areca husk Bio-char

Crystallinity analysis of synthesized biochar is done through X-Ray Diffraction (XRD) method. The crystallinity index is calculated using equation 1. (Amiralian N., et Al., 2015)Crystalline index $\mathcal{L}$

$$= \left[\frac{I_{200} - I_{am}}{I_{200}}\right] \times 100 \ldots\ldots (1)$$

I_{200} is the diffracted intensity at the maxima (200 planes) peak which represents crystalline and amorphous regions and I_{am} is the diffracted intensity of the amorphous fraction near to maxima.

(4) Chemical composition of areca husk bio-char

Fourier transform infrared spectra were recorded using a SHIMADZU IR Prestige -21 spectrophotometer for wavenumber ranging from 4500 cm^{-1} to 350 cm^{-1} with the resolution of 4 cm^{-1} to study the chemical composition areca husk bio-char.

Results and discussions

(a) TGA of Areca Husk

Figure 1 represents the TGA for AHF. Referring to figure 1, the declination at 60–100^0C is due to initial weight loss de-moisturization, the next stage decomposition at 270-330^0C corresponds to hemicellulose decomposition and cellulose chain breakdown on glycosidic linkage and further slow degradation caused by lignin chain decomposition (Yusriah L., et Al., 2014). As a result of this, the pyrolysis temperature can be optimized to 250^0C. Beyond 300^0C the yield ratio of bio-char to raw husk

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

will be less. Below 270^0C the amount degradation of cellulose will be less. Due to the cellulose decomposition, the expected char will be more amorphous and the presence of lignin controls the ash production while pyrolysis treatment.

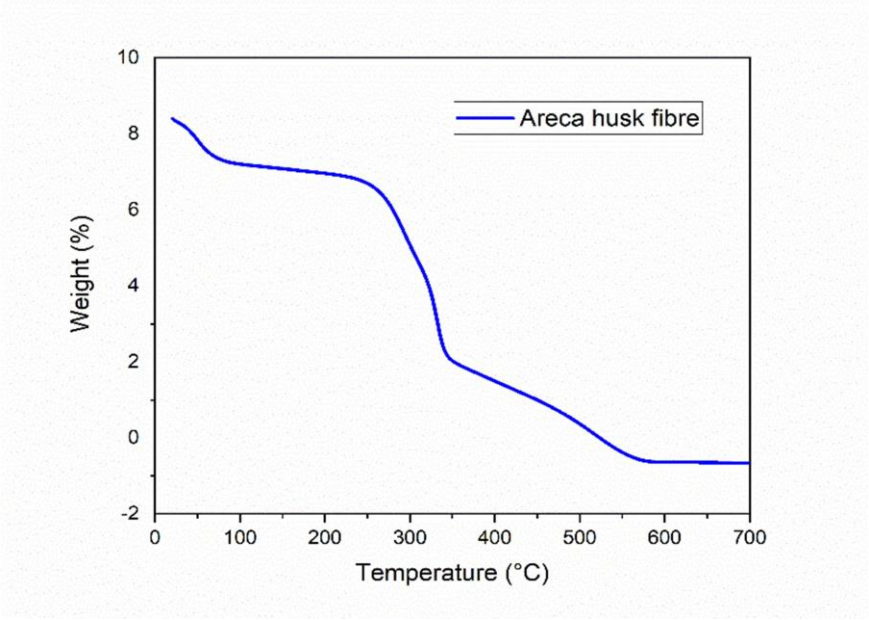


Fig 1: TGA curve of Areca Husk Fiber

(b) Surface Morphology Analysis of Areca Husk Bio-char

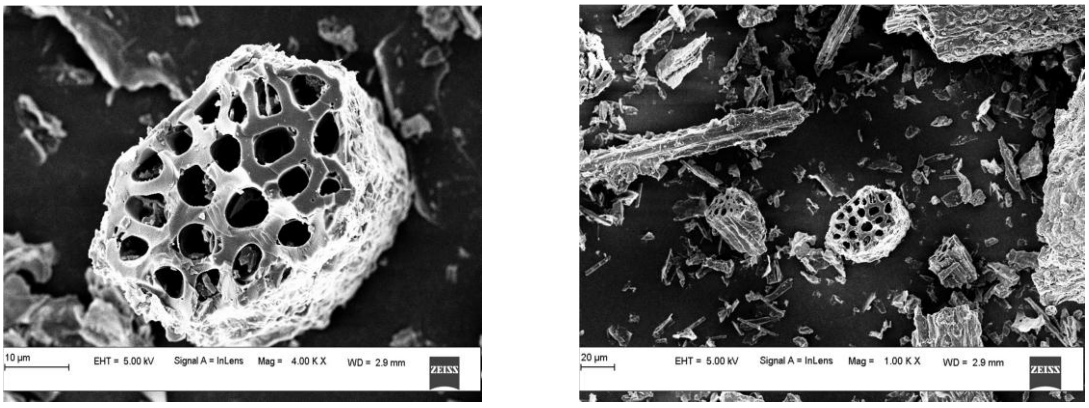


Figure 2: FE-SEM images of pyrolyzed areca husk.

Fig 2 helps to examine the surface and the size distribution of the pyrolyzed areca husk. SEM images of Areca husk bio-char shows well defined pores and smooth wall dense surfaces. The rod like structure or block like structure is char form of areca husk fibre (AHF). The ununiformed amorphous structures are from fruit wall and ash. The structure which looks like honeycomb is likely due to carbonaceous skeleton structures of AHF. (Liang B., et Al., 2006) As the pyrolytic temperature is well within the lignin degradation temperature limit, the lignin structure will remain rigid and the cellulose chain degrades to form the cavities in the fibers. Theporosity of the bio-char increases the water-holding capacity, moisture retention and surface

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

area. The vast size distribution increases the eminent approach to the agricultural application of bio-char.

(c) Elemental Composition

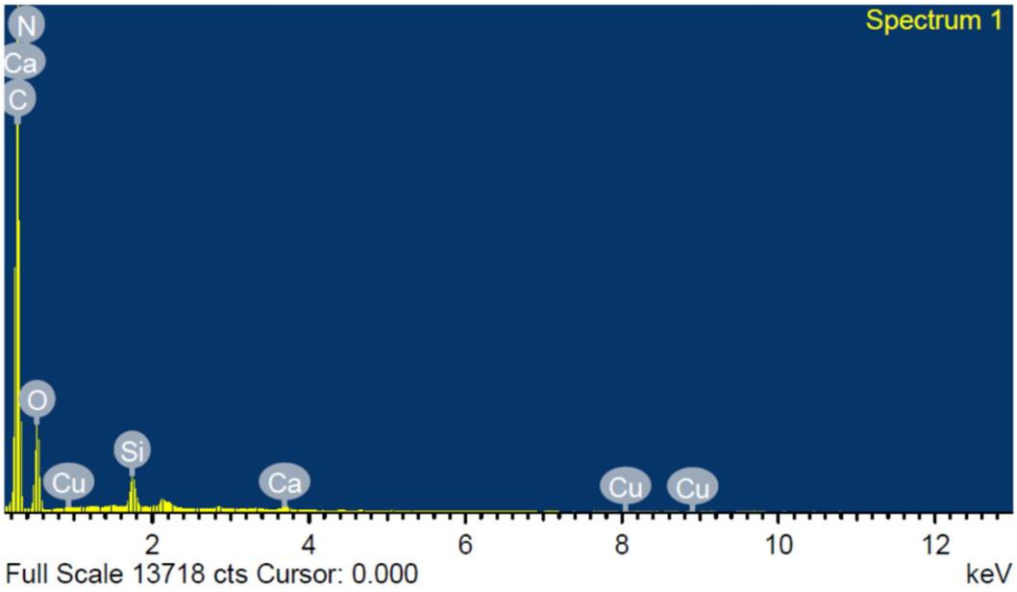


Figure 3: EDAX measurement of pyrolyzed areca husk.

EDAX measurement gave elementary composition of bio-char as shown in figure. The majority of the weight composition of the synthesized char is composed of Carbon(C) followed by Oxygen (O), Silicon (Si), Calcium (Ca) and Copper (Cu). High Carbon deposition has occurred in the form of Coke and carbon dioxide. The raw areca husk contributes a high amount of fixed carbon, the pyrolysis process evinces a greater than 75% of Carbon concentration in the bio-char as shown in table 1.

Table-1: Elementary weight % of Areca husk Bio-char

Elements	**Weight (%)**
Carbon	75.17647
Oxygen	14
Silicon	8.941176
Calcium	1.764706
Copper	0.117647

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

(d) Crystallinity Analysis of areca husk.

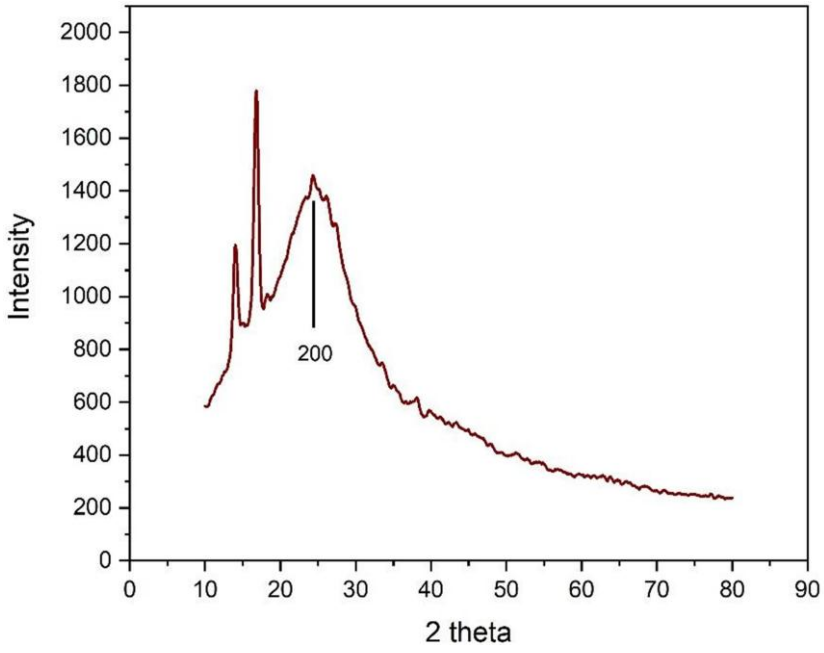


Figure 4: XRD of Areca Husk Bio-char

Figure 4 shows the X-Ray Diffraction pattern of bio-char. The sharp peak for bio-char at 18^{o} and 14^{o} reflects the pattern for Calcium oxide (CaO) crystals (Ramli M., et Al., 2019). Due to the Bordeaux mixture, the Ca was present in the Husk which is the cause of the formation of CaO crystals during the pyrolysis process. The major peak pattern at 22^{0} provides information regarding amorphous carbon present in the bio-char. The crystallinity index is found to be 13.5%.

(e) Fourier Transform IR-Spectra of areca husk bio-char

FTIR spectra for wet areca husk bio-char are given in figure 5. The broad absorption peaks between 3600 cm^{-1} and 3000cm^{-1} decrease the intensity of hydroxyl groups resulting in the loss of O-H bonds in bio-char, this increases the hydrophobicity of pyrolyzed bio-char (Zheng A., et Al., 2012) The peak around 1724 cm^{-1} is due to the presence of carboxylic groups. The sharp absorption peaks near 1590 cm^{-1} and 1060 cm^{-1} confirms the presence of aliphatic chains of lignin and asymmetric stretching of cellulose chains respectively (Gogoi D., et Al., 2017).

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

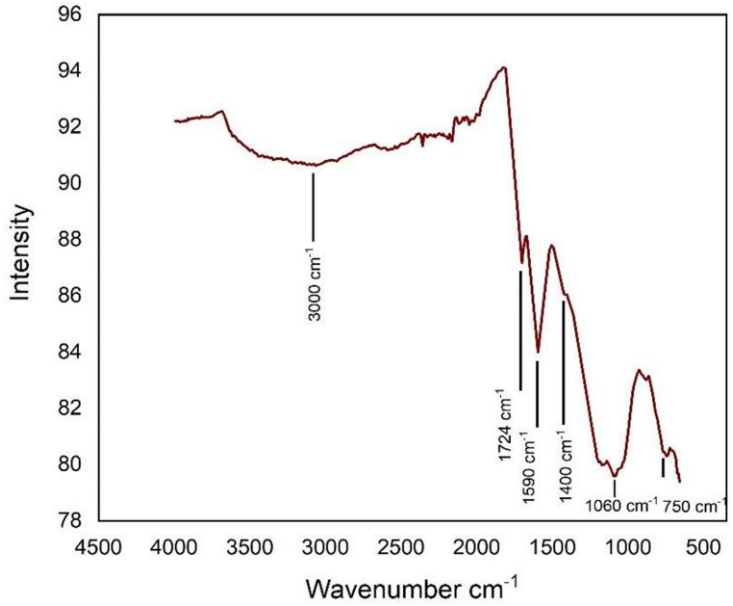


Figure 5: FTIR spectra of Areca Husk Bio-char

The areca husk bio-char exhibits high porosity and high carbon deposition. The XRD pattern shows that the bio-char is amorphous in nature and FTIR confirms the lignocellulose traces. The synthesized bio-char can be used in agriculture sector as carbon source and an agent to increase the soil water retention ability. It also can be used to treat the waste water, in super capacitors, cosmetics and many more. Utilizing areca husk to produce bio-char will be a cost effective, environment friendly act and it will be an appropriate solution to use an agro-waste to useful material.

Conclusion

In this present study, Pyrolysis temperature for areca husk was optimized by thermogravimetric analysis which was found to be 250 ^{0}C. The areca husk bio-char showed high porosity, rich in carbon concentration. The XRD study showed that the areca husk bio-char is amorphous in nature and crystallinity was found to be 13.5%. The FTIR result confirmed the presence of lignocellulose content and hydrophobicity in the bio-char.

Reference

(1) *Tripathi N., Hills C. D., Singh R. S., & Atkinson C. J. (2019). Biomass waste utilisation inlow-carbon products: harnessing a major potential resource. Npj Climate and AtmosphericScience, 2(1), 35, . https://doi.org/10.1038/s41612-019-0093-5*

(2) *Srinivasa C. V., Bharath K. N. (2011). Impact and Hardness Properties of Areca Fiber-Epoxy Reinforced Composites. Srinivasa and Bharath, 351-356, 2(4)*

(3) *Sheeka Subramani B., Shrihari S., Manu B., & Babunarayan K. S. (2019). Evaluation ofpyrolyzed areca husk as a potential adsorbent for the removal of Fe2+ ions from aqueoussolutions. Journal of Environmental Management. 246, 345–354.https://doi.org/10.1016/j.jenvman.2019.04.122*

(4) *Gogoi D., Bordoloi N., Goswami R., Narzari R., Saikia R., Sut D., Gogoi L., & Kataki R.(2017). Effect of torrefaction on yield and quality of pyrolytic products of arecanut husk:An agro-processing wastes. Bioresource Technology. 242, 36–44. https://doi.org/10.1016/j.biortech.2017.03.169*

(5) *Kyu T. T., Lwin T., Min M., Aye M., & Maung Y. M. (2020). PREPARATION AND CHARACTERIZATION OF SELECTED BIOCHAR FROM BIOLOGICAL WASTES. In J. Myanmar Acad. Arts Sci (Vol. 2).*

(6) *Weber K., & Quicker P. (2018). Properties of biochar. Fuel, 217, 240–261. https://doi.org/10.1016/j.fuel.2017.12.054*

(7) *Tripathi M., Sahu J. N., & Ganesan, P. (2016). Effect of process parameters on productionof biochar from biomass waste*

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

through pyrolysis: A review. In Renewable and SustainableEnergy Reviews(Vol. 55, pp. 467–481). Elsevier Ltd. https://doi.org/10.1016/j.rser.2015.10.122

(8) *Amiralian N., Annamalai P. K., Memmott P., & Martin D. J. (2015). Isolation of cellulosenanofibrils from Triodia pungens via different mechanical methods. Cellulose, 22(4), 2483–2498. https://doi.org/10.1007/s10570-015-0688-x*

(9) *Yusriah L., Sapuan S. M., Zainudin E. S., & Mariatti M. (2014). Characterization of physical, mechanical, thermal and morphological properties of agro-waste betel nut (Arecacatechu) husk fibre. Journal of Cleaner Production, 72, 174–180. https://doi.org/10.1016/j.jclepro.2014.02.025*

(10) *Liang B., Lehmann J., Solomon D., Kinyangi J., Grossman J., O'Neill B., Skjemstad J. O., Thies J., Luizão F. J., Petersen J., & Neves E. G. (2006). Black Carbon Increases Cation Exchange Capacity in Soils. Soil Science Society of America Journal, 70(5), 1719–1730. https://doi.org/10.2136/sssaj2005.0383*

(11) *Ramli M., Rossani R. B., Nadia Y., Darmawan T. B., Febriani Saiful, & Ismail Y. S. (2019). Nanoparticle fabrication of calcium oxide (CaO) mediated by the extract of red dragon fruit peels (Hylocereus Polyrhizus) and its application as inorganic–anti- microorganism materials. IOP Conference Series: Materials Science and Engineering, 509,012090. https://doi.org/10.1088/1757-899X/509/1/012090*

(12) *Zheng A., Zhao Z., Chang S., Huang Z., He F., & Li H. (2012). Effect of Torrefaction Temperature on Product Distribution from Two-Staged Pyrolysis of Biomass. Energy & Fuels, 26(5), 2968–2974. https://doi.org/10.1021/ef201872y*

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Asia Pacific Journal of Research
A peer reviewed international Journal
IMPACT FACTOR : 6.58
Print -ISSN -2320 - 5504
Online-E-ISSN - 2347 - 4793

FLORISTIC STUDY OF RIVERINE ISLANDS (KUDRU'S) OF MULKI, D.K, KARNATAKA

Pratheeksha[1] Ajith Kumar S.B.[2] Krishna Kumar .C[3]

[1] Assistant Professor, Poornaprajna College Udupi, pratheekshakotian16@gmail.com , Tel.: +91 8548073396 (M).

[2] Assistant Professor, Nehru Memorial College Sullia, ak5785604@gmail.com, Tel: +91 7899571590 (M)

[3] Professor, Department of Applied Botany, Mangalore University, Mangalagangothri, kkgtaxo13@gmail.com , Tel: +91 9449330901(M)

ABSTRACT:

Floristic study refers to the variety and variability of plants present in the given region. A floristic study documents all the plant species found within a specific geographical area Mangroves are one of the unique ecosystems with rich and diverse species of flora and fauna, not found elsewhere. A 'Kudru' is one of important mangrove/riverine ecosystem; located on the banks of river Shambavi at Mulki town of coastal Karnataka between 13.1°N latitude and 74.8°E longitudes spread over 0.5-2 sq. km. The present investigation has been carried out during the pre-monsoon, monsoon and post-monsoon seasons between 2015 and 2019, to understand the floristic diversity & impact of human habitations on this fragile ecosystem and the possible ways to rehabilitate the rare and threatened plant species of the area. The results revealed that a total of10 true mangrove species of 5 families, 15mangrove associate species of 10 families, 5 coastal plants of 5 families and 34 other plant species were recorded during the study. Awareness was created among the local communities for the need of the mangrove ecosystem and was involved in conservation of the endangered species.

Key words: Kudru, mangroves, ecosystem, monsoon, endangered.

Introduction:

The most beautiful features of the earth are Biodiversity & most dynamic creature present on earth is plants. The plants are health of the ecosystem and wealth of the country. The Human being is intimately dependent on plant resources. India is a big country covering wide diversity in environmental and biogeographically condition which lead to the development of a wide range of vegetation types **(Champion and Seth, 1968)** and represents a very rich flora including a large number of endemic species **(Chatterjee, 1940; Nayar, 1980; Reddy *et al*., 2002).**

Floristic study refers to the variety and variability of plants present in the given region **(Christy and Binu, 2020).**A floristic study documents all the plant species found within a specific geographical area. Large-scale floristic projects involve development of keys, detailed descriptions, and illustrations of the plants. Small scale floristic projects produce a simple list of species found in an area.

Mangroves, a unique ecosystem seen along the estuaries or backwater of the tropics and sub tropics, are also considered to be one of the most fragile ecosystems in the world. The mangrove ecosystem occurs at the interface of land and sea. They are very well known for their wide adaptations to the extreme harsh conditions prevailing in the marine environment they thrive. They possess wide range of morphological and physiological peculiarities seen nowhere else in the plant kingdom **(Hutchings & Saenger, 1987)**

Mangrove species/flora is classified into two types, namely "truemangroves" and "associate mangroves". True mangroves are those which have physiologically adapted for saline environment, possess vivipary. **Tansley and Fritsch (1905)** first introduced the criteria to classify mangrove species in Ceylon into true mangroves and mangrove associates (semi-mangroves). **Tomlinson (1986)** used fairly rigid criteria to distinguish true mangroves from mangrove associates. Tomlinson's

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

criteria gave a very 'clear' standard to classify true mangroves and mangrove associates and it has been accepted widely **(Duke, 2006; Kathiresan and Bingham, 2001; Lacerda *et al.*, 2002; Parani *et al.*, 1998; Saenger, 2002; Wang *etal.*, 2003)** and most taxa have been classified clearly **(Parani *et al.*, 1998; Saenger, 2002).**

The word "kudru" refers to small patches of Islands lies nearby Estuaries/backwaters. These are the land masses formed in a river due to the deposition of silt and sediments by the river. Such three kudru's located in-between Mulki and Hejamadi village of Dakshina Kannada and Udupi district, where Shambhavi and Pavanje river meats Arabian Sea. They are namely "Chennaya kudru", "Nadi kudru" (of Udupi district) and "chandrashanu Bhogara kudru" (Dakshina Kannada). They lie between the co-ordinates 13.1 degree north and 74.8 degree east at an altitude of 7m, spreads across about 1.8 sq.km.

Location and Physiography:

Dakshina Canada district lies in the coastal region of Karnataka between the north latitudinal parallels of $12^{o}27'$ and $13^{o}11'$ and east longitudinal parallels of $74^{o}46'$ and $75^{o}40'$ occupying the area 4,861 sq.km. Surrounded by the Arabian Sea in the west and Udupi in the north-west. Mulki is a town located in D.K on the southern banks of Shambhavi River. Coordinates $13.1^{o}N$ and $74.8^{o}E$. Udupi district located at coordinates $13.3^{o}N$ and $74.74^{o}E$ about$68.23km^{2}$. Hejamadi is a village in the Udupi district located on the north banks of river shambhavi.

Climate & soil:

The climate is generally said to be wet-monsoon type as the south-west monsoon winds cause very high rainfall over the coastal areas. The year may be divided into three distinct seasons, summer during March-May, rainy season from June-October and the winter from November- February.The top soil layer fount in an estuary or salt marsh or in riverine islands is composed of peat or salt crust. In dense areas with higher concentrations of organic material, this layer will contain under composed plants and sea animals. The drying swamps marshy areas show's soil with high concentration of salts.

Vegetation:

Mangroves are the dominant vegetation in the study area. *Rhizophora mucronata* Lam. show's thick formation. Other than the angiosperms; *Acrostichum aureum* L., *Enteromorpha intestinalis* (L.) Nees (macro algae) and *Psilotum nudum* (L.) P.Beauv (lower pteridophyte) is present commonly. In coastal sand; *Canavalia rosea* (Sw.) DC., *Ipomoea pes-caprae*(L.) R.Br., *Scaevola taccada*(Gaertn.) Roxb., is present as natural flora. Due to the anthropogenic activity such as land filling, the species like *Desmodium heterocarpum* (L.) DC., *Antidesma ghaesembilla* Gaertn. are also present.

Fig 1: Mangrove swamp.

Fig 2: Marshy area covered by *Fimbrystylis spp.*

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Fig 3: Shambavi River.

Fig 4: *Rhizophora mucronata* Lam. Formation.

Fig 5: Salt deposition in drying swamps

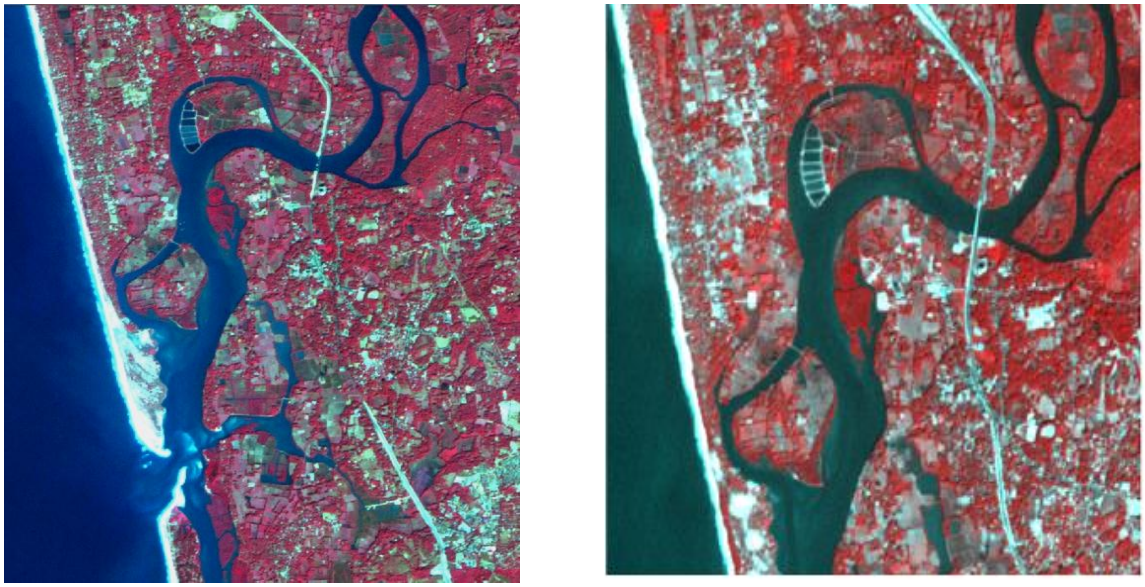


Fig 6: Vegetation covers of Study area

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Review of Literature:

Mangrove has been variously defined in literature. The oxford dictionary mentioned the word 'Mangrove' since 1613, indicating tropical trees or shrubs found in coastal swamps with tangled roots that grow above the ground. The term mangroves refer to an ecological group of halophytic plant species which is known as the salt tolerant forest ecosystem. The Americans, the Spanish, and the Portuguese used the term 'Mangle' and 'Mangue' indicating trees and shrubs of the genus *Rhizophora* **(Mepham & Mepham, 1984).**

They form an inter-phase ecosystem between land and sea along the tropical and subtropical coastline of 128 countries and territories **(Spalding *et al*., 2010).** According to **Tomlinson (1986),** mangroves constitute taxonomically diverse angiosperm plants exhibiting a set of physiological adaptations. **Li and Lee (1997)** used the term 'True mangrove' and 'Semi-mangrove'. 'Mangrove associate' was the advanced term used by many authors for the herbaceous, sub-woody and climber species occupying both mangrove habitat and its surrounding peripheral regions (**Watson, 1928**; **Chai, 1982**).Most recently, **Spalding *et al*. (2010)** used the term 'Core mangroves' for the species that dominates most of the mangrove communities.

The mangrove cover in India was estimated to be 6,740km2 which was only 7% of the total world mangroves **(Krishnamurthy *et al*., 1987)**. Total 69 species true mangroves of belonging to 27 genera and 20 families reported from Tamilu Nadu, India **(Selvam & Karunagaran, 2004)**. Phytosociological analysis of mangroves of Kannur District reveals that the 12 species under 9 genera belonging to 7 families. Rhizophoraceae represented maximum genera of 4 species **(Vidyasagaran and Ranjan, 2011).**

Roa and Suresh (2001) reported ***Avicennia alba* Blume.** as widely present all over the Karnataka coast. In the back waters of the river like Mulki, Udyavara hole, Swarna and Sita nadi mangrove formation of ***Avicennia officinalis* L., *Bruguiera gymnorrhiza* (L.) Lam., *Cerbera odollum* Gaertn. *Exoecaria agallocha* L., *Kandelia candel* (L.)Druce, *Sonneratia alba* Sm.** were reported by **Bhat (2003).**Nine true mangroves of six families and ten associated species of nine families were recorded from Kundapura district of Udupi **(Kumar and Kumara, 2012).**

While reviewing the literature available no exclusive works on floristic studies of mangroves have been undertaken in the study area. There also been various threats observed with respect to the fragile mangrove ecosystem in the study area due to construction of roads, bridges etc. The present study undertaken to document the mangrove species and to conserve endangered species in the study area.

Materials and Methods:

The present investigation has been carried out during the pre-monsoon, monsoon and post-monsoon seasons between 2017-2019. The identification of plants was made from fresh specimens and macroscopic features have been used. For identification of species Flora of presidency of madras (**Gamble, 1915-1935)** and Flora of South Canara (**Bhat, 2014**) is used. Field visit done weakly once and herbarium of each specimen are done by using 4% formalin **(Santapau, 1955, Fosberg and Sachet, 1965; Jain, 1977).** Photographs of each species are taken by SLR camera. List of species and photographs are provided. Remote sensing were used to know the mangrove vegetation cover of the study area. False colour composite IRS-Satellite image included.

Result and discussion:

The present study shows there is **64** plant species of **33** families. In that **10 true mangrove** species of **5** families, **14 mangrove associate** species of **10** families, **5 coastal plants** of **5** families and **35** other plant species.Other than the angiosperms ***Acrostichum aureum* L., *Psilotum nudum* (L.) P.Beauv., *and Entiromorpha intestinalis* L.** present in study areaAll the three Islands are rich in mangrove species because of inflow of the sea water in to the Island regularly. There was no mangrove distraction seen in the year of 2017 but there is slight mangrove distraction observed in 2018-2019 because of human habitation, sea wall construction, bridge construction and shrimp culture.

Table 1: List of True mangroves

SL. NO.	FAMILY	SPECIES
1	Acanthaceae	*Acanthus ilicifolius* Linn.
2	Acanthaceae	*Avicennia officinalis* L.
3	Acanthaceae	*Avicennia marina* (Forssk.) Vierh.
4	Rhizophoraceae	*Rhizophora mucronata* Lam.
5	Rhizophoraceae	*Bruguiera gymnorrhiza* (L.) Lam.
6	Rhizophoraceae	*Bruguiera cylindrica* (L.) Blume.
7	Rhizophoraceae	*Kandelia candel* (L.) Druce.
8	Primulaceae	*Aegiceras corniculatum* (L.) Blanco
9	Euphorbiaceae	*Excoecaria agallocha* L.
10.	Lythraceae	*Sonneratia alba* Sm.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Table 2: Mangrove associate

SL.NO.	FAMILY	SPECIES
1.	Cyperaeae	*Cyperus javanicus* Houtt.
2.	Cyperaeae	*Cyperus malaccensis* Lam.
3.	Cyperaeae	*Fimbristylis ferruginea (L.)* Vahl
4.	Cyperaeae	*Eleocharis geniculata* (L.) Roem. & Schult.
5.	Poaceae	*Sporobollus verginicus* (L.) Kunth
6.	Typhaceae	*Typha domingensis* Pers.
7.	Amarylidaceae	*Crinum viviparum* (Lam.) Ansari & Nair
8.	Lamiaceae	*Clerodendrum inerme* R. Br.
9.	Lamiaceae	*Premna serratifolia* L.
10.	Malvaceae	*Thespesia populnea* (L.) Sol.ex.Correa
11.	Apocyanaceae	*Cerbera odollum* Gaertn.
12.	Fabacae	*Derris trifoliata* Lour.
13.	Fabacae	*Derris scandens* (Roxb.) Benth.
14.	Fabacae	*Caesalpinia crista* L.

Table 3: Other plant species

SL. No.	FAMILY	SPECIES
1.	Convolunaeae	*Ipomoea pes-caprae* (L.) R. Br.
2.	Convolunaeae	*Ipomoea cairica* (L.) Sweet.
3.	Fabaceae	*Canavalia rosea* (Sw.) Dc.
4.	Fabaceae	*Canavalia cathartica* Thouars
5.	Fabaceae	*Desmodium heterocarpum (*L.*)* DC.
6.	Fabaceae	*Crotalaria verrucosa* L.
7.	Fabaceae	*Crotalaria pallida* Aiton
8.	Fabaceae	*Crotalaria retusa* L.
9.	Cyperaeae	*Eleocharis dulcis* (Burm.f.) Trin.
10.	Cyperaeae	*Cyperus difformis* L.
11.	Cyperaeae	*Lipocarpha gracilis* (Rich.) Nees.
12.	Colchicinaceae	*Gloriosa superba* L.
13.	Commelinaceae	*Commelina benghalensis* L.
14.	Commelinaceae	*Cyanotis cristata* (L.) D. Don
15.	Commelinaceae	*Murdannia nudiflora* (L.)Brenan
16.	Amaryllidaceae	*Crinum asiaticum* L.
17.	Hypoxidaceae	*Curculigo orchioides* Gaertn.
18.	Campanulaceae	*Sphenoclea zeylanica* (L.) L.
19.	Rubiaceae	*Ixora coccinea* L.
20.	Rubiaceae	*Hydrophylax maritime* L.f.
21.	Goodoniaceae	*Scaevola tacada* (Gaertn.) Roxb.
22.	Boraginaceae	*Heliotropium indicum* L.
23.	Plantanginaeae	*Scoparia dulcis* L.
24.	Lauraceae	*Cassytha filiformis* L.
25.	Santalaceae	*Santalum album* L.
26.	Amaranthaceae	*Celosia argentea* L.
27.	Phyllanthaceae	*Antidesma ghaesembilla* Gaertn
28.	Euphorbiaceae	*Euphorbia hirta* L.
29.	Malvaceae	*Hibiscus surattensis* L.
30.	Malvaceae	*Melochia corchorifolia* L.
31.	Muntingiaceae	*Muntingia calabura* L.
32.	Balsamaceae	*Impatiens minor* (DC.) Bennet.
33.	Myrtaceae	*Syzygium caryophyllatum* (L.) Alston
34.	Astraceae	*Launaea sarmentosa (Willd) Sch.Bip.*
35.	Astraceae	*Eclipta prostrata* (L.) L.
36.	Asteraeae	*Epaltes divaricata* (L.). Cass.
37.	Astraceae	*Sphaeranthus africanus* L.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

38.	Linnaceae	*Hugonia mystax* Cav.
39.	Azoiaceae	*Sesuvium portulacastrum* (L.)L.
40.	Vitaceae	*Cayratia trifolia* (L.) Domin

Conclusion:

The present study shows there is **64** plant species of **33** families. In that **10 true mangrove** species of **5** families, **14 mangrove associate** species of **10** families, **5 coastal plants** of **5** families and **35** other plant species. All the three Islands are rich in mangrove species because of inflow of the sea water in to the Island regularly. There was no mangrove distraction seen in the year of 2017 but there is slight mangrove distraction observed in 2018-2019 because of human habitation, sea wall construction, bridge construction and shrimp culture. Even though there is slight distraction mangroves are rich in these islands comparing with other tidal forests of Dakshina kannada.

Photographs of True Mangroves:



Fig 7: *Acanthus ilicifolius* Linn. Fig 8: *Avicennia officinalis* L. Fig 9: *Avicennia marina* (Forssk.) Vierh.



Fig 10: *Rhizophora mucronata* Lam. Fig 11: *Bruguiera gymnorrhiza* (L.) Lam. Fig 12: *Bruguiera cylindrica* (L.) Blume.



ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Fig 13: ***Kandelia candel*** **(L.) Druce. Fig 14:** ***Aegiceras corniculatum*** **(L.) Blanco. Fig 15:** ***Excoecaria agallocha*** **L.**



Fig 16: ***Sonneratia alba*** **Sm. Fig 17**: ***Acrosticum aureum*** **L. Fig18:** ***Acanthus ilicifolius*** **L.**

Photographs of Mangrove associates:



Fig 19: ***Cyperus javanicus*** **Houtt. Fig20:** ***Cyperus malaccensis*** **Lam. Fig 21:** ***Fimbristylis ferruginea*** **(L.) Vahl.**

Fig 22: ***Typha domingensis*** **Pers.** **Fig 23:** ***Crinum viviparum*** **(Lam.) Ansari & Nair**


Fig24: ***Clerodendrum inerme*** **R. Br** **Fig25:** ***Premna serratifolia*** **L.**

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Fig 26: *Thespesia populnea* Sol. Ex. Correa

Fig 27*: Cerbera odollum* Gaertn.

Fig 28: *Derris trifoliata* Lour.

Fig 29: *Derris scandens* (Roxb.) Benth

Fig 30: *Caesalpinia crista* L.

References:

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

1. Bhat, K.G. (2003). *Flora of Udupi*. Indian Naturalist, Udupi.
2. Bhat, K.G. (2014). *Flora of South Kanara (Dakshina Kannada and Udupi Districts of Karnataka)*. Indian Naturalist, Udupi.
3. Chai, P.P.K. (1982) Ecological studies of mangrove forest in Sarawak. PhD thesis, Universiti Malaya.
4. Champion, H.G., & Seth, S.K. (1968). *A Revised Survey of the Forest Types of India*. Government of India Press, Delhi, India.
5. Chatterjee, D. (1940). Studies on the Endemic Flora of India and Burma. *Journal of the Asiatic Society of Bengal*, 5, 19-67.
6. Christy, A., & Thomas, B. (2020). Phytodiversity of chasmophytic habitats at Olichuchattam Waterfalls, Kerala, India. *Journal of Threatened Taxa*, *12*(9), 16099-16109.
7. Duke, N. C. (2006). *Australia's mangroves: the authoritative guide to Australia's mangrove plants*. MER.
8. Fosberg, F. R., & Sachet, M. H. (1965). Manual of Tropical Herbaria (Regnum Vegetabile 39). *International Bureau for Plant Taxonomy & Nomenclature*, Utrecht, Netherlands.
9. Gamble, I.S., &Fischer, C.E.C. (1915-1935). *Flora of the Presidency of Madras*. Adlard and Son.
10. Hutchings, P., & Saenger, P. (1987). Ecology of mangroves. *Ecology of mangroves.*
11. Jain, S. K. (1977). *Handbook of field and herbarium methods*. Today and Tomorrow Printers & Publishers, New Delhi.
12. Kathiresan, K., & Bingham, B. L. (2001). Biology of mangroves and mangrove ecosystems.
13. KM, V. K., & Kumara, V. (2012). Diversity of true mangroves and their associates in the Kundapura region, Udupi district, Karnataka, Southwest coast of India. *Current Botany*, *3*(2).
14. Krishnamurthy, K., Chaudhary, A., and Untawale, A. G. 1987. Mangroves in India: Status Report. Govt. of India, Ministry of Environment and Forests, New Delhi. pp 150.
15. Lacerda, L. D., Conde, J. E., Kjerfve, B., Alvarez-León, R., Alarcón, C., & Polanía, J. (2002). American mangroves. In *Mangrove ecosystems* (pp. 1-62). Springer, Berlin, Heidelberg.
16. Li, M. S., & Lee, S. Y. (1997). Mangroves of China: a brief review. *Forest Ecology and Management*, *96*(3), 241-259.
17. Mepham, R. H., & Mepham, J. S. (1985). The flora of tidal forests—a rationalization of the use of the term 'mangrove'. *South African Journal of Botany*, *51*(2), 77-99.
18. Nayar, M. P. (1980). Endemic flora of Peninsular India and its significance. *Nelumbo-The Bulletin of the Botanical Survey of India*, 22(1-4), 12-23.
19. Parani, M., Lakshmi, M., Senthilkumar, P., Ram, N., & Parida, A. (1998). Molecular phylogeny of mangroves V. Analysis of genome relationships in mangrove species using RAPD and RFLP markers. Theoretical and Applied Genetics, 97(4), 617-625.
20. Rao, T.A., & Suresh, P.V.(2001). *Coastal ecosystems of the Karnataka State, India-I. Mangroves.* Karnataka Association for the Advancement of Sciences, Central College, Bangalore.
21. Reddy, C. S., Murthy, M. S. R., & Dutt, C. B. S. (2002). Vegetation diversity and endemism in Eastern Ghats, India. *In Proceedings of National Seminar on Conservation of Eastern Ghats, EPTRI, Hyderabad*, 109-134.
22. Saenger, P. (2002). *Mangrove ecology, silviculture and conservation*. Springer Science & Business Media.
23. Santapau, H. (1955). *Botanical collector's Manual-A Handbook.* Govt. Press, New Delhi.
24. Selvam, V., Eganathan, P., Karunagaran, V. M., Ravishankar, T., & Ramasubramanian, R. (2004). Mangrove Plants of Tamil Nadu. *MS Swaminathan Research Foundation, Chennai, India, 56pp*.
25. Spalding, M. (2010). *World atlas of mangroves*. Routledge.
26. Tansley, A. G., & Fritsch, F. E. (1905). Sketches of vegetation at home and abroad. I. The flora of the Ceylon littoral. *New Phytologist*, *4*(1), 1-17.
27. Tomlinson, P. B. (1986). the Botany of Mangroves Cambridge University Press London.
28. Vidyasagaran, K., Ranjan, M. V., Maneeshkumar, M., & Praseeda, T. P. (2011). Phytosociological analysis of Mangroves at Kannur district, Kerala. *International journal of environmental sciences*, *2*(2), 671.
29. Wang, Y., Bonynge, G., Nugranad, J., Traber, M., Ngusaru, A., Tobey, J., & Makota, V. (2003). Remote sensing of mangrove change along the Tanzania coast. *Marine Geodesy*, *26*(1-2), 35-48.
30. Watson, J. G. (1928). Mangrove forests of the Malay Peninsula. *Malayan forest records*, *6*.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Asia Pacific Journal of Research
A peer reviewed international Journal
IMPACT FACTOR : 6.58
Print -ISSN -2320 - 5504
Online-E-ISSN - 2347 - 4793

ETHNOVETERINARY PRACTICES IN TURUVEKERE TALUK OF TUMAKURU DISTRICT, KARNATAKA STATE, INDIA.

SUDHAMA. V. N.

Department of P.G. Studies in Botany, I.D.S.G. Government College,
Chikkamagaluru -577102, Karnataka, India.
Corresponding author: E-mail: sudhamavasi@gmail.com

ABSTRACT

Ethnoveterinary practices include the use of local medicinal plants to prevent, cure or treat various ailments in animals. It can be considered as traditional knowledge, which is used for the well-being of animals. The present study 15 practitioners were met and discussed about their traditional knowledge for treating bovines and medicinal value that is under conservation with the help of local peoples. Present study divulges that 45 medicinal plants belonging to 42 families were used by traditional practitioners for curing common cattle diseases and ailments like bone fracture, infertility, constipation, retention of placenta, broken horn etc. From this study it was concluded that acute life threatening infections and epidemics, modern medicine such as antibiotics and anti-Helminthic will remain the first choice but for common and chronic conditions like skin disease, wound, diarrhoea, ephemeral fever etc. Ethno veterinary medicines remain the choicest and healthy treatment.

In addition, the current trend of rising pharmaceutical demand in India and elsewhere has led to an unscientific and excessive exploitation of plant resources. Therefore, it is crucial to chronicle empirical knowledge of medicine and sustainable use of plant resources in addition to conserving these native species of medicinal plants.

***Key words**: Ethnoveterinary, practitioners, bovine disease, herbals, Turuvekere.*

1. INTRODUCTION

In Indian agriculture, livestock play an important role in the farmer's life. They provide farm power, rural transportation, manure, fuel, milk, and meat, but they also play a significant role in the rural economy by providing income and employment to farmers and members of the underprivileged sections of society [1].

Ethno veterinary medicine was practiced as early as 1800 B.C. at the time of King Hamurabi of Babylon who formulated laws on veterinary fees and charged for treating cattle and donkeys [2]. In ancient time hunting gathering life style was closely associated with wild animals and at the same time, there is a rich and efficient ethno veterinary traditional exist in the villages of India [3]. They comprise of belief knowledge, practices skills pertaining to health care and management of livestock. Therefore, it is essential that this precious traditional knowledge be carefully documented from elderly and experienced tribal practitioners before it is lost forever [4].

Ethnobotanical studies divulge that the indigenous knowledge of a community is a key player in the identification of medicinal plants and such plants have been often tested by generations of indigenous people [5]. Ethnoveterinary medicines are used extensively and quite effectively for primary health care treatment to make domestic animals productive and healthy [6, 7]. For certain common diseases and more chronic conditions such as skin diseases, worms, wounds, reproductive disorders, and mild diarrhoea, ethno veterinary medicine has much to offer and can be a cheap and readily available alternative to costly imported drugs. The search for alternatives is especially important [8].

Recognition of ethno veterinary practices in this region and their documentation is necessary for creating new herbal-based treatments. Thus, the present study was carried out to gather traditional knowledge from the animal keepers of different age and education status.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

2. MATERIALS AND METHODS

2.1 Study area: The study was conducted in Turuvekere Taluk in Tumakuru district of Karnataka state, India. Turuvekere is located in 13°10'N 76°40'E / 13.16°N 76.67°E.

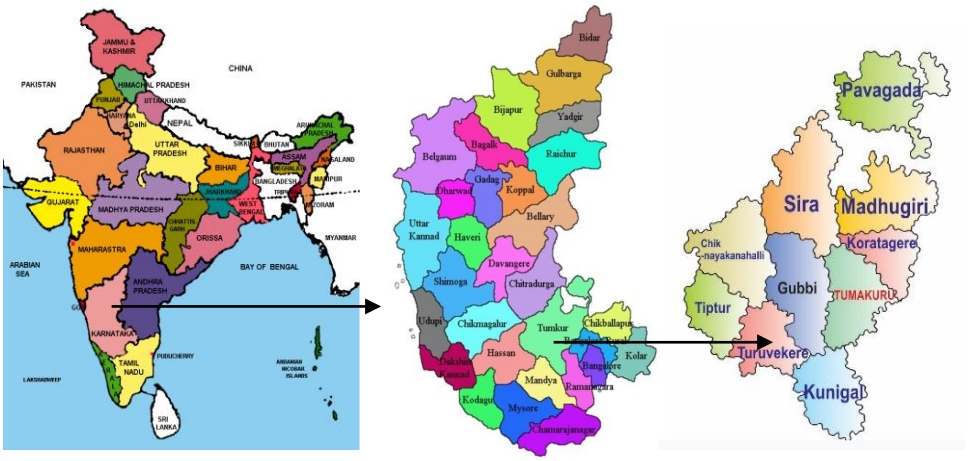


Figure 1. Study area showing the map of India, Karnataka State and Tumakuru District including Turuvekere taluk

2.2 Topography, Climatic conditions and Vegetation of the area

The forests are widely varying in their formation and growth they contain highly valuable known and unknown medicinal plants the vegetation consist of a grasses and group cover which serve to bind the soil, the dry thorny scrub and deciduous forest spread over the areas of Turuvekere Taluk. The temperature of Turuvekere varies from in between 27°C to 38°C and Average humidity of minimum 20%, Maximum 36% and annual rainfall ranges from 600mm to 900mm.The soil is of black mixed red having average water percolation.

2.3 Methodology

The ethno medicinal information was collected through a semi-structured questionnaire by interview with the traditional herbal healers and knowledgeable elders in their local language in the study area to gather the traditional knowledge on curing bovine diseases. The response include details about the botanical and common names of the plants used, mode of treatment, methods of drug preparation (decoction, paste, powder, juice or direct plant parts), dosage and duration and types of administration, were documented by interacting with them as well as through direct observations, the information's regarding the curing of cattle and poultry diseases using plants were collected.

The plants which are used to cure the diseases and so many ailments were collected during the survey by wandering with the medicine practitioners who knows the plants very well; the identity of collected specimens was confirmed by the valid literature and floras [9, 10, and 11]. Prepared herbarium specimens were deposited in the Department of Botany I.D.S.G. Govt. College Chikkamagaluru, Karnataka.

3. RESULTS

Fifteen traditional Ethno-veterinary practitioners in the age group 47-87 years were interviewed during survey. They informed about the availability of herbal plants in present day compared to olden days and their ecological status. After each interview the interviewed person were requested to show the medicinal plants they informed, the medicinal plants shown by them were collected and photographed.

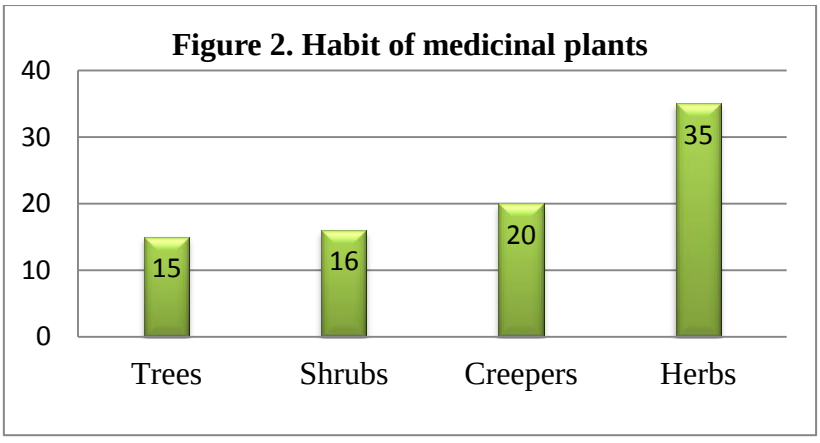
The Ethno veterinary practices in Turuvekere Taluk enlightenment us that 85 species belonging to 42 families. About 28 species (32%) were collected from cultivated and 58 species (67%) collected from wild land. Among them maximum number of plants belonged to herbs with 35 species followed by 20 species of creepers, 16 species of shrubs and the remaining 15 species were trees (Figure- 2). Different parts of plants used in the formulation to treat diseases of animals; leaves account for 51% followed by 12% of fruits, 10% of roots, whole plants and seeds 9% each, 6% of barks, 3% of stems, bulb and rhizomes each 2% (Figure- 3).

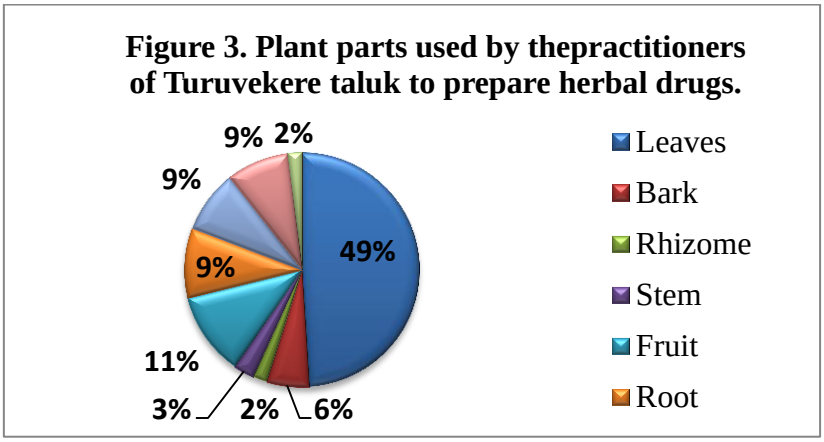
Practitioners treat dysentery, fever, foot and mouth disease, skin disease, joint dislocation, swelling of udder, poisonous bite, throat cancer, horn fracture, retention of placenta, internal and external parasites, Joint swelling, pneumonia, Haemorrhage etc. Local people are highly dependent on the herbal remedies of Ethno veterinary medicine. The different Ethno veterinary practices have been documented (Table-1) which they commonly used to treat their animal against various diseases. Medicines are prepared in the form of juice, powder, decoction and paste, while majority of them are in combination with other plant parts and animal products like butter milk, cow dung, cow milk etc.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Table 1: List of ethnomedicinal plants used against different diseases treated by traditional practitioners of Turuvekere taluk.

Sl. No.	Disease(s) treated	Binomial of Plant(s) used
1.	Skin allergy	*Azadiricta indica* A.Juss, *Curcuma longa* auct. non L. *Aloe vera* (L.) N. Burman
2.	Retention of placenta	*Raphonus sativus* L., *Abelmaschus esculenta* (L.) Moench, *Saccharum officinarum* L.
3.	Insect control	*Azadiricta indica* A.juss, *Aristolochai indica* L.
4.	Swelling of udder	*Commelina latifolia* Hochst. ex A.Rich., *Kickxia sparia* (L.) Dumort., *Coleus amboinicus* Lour.
5.	Poisonous bite	*Citrullus colocynthis* (L.)Schrader
6.	Diarrhoea	*Ferula jaeschkeana*. Ver, *Swertia chirayatchirayita* (Roxb.ex Flem.)
7.	Leucorrhea	*Celiosia argentea* L.
8.	Bone fracture	*Dodonaea viscosa* (L.) Jacq.
9.	Alapecia areata	*Cyanthillium cinereum* (L)H Rob, *Sesamum indicum* L.
10.	Horn fracture	*Pterocarpus marsupium* Roxb.
11.	Hoematochezia in goats	*Tylophora indica* (N.Burman) Merr.
12.	Foul pox in poultry	*Curcuma longa* auct. non L., *Azardirachta indica* A. Juss.
13.	Pneumonia	*Euphorbia hirta* L., *Xanthium strumarium* L.
14.	Rheumatic diseases in goats	*Hemidesmus indicus* (L.) R.Br., *Sesamum indicum* L.
15.	Pink eye	*Albizia amara* (Roxb.) Boivin
16.	Swelling of shoulder	*Phyllanthus nirusis* auct. non L., *Azima tetracantha* Lam.
17.	To enhance milk production	*Leucaena leucocephala* (Lam.) de Wit, *Sida rhombifocia* L.
18.	Constipation	*Acacia sinuta* (Lour.) Merr.





ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

4. DISCUSSION

According to the study, different villages use different combinations of medicinal plants to treat illnesses. For instance, in Doddagoraghatta village, traditional healer Thimmappa used albergine fruit to treat infertility, while Venkatayya of Chimanahalli used coconut inflorescence and tender coconut. To enhance milk production Mallikarjun and Puttagangamma of Kurubarahalli used broad beans and coconut, whereas in the village of Harikaranahalli they used jumbay and sida leaves.

In the present study for the treatment of accidental wound, the healers used eucalyptus oil alone whereas Lakshminarayana [12] reported the use of *Terminalia chebula* and *Garuga pinnata* bark paste is applied topically on the wound for healing. Swelling of udder in cattle is cured by applying paste made by *Aloe vera* pulp with two spoons of turmeric powder, lemon juice and castor oil. Similar studies conducted in Andhra Pradesh for the treatment of udder edoema in cattle mentioned the use of Musa sp. inflorescence that is burned into ashes and used with cow ghee [12].

According to Mahalingayya leg fracture in cattle is cured by Switch borel leaf tied to the fracture part. Similar problem is cured by applying *Polygonum* leaves on brokened legs and tied the fractured part with gunny bag coated with boiled paddy husk and raagi flour then covered the area with bamboo sticks [13]. For the treatment of Hemorrhage the healer Ramalingayya used *Ficus religious* leaves whereas the same plant used against fever [13].

In the present study for the treatment of wound in goat the healer used *solanum nigrum* root and bark whereas same plant leaves and fruits used to cure fever in cattle reported by Vaishnavi Venugopalan *et al*. *Tylophora indica* plant is used to treat lack of appetite reported by Ramachandra Naik *et al.*, Similarly same plant used to treat hoematochezia in the present study by Venkatayya chimmanahalli[14].

Bhimmanna, Siddanahatti used Vitex *negunda* plant leaves smoke is used to control ectoparasites infection. Harsha [15] reported same plant used against poisonous bite. In the current study, *Azardirachta indica* bark, leaves, and fruit are used to treat sheep pox, skin allergies, and insect-related wounds in goats, same as Varshneya is used to treat various diseases in cattle, sheep, and poultry.

Retention of Placenta can be treated by using *Raphanus sativus, Albelmoschus esculenta, Sacchrum officinarum* and other practitioners use *Mimosa pudica* leaves paste. Sri Balaji and Vikrama Chakravarthi [16] reported that feeding bamboo leaves or a mixture of oil bran and bajra grain to treat retention of placenta.

5. CONCLUSION

The Ethno-veterinary medicinal plant species were collected with the help of local people from the surrounding areas, forests and are being used as remedies for various bovine ailments. The documentation of ethno-veterinary medicinal plant surveys is crucial to the discovery of potentially life-saving treatments for a variety of veterinary ailments. The current study listed 86 plants from 42 families having 35 different Ethno veterinary uses.

The rural inhabitants of Turuvekere Taluk have a traditional medical system for treating a variety of diseases in domestic animals. Therefore, it is essential for the younger generation's sustainable use of natural resources to preserve this elder generation's traditional wisdom. The majority of the ingredients utilised in ethnoveterinary techniques were readily accessible in homes or close by environments. These elements are largely derived from the wild. This put a great deal of strain on the forest resources in other areas.

Further research focusing on these plants might give information regarding the bioactive compounds to fight diseases in an effective manner. The documentation of each knowledge play an important role in framing the health policies for the people in other regions can make use of it. Other local Communities need support and encourage protecting their knowledge and resources. It is necessary to conserve the threatened medicinal plants from extinction and to document the plants information before disappearing.

REFERENCES

1. *Verma, R. K. (2014). An ethno botanical study of plants used for the treatment of livestock diseases in Tikamgarh District of Bundelkhand, Central India. Asian Pacific Journal of Tropical Biomedicine, 4(1), S460-467.*
2. *Schillhorn van Veen, T.W. (1997). Sense or nonsense? Traditional methods of animal parasitic disease control, Veterinary Parasitology, 71 (2-3), 177-194.*
3. *Sannigrahi, S., Majumder, U. K., Pal, D. K., Mishra, S. L. and Maity, S. (2011). Flavonoids of Enhydra Fluctans Exhibits analgesic and anti-inflammatory activity in different animal models. Pakistan Journal of Pharmaceutical Sciences, 24 (3), 369-375.*
4. *Sikarwar, R. L. S., & Vivek Kumar (2005). Ethnoveterinary knowledge and practices prevalent among the tribals of central India. Journal of Natural Remedies, 5(2), 147-152.*
5. *Cox, P.A. (2000). Will tribal knowledge survive the millennium? Science, 287, 44–45.*
6. *Kumar, D. (2002). The use and relevance of ethnoveterinary practices in sheep. Indian Journal of small ruminants, 8(2), 124-128.*
7. *Constance McCorkle, Evelyn Mathias and Tjaart W Schillhorn van Veen. (1996). Ethnoveterinary research and development, Intermediate Technology Publications, London.*
8. *Parashurama, T.R., & Kavyashree, S. (2017). Ethno-Veterinary Health Care Plants in Jagalur Taluk of Davangere District, South India. International Journal of Science and Research, 4(6), 2963-2971.*

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

9. *Gamble, J. S. (1967). The Flora of Presidency of Madras, Second reprinted ed., Botanical Survey of India, Calcutta, 1: 1-408.*
10. *Gamble, J. S. (1967). The Flora of Presidency of Madras, Second reprinted ed., Botanical Survey of India, Calcutta, 2: 409-942.*
11. *Gamble, J. S. (1967). The Flora of Presidency of Madras, Second reprinted ed., Botanical Survey of India, Calcutta, 3: 943-1389.*
12. *Lakshminarayana, V., & Narasimha Rao, G. M. (2013). Ethnoveterinary practices in North Coastal District of Andhrapradesh, India. Journal of Natural Remindies, 13(2), 109-117.*
13. *Raveesha, H.R., & Sudhama, V.N. (2015). Ethnoveterinary Practices in Mallenahalli of Chikmagalur Taluk, Karnataka.* Journal of Medicinal Plants Studies, 3, *37-41.*
14. *Ramachandra Naik, M., Vaishnavi Venugopalan., Preethi Kumaravelayutham and Krishnamurthy, Y.L. (2012). Ethnoveterinary uses of medicinal plants among the Lambani community in Chitradurga district, Karnataka, India. Asian Pacific Journal of Tropical Biomedicine, S470-S476.*
15. *Harsha, V. H., Shripathi, V and Hegde, G. R. (2005). Ethno Veterinary practices of in Uttara Kannada district of Karnataka. Indian Journal of Traditional Knowledge, 4(3), 253-258.*
16. *Sri Balaji, N., & Vikrama Chakravarthi, P. (2010). Ethnoveterinary Practices in India – A Review. Veterinary World, 3(12)-549-551.*

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Asia Pacific Journal of Research
A peer reviewed international Journal
IMPACT FACTOR : 6.58
Print -ISSN -2320 - 5504
Online-E-ISSN - 2347 - 4793

REVIEW ON THE DIVERSITY AND DISTRIBUTION OF FRESHWATER CRABS OF THE WESTERN GHATS, INDIA

Divyashree G. Naik[1] and Krishna M. P.[2]

[1] Department of Zoology, Vivekananda College of Arts, Commerce and Science (Autonomous), Puttur- 574203. Karnataka, India. Email Id: dshree100@gmail.com

[2] Department of Zoology, F M K M Cariappa Mangalore University College, Madikeri- 574201. Karnataka, India - mkmpkrishna@gmail.com

ABSTRACT

Western Ghats are one of recognised biodiversity hotspots which show highest endemism for Crustaceans, Amphibians, Reptiles, Aves and much more. Nearly 60% (75/125) of the freshwater crabs were documented in the Western Ghats regions with approximately 70% endemism species. Henceforth a systematic review related to the diversity and distribution of freshwater crabs of Western Ghats was undertaken. In this article, the diversity and distribution of the freshwater crabs in the Western Ghats Regions have been reviewed. The distribution of the freshwater crabs will vary on different types of microhabitats and altitudes. The conservation is very crucial matter for the freshwater crabs because they depend on microhabitats which are destroyed in the name of development and lack of awareness. It is very important to study the diversity, distribution of the freshwater crabs to conserve and classify them on the basis of their availability. Freshwater crab conservation is critical since the bulk of the Western Ghats crab species are either 'Data Deficient' (36%) or have not been evaluated for their conservation status (50%) by the IUCN.

Key words: Diversity, Distribution, Western Ghats, Conservation.

Introduction

Out of 6,700 crab's species, approximately 1,300 are Brachyuran crabs in world (Yeo, et al., 2008). True freshwater crabs are those that have adapted to living in freshwater, semi-terrestrial, or terrestrial environments and are distinguished by their capacity to complete their life cycle without relying on the marine environment. They are assigned to eight exclusively freshwater Families- Pseudothelphusidae and Trichodactylidae (Mexico, Central and South America), Potamonautidae (Africa and Madagascar), Deckeniidae and Platythelphusidae (East Africa), Potamidae (North Africa, southern Europe, Asia), Gecarcinucidae (Seychelles, Asia), and Parathelphusidae (Asia, Australasia) (Martin and Davis, 2001).

Freshwater crabs are generally nocturnal, omnivorous and scavengers who eat predominantly plant materials, but some are opportunistic carnivores who eat live food like fish and prawns (Ng, 1988), and cannibalism is prevalent, this behaviour increases with higher density and declines with low density. Many species of fish, birds, caimans, turtles, and mammals rely on crabs for sustenance (Ng, 1988; Magalhaes, 2003).

Numerous euryhaline species or secondary freshwater species from predominately marine brachyuran groups have been reported in freshwater crabs (e.g., Sesarmidae, Varunidae, Hymenosomatidae). Although these freshwater animals are perfectly suited to live in both freshwater and on land, most do not have direct development in their life cycle, and most have one or more larval phases.

Distribution

Some crabs, such as potamids, are completely adapted to living in fresh water and are not thought to be able to survive in salt water for long periods of time, while others, such as parathelphusids, are more tolerant of saline conditions and can survive immersion in salt water for short periods of time. Terrestrial organisms can be found far from permanent freshwater sources due to travelling through the forest floor litter or even climbing trees in some situations (Ng, 1988; Ng and Tay, 2001; Cumberlidge, *et al*., 2005). These freshwater crab species do not need to be immersed in fresh water on a regular basis and can get water via diet, drinking dew or random water, or capillary or osmotic uptake from moist substrata. Such species are also categorised as ''freshwater-dependent'' species.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Freshwater crabs distributed from clear, fast-flowing mountain streams to slow lowland rivers and streams, as well as peat and freshwater swamps, stagnant ponds and rice fields, and even pools in tree holes and leaf axils. Many of them have evolved to live in caves. The Western Ghats' freshwater crabs may be found from low-lying regions to high mountain summits (2472m above sea level). *Barytelphusa cunicularis, Snaha escheri, Travancoriana granulata, Travancoriana schirnerae, Vanni nilgiriensis, V. pusilla,* and *Vela pulvinata* are among the seven species that live over 2000 metres. *Travancoriana granulata* and *Vanni pusilla* are only found at high elevations (1708–2472 m) (Pati and Sharma, 2013; Roux, 1931; Bott, 1970; Bahir and Yeo, 2007 and Rajesh, *et al.,* 2017).

Diversity of Freshwater crabs in Western Ghats

Currently, India is the only home to almost 63 percent of genera (22/35 genera) and 86 percent of species (107/125 species) of freshwater crabs. Western Ghats is home for 75 species. Similarly, the Western Ghats crabs have a high level of endemism, with 67 percent of genera (12/18 genera) and 70 percent of species (52/75 species) being endemic (Pati and Pradhan 2020; Pati and Thackeray, 2018; Klaus, *et al.,* 2014; Pati, *et al*., 2016, 2013, 2014; Kumar, *et al*., 2017; Roux, 1931; Bahir and Yeo, 2007; Raj, *et al.,* 2017).

The Western Ghats' freshwater crabs may be found from low-lying regions to high mountain summits (2472m above sea level). Above the average height (1200m) of the Western Ghats, ten genera (56%) and 21 species (34%), respectively, may be found. *Barytelphusa cunicularis, Snaha escheri, Travancoriana granulata, T. schirnerae, Vanni nilgiriensis, V. pusilla,* and *Vela pulvinata* are among the seven species that live over 2000 metres. *Travancoriana granulata* and *Vanni pusilla* are only found at high elevations (1708–2472 m) (Pati, *et al*., 2013; Roux, 1931; Bott, 1970; Bahir and Yeo, 2007; Rajesh, *et al.,* 2017).

The existence of 62 species in 18 genera of the family Gecarcinucidae was discovered in updated data on the freshwater crabs of the Western Ghats. The Western Ghats crabs have approximately half as many Indian genera and species (18/35 genera and 75/125 species) and more than two-thirds as many Indian gecarcinucid genera and species (18/24 genera and 62/90 species) as the Indian gecarcinucids (Pati and Thackeray, 2018; Pati, *et al.,* 2019; Mitra, 2019). The Northern Western Ghats have 27 species in 6 genera, the Central Western Ghats have 21 species in 8 genera, and the Southern Western Ghats have 27 species in 12 genera of freshwater crabs.

Barytelphusa cunicularis, the first species ever reported from the Western Ghats, was initially described as *Thelphusa cunicularis* by Westwood in the work of Sykes in 1836. Only Gecarcinucidae family live in the Western Ghats, and there are 60 species coming under this (Pati, *et al.,* 2019). They may be found in a variety of watery, semi-terrestrial, and terrestrial habitats, as well as cryptic habitats such as basalt rocks and phytotelmata (Pati, *et al.,* 2018; 2016; Klaus, *et al.,* 2014; Kumar, *et al.,* 2017).

Within the Western Ghats, two species of *Oziotelphusa* (*Oziotelphusa biloba* and *Oziotelphusa ravi*) may be found. While *Oziotelphusa biloba* has been recorded from a few locations in Kerala's Palakkad and Thrissur districts (Pati, *et al*., 2014; Rajesh *et al.,* 2017) *Oziotelphusa ravi* has also recently been characterised from a location in Tamil Nadu's Kanyakumari district (Raj, *et al.,* 2017).

In the Western Ghats, Genus *Ghatiana* (11 species) is the genus which has the greatest number of species (10 species), followed by *Sahyadriana* (10 species), *Vanni* (7 species), and *Travancoriana* (6 species). There are few more genera with only one species like *Inglethelphusa, Kani*, and *Lamella.* Except *Cylindrotelphusa* and *Oziotelphusa*, every known species of each genus is observed in Western Ghats *(*Pati and Pradhan, 2020; Pati, *et. al*., 2022).

The only species of *Barytelphusa* found in the Western Ghats is *Barytelphusa cunicularis*. Only the Northern Western Ghats include members of *Gecarcinucus, Gubernatoriana, Inglethelphusa*, and *Sahyadriana* genuses; the Central Western Ghats have *Arcithelphusa*; and the Southern Western Ghats have *Baratha, Kani, Karkata, Lamella, Pilarta,* and *Snaha (*Pati and Pradhan, 2020). *Ghatiana dvivarna* is newly recognised 75th species in Idagundi Range, Yellapur Division of the Western Ghats by group of Bhajanthri, Hegade, Pati and Thakare in 2022.

Freshwater crab diversity is greatest in the Southern Western Ghats (27 species in 12 genera), followed by the Northern Western Ghats (27 species in 6 genera) and Central Western Ghats (22 species in 8 genera) (Pati and Pradhan, 2020). In terms of genus-species ratios and locality records, the Northern Western Ghats appear to be quite extensively investigated for freshwater crabs. The Central Western Ghats have been under-explored, as evidenced by the low number of location records (Pati and Pradhan, 2020; Pati, *et. al*., 2022).

Crabs from the Western Ghats have a startling amount of endemism (Raghavan, *et al*., 2015). This might be owing to the isolated mountains, known as 'sky islands,' that operate as a geographical barrier (Pati and Thackeray, 2018; Klaus, *et al.,* 2014; Pati and Sharma, 2013).The vast majority of true freshwater crab species are point endemics owing to their generally limited dispersal abilities, relatively low fecundity, and stenotopic habits (Cox, 2001).

Threats for the Freshwater crabs in Western Ghats

The limited ranges of most freshwater crab species offer severe conservation challenges. Fortunately, for the time being, the species with the most restricted ranges are usually those that live on offshore islands or in mountains, regions where man has had less of an influence. Lowlands have been disproportionately affected by the loss of natural forest as a result of land development and agriculture.

Freshwater crab conservation is critical since the bulk of the Western Ghats crab species (53/62 species, or 86 percent) are either 'Data Deficient' (22 species, 36 percent) or have not been evaluated for their conservation status (31 species, 50 percent) (IUCN, 2020). Only two species (*Oziotelphusa biloba* and *Oziotelphusa wagrakarowensis*) were classified as 'Vulnerable' by the IUCN (2020), whereas seven species (11 percent) were assigned the category of 'Least Concern'.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Conclusion

Freshwater crab conservation needs the information regarding the distribution range and population size of freshwater crab species, which is critical to determine the conservation status. Species need to be conserved along with habitat for which proper understanding diversity of the species and their association is very essential.

References

1. Bahir, M. M. and Yeo, D. C. J. (2007). The Gecarcinucid freshwater crabs of southern India (Crustacea: Decapoda: Brachyura). *The Raffles Bulletin of Zoology*, Supplement 16, National University of Singapore, 309-354.
2. Bott, R. (1970). Betrachtungen uber die Entwicklungsgeschichte und Verbreitung der Süsswasser-Krabbennach der Sammlung des Naturhistorischen Museums in Genf/Schweiz. *Revue Suisse de Zoologie*, 77(2), Geneve, Kundig, 327-344.
3. Chia, O. K. S. and Ng. P. K. L. (2006). The freshwater crabs of Sulawesi, with descriptions of two new genera and four new species (Crustacea: Decapoda: Brachyura: Parathelphusidae). *Raffles Bulletin of Zoology*, 54(2), 381–428.
4. Cox, C. B. (2001). The biogeographic regions reconsidered. *Journal of Biogeography*, 28(4), 511–523.
5. Cumberlidge, N. (1999). The Freshwater Crabs of West Africa: Family Potamonautidae. Institute Recherche pour le Developpeme, *Collection Faune et FloreTropicales*, Paris, 36, 1–382.
6. Cumberlidge, N., Fenolio, D. B., Walvoord, M. E. and Stout, J. (2005). Tree-climbing crabs (Potamonautidae and Sesarmidae) from phytotelmic microhabitats in rainforest canopy in Madagascar. *Journal of Crustacean Biology*, 25, 302–308.
7. IUCN. (2020) The IUCN Red List of Threatened Species.
8. Klaus, S., Fernandez, Katrina and Yeo, D. C. J. (2014). Phylogeny of the freshwater crabs of the Western Ghats (Brachyura, Gecarcinucidae). *Zoologica Scripta*, 43(6), 651-656.
9. Kumar, A. B., Raj, S. and Ng. P. K. L. (2017). Description of a new genus and new species of a fully arboreal crab (Decapoda: Brachyura: Gecarcinucidae) from the Western Ghats, India, with notes on the ecology of arboreal crabs. *Journal of Crustacean Biology*, 37(2), 157-167.
10. Magalhaes, C. (2003). Familias Pseudothelphusidae e Trichodactylidae. In Melo, G. A. S. (Eds), Manual de Identificac¸a˜o dos Crustacea Decapoda de A´ guaDoce do Brasil. Editora Loyola, Sa˜o Paulo, 143–287.
11. Marijnissen, S. A. E., Ellinor, E., Michel, Daniels, S. R., Erpenbeck, D. S. B. J. Menken and Schram, F. R. (2006). Molecular evidence for recent divergence of Lake Tanganyika endemic crabs (Decapoda: Platythelphusidae). *Molecular Phylogenetics and Evolution*, 40, 628– 634.
12. Martin, J. W. and Davis, G. E. (2001). An updated classification of the recent Crustacea. *Natural History Museum of Los Angeles County Science*, USA, Series 39, 124.
13. Mitra, S. (2019). A new species of *Himalayapotamon Pretzmann*, 1966 (Decapoda: Brachyura: Potamidae: Potaminae) from Western Himalaya, India. *Journal of Environment and Sociobiology*, 16(2), 121- 131.
14. Ng, P. K. L. and Tay, F. W. M. (2001). The freshwater crabs of Sri Lanka (Decapoda: Brachyura: Paratelphusidae). *Zeylanica*, 6(2), 113–199.
15. Ng, P. K. L. and Yeo, D. C. J. (2007). Malaysian freshwater crabs: conservation prospects and challenges. In Chua, L. S. L., Kirton, L. G. & Shaw, L. G. (Eds), Status of Biological Diversity in Malaysia and Threat Assessment of Plant Species in Malaysia. Proceedings of the Seminar and Workshop, 28–30 June 2005, Forest Research Institute Malaysia (FRIM), 95–120.
16. Ng, P. K. L., (1988). The Freshwater Crabs of Peninsular Malaysia and Singapore. Department of Zoology, National University of Singapore, Shinglee Press, Singapore, 1(8), 1–156.
17. Pati, S. K., Thackeray, T., Bajantri, P. P. and Hegde, G. D. (2022). A New Species of the Freshwater Genus Ghatiana Pati and Sharma, 2014 (Brachyura: Gecarcinucidae) from the Central Western Ghats, India. Nauplius. 30.
18. Pati, S. K., Thackeray, T. and Khaire, A. (2016). Five new species of freshwater crabs of the genera Ghatiana Pati and Sharma, 2014, and Gubernatoriana Bott, 1970 (Crustacea, Decapoda, Brachyura: Gecarcinucidae Rathbun, 1904) from the Western Ghats, India. *Zootaxa*, 4083(4), 569-586.
19. Pati, S. K. and Pradhan, R. N. (2020). An Overview of the Freshwater Crabs (Brachyura: Gecarcinucidae) of the Western Ghats, India. *Oceanography and Fisheries Open Access Journal*, 12(3): 555836.
20. Pati, S. K. and Sharma, R. M. (2013). A new species of freshwater crab, *Travancorianagranulata* n. sp. (Brachyura: Gecarcinucidae) from the southern Western Ghats of India. *Zoosyst and Evol*, 89(2), 275-281.
21. Pati, S. K. and Thackeray, T. (2018). The freshwater crab genera Ghatiana Pati & Sharma, Gubernatoriana Bott, and Inglethelphusa Bott (Crustacea: Decapoda: Brachyura: Gecarcinucidae) revisited, with descriptions of a new genus and eleven new species. *Zootaxa*, 4440(1): 1-73.
22. Pati, S. K., Sharma R. M. and Sureshan, P. M. (2019). Freshwater crabs (Decapoda: Brachyura: Gecarcinucidae). In: The Director (Ed), Fauna of Malabar Wildlife Sanctuary, Kozhikode, Kerala, Conservation Area Series 62. *Zoological Survey of India*, Kolkata, India, Pp. 11-15.
23. Pati, S. K., Sharma, R. M. and Sureshan, P. M. (2014). Freshwater crabs (Crustacea: Decapoda: Brachyura: Gecarcinucidae) in the collection of Western Ghat Regional Centre, Zoological Survey of India, Kozhikode. Records of the *Zoological Survey of India*, Kolkata, India,114(4): 651-668.
24. Raj, S., Kumar, A. B. and Ng, P. K. L. (2017). A new species of freshwater crab of the genus Oziotelphusa Müller, 1887 (Crustacea: Decapoda: Brachyura: Gecarcinucidae) from Tamil Nadu, southern India. *Zootaxa*, 4363(2), 225-236.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

25. Rajesh, L., Raj, S., Pati, S. K. and Kumar, A. B. (2017). The freshwater crabs (Decapoda: Brachyura) of Kerala, India. *Journal of Aquatic Biology and Fisheries*, 5, 132-153.
26. Roux, J. (1931). Crustacés Décapodesd'eaudouce de l'Indeméridionale. *Revue Suisse de Zoologie*, 38(2), 31-62.
27. Yeo, D. C. J. and Ng, P. K. L. (2003). Recognition of two subfamilies in the Potamidae Ortmann, 1896 (Brachyura, Potamidae), with a note on the genus Potamon Savigny. *Crustaceana*, 76, 1219–1235.
28. Yeo, D. C. J., Ng, P. K. L., Cumberlidge, Neil, Magalhaes, Celio, Daniels, Savel, R. and Campos, Martha, R. (2008). Global diversity of crabs (Crustacea: Decapoda: Brachyura) in freshwater, *Hydrobiologia*, Springer, 595:275–286.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Asia Pacific Journal of Research
A peer reviewed international Journal
IMPACT FACTOR : 6.58
Print -ISSN -2320 - 5504
Online-E-ISSN - 2347 - 4793

A COMPREHENSIVE SURVEY ON OPERATING SYSTEMS FOR SMART HOME NETWORKS

Suparna N
Department of PG Studies and Research in CSc
Mangalore University
Mangalore, Karnataka
suparnarai@gmail.com

Manjaiah D H
Department of PG Studies and Research in CSc
Mangalore University
Mangalore,Karnataka

ABSTRACT

The entire world is leaping with the biggest technological steps and moving towards automated lifestyles with either Artificial Intelligence networks or IoT networks. The researchers in the field of Computer Science are steering extensive studies to provide various services and Smart Home Automation is one such services. This study guides those enquirers who want to choose a safe and secure smart home system with suitable operating system (OS) that assists the development of reliable application software for home automation by providing a convenient and safe abstraction of IoT devices. The study has taken up comparison of existing surveys and available Operating Systems for Smart Home Networks.

KEY WORDS: Smart Homes, Cooja, Constrained devices, TinyOS, Contiki.

INTRODUCTION

The researchers in the fields of science and technology always hanker to make the fruitions of their projects to revolutionize various fields like homes, health, education, constructions, automobiles, a nation's infrastructure and agriculture etc[1]. The field of IoT is such an affluence in technology where anything and everything can be connected to internet and can be controlled remotely. The use of sensors to accumulate data without any human intervention has made IoT a ubiquitous field and has amplified the process of transfiguring the human lifestyle. Studies and researches in this field fall into numerous categories.

The extensive survey of research papers in the field of IoT shows that most of the researchers have taken up common issues in the fields such as security, performance analysis of IoT networks, performance analysis of various protocols, the IoT Eco system, the performance of Operating Systems etc. The OS plays a major role in IoT networks because most of the components and devices here have constrained resources. IoT OS has varied hardware constraints such as low memory, less computation power, limited resources and low battery life etc. studies have shown that IoT OS must be equipped to handle these constraints however the complexity of OS must be kept low because MCU will work at very low clock cycle. Though a number of Operating Systems for IoT, are now available, many of them need optimization with reduced complexity. This paper contributes a distinct comparison perspective about IoT OSes.

THE IMPETUS FOR THE STUDY

Home automation is no longer a dream or a part of a sci-fi movie. A smart home has come to existence and the number of families adapting smart home technology is increasing worldwide exponentially. IoT Home Automation is nothing but controlling electrical or electronic appliances of our homes using internet-connected systems. The Operating Systems used in IoT networks are called Smart Home Operating Systems and are designed to coalesce all the connected-devices across the home and control them all from a single platform. A comprehensive smart home OS must be able to create an intelligent system by providing technical support for all kinds and categories of IoT devices. An exemplar to choose a smart home OS is the need of the hour and thus we took up a critical survey of Smart Home Operating Systems. We also studied the existing survey papers and listed the features reflected in those surveys.

IOT ECOSYSTEM

A set of interconnected devices such as processors, sensors, actuators and communication hardware enabled with internet connection constitutes an IoT ecosystem. The basic functioning of IoT system is to acquire, transmit and perform some tasks on the data they obtain from their environments.[2] The Internet Engineering Task Force (IETF) has classified the constrained

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

devices used in IoT field into different [3] according to the required memory for storing code and data[4]. Because the Operating System inhabits the major portion of the memory, legions of researchers are to thriving to develop tiny Operating Systems suitable for resource-constrained devices.

ARCHITECTURE OF OPERATING SYSTEMS

In an effort to reduce memory footprint, the researchers are striving to lessen the complexity of the IoT OS and this has led to no single consensus on architecture for IoT, agreed universally.

The structural design of IoT frameworks and protocols defines its architectures. It is an outline that specifies the functions and principles of physical components of IoT. As of now researchers are using five well known architectures of IoT OS viz., Monolithic architecture, Micro kernel architecture, Three and Five layered architecture, Service Oriented Architecture, Cloud and Fog based architecture[4],[5].

Monolithic architecture is a combination of necessary OS components and applications. Services are implemented separately and each service has an interface for another service. The monolithic approach results in an underprivileged design choice for the OS.

Micro-kernel architecture provides minimum functionality in the kernel. The application and OS are built as a set of interacting modules. Therefore, the kernel size is reduced. Another type of OS architecture is the virtual architecture, which works on the principle that a virtual machine is exported to user programs, which resemble hardware[6].

The three-layered architecture consists of perception layer, network layer and application layer. As their names suggest, data is sensed and gathered at the perception layer, transported at the network layer and processed and the final product is given at the application layer.

In five-layered architecture, along with the three basic layers of three-layered architecture, two more layers are added to give more abstraction to the IoT architecture. The five layers are perception, transport, processing, middleware and application layer[4].

Service Oriented Architecture : SOA or Service Oriented Architecture is a concept that is designed to build systems that provide services to applications. It is a design pattern and not restricted to any programming language

A service is a well-defined, self-contained function that represents a unit of functionality. A service can exchange information from another service.Here the API does not change even if the inner technology and codes are changed. It is not dependent on the state of another service. It uses a loosely coupled, message-based communication model to communicate with applications and other services.

In fog-based architecture, four layers are present between the physical layer and transport layer which are monitoring, pre-processing, storage and security. The monitoring layer observes and checks the data obtained from the sensors. The pre-processing layer performs operations on the sensed data. The storage layer gathers all the processed data. The security layer is responsible for the integrity and privacy of the data.

The Table 1 collates some IoT OS projects and the papers published on these projects. We studied some of the projects with the help of the articles and documentations published by the creators of the Operating System itself. Adam Dunkels developed Contiki in 2002 and published the paper [7]. Similarly Richard Barry created FreeRTOS and published a handson Tutorial Guide on FreeRTOS in 2003[8]

Project Name	Organization	Year	Community	Research papers published on the Project
Zephyr	Linux Foundation	2016	JIRA mailing lists, IRC and GERRIT.	[9],[10],[11],[12],[13]
Tiny OS	EECS Department of U.C. Berkeley.	2007	tinyos-help,tinyos-2- commits	[14],[15],[16],[17],[18],[19],[20]
RIOT	Free University of Berlin French Institute for Research in Computer Science and Automation Hamburg University of Applied Sciences	2013	RIOT Forum	[21], [22], [23], [24],[25] [26],[27]
Contiki	Adam Dunkels	2002	Contiki Forum	[28], [29], [30], [7]
Mantis OS	MANTIS Wireless Sensor Networking Project, Department of Computer Science,University of Colorado at Boulder	2003	Blogs	[31],[32],[33],[34]

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

LiteOS	Huawei	2007	Linux Lite	[35], [36],[37],[38], [39]
FreeRTOS	Richard Barry ; Real Time Engineers Ltd.	2003	FreeRTOS Forum	[27],[40],[8],[41],[42]
Apache Mynewt	Apache Software Foundation		--	
ARM mbed	ARM employees Simon Ford and Chris Styles	2007	Arm Mbed OS support forum	[43], [44], [45], [46], [47], [48]
Yocto	The Linux Foundation	2010	Linux Forum	[49], [50], [51], [52], [53], [54], [55], [56]
Raspbian	Mike Thompson and Peter Green at Raspberry Pi Foundation	2012	Raspberry Pi Forums	[57], [58], [59], [60]
Brillo	Google	2015	Google Forums	[61]
Android Things	Google	2018-2022	Google Forums, Google Developers	[62], [63], [64], [65], [66]
Erika Enterprise	Evidence Srl, ReTiS Lab	2002	Tuxfamily	[67], [68], [69], [70], [71], [72]
OpenTag	JP Norair	2011	JP Norair's Blogs	[73], [74]
uClinux	D. Jeff Dionne and Kenneth Albanowski	1998	Linux Forums	[75], [76], [77], [76], [78]
MicroC/OS-III	Micrium, Inc. Micro-Controller Operating Systems; designed by Jean J. Labrosse	1991	Element14 Community	[79], [80], [81], [76], [82]
NutOS	Dave Hudson – Original project was *Liquorice*.	2000	Ethernut mailing list.	[83], [84], [85], [86]
Windows IoT	Microsoft	1999	Microsoft Blogs	[87], [88], [89], [90], [91], [92]

Table 1: The Operating Systems for IoT projects and the papers published on those projects

COMPARISON OF EXISTING SURVEY PAPERS

There are many survey papers which discuss the various features of Operating Systems for IoT and most of them compared only freeware OS. In some articles, authors have studied only three or four Operating Systems but have considered more number of features. The table 2 compares this paper with some other survey papers with respect to number of Operating Systems studied. Though some OS have become obsolete, it is necessary to study them because some distinct features and technologies were implemented in those projects. Table 3 gives a list of features studied by various authors and researchers in their articles.

AN OVERVIEW OF SOME OPERATING SYSTEMS FOR SHN

Tiny OS: This is an application specific and component based Operating System that requires a memory footprint of 400bytes [93]. TinyOS written using the programming language nesC and available with BSD license. The SDK for TinyOS consists of TinyDT, TinyOS Eclipse Plugin – YETI 2 and Eclips Editor plugin[94]. It provides excellent support for networking and has incorporated applications running on multiple wireless bands and standards [17].

Zypher: With a smallest memory footprint, Zephyr is a secure and flexible real time operating system best suited for smart home networks as it supports more than 100 developer boards. Zephyr requires only 8KB RAM and this suited for all types of home automation. With monolithic kernel, Zephyr supports various architectures such as RISC-V 32, ARM Cortex-M, , Tensilica Xtensa, NIOS-II, and Intel x86. This OS is programmed using Python using Kconfig and devicetree as its configuration systems and thus can be ported to non-linux operating systems. The project has multi threading services and priority based pre-emptive scheduling with round-robin time slicing.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

RIOT: Real Time IoT is a microkernel-based operating system with a minimum RAM footprint of 1.5kB and ROM required is around 5KB[95].RIOT supports 16 and 32bit MCUs such as MSP430 or a ARM7[96]. It does not need a Memory Management Unit (MMU) nor a Floating Point Unit (FPU)[24].The RIOT project is developed with a tickless scheduler for energy efficiency and for real time scheduling it uses Deterministic O(1) scheduling [25]. It has a modular structure with low latency interrupt handling. It offers pre-emptive multithreading service with powerful IPC[24].

Mantis OS: MANTIS is the abbreviation Multimodal Networks of In-Situ(micro sensor nodes) and it is a POSIX-like lightweight Operating System. It is popular for its energy efficiency and multi-threaded mode. It is a cross-platform embedded OS with pre-emptive time-sliced scheduling. With a RAM requirement of 500KB,this OS is well suited for smart home networks. [31], [32], [34].

LiteOS: This lightweight OS has a Unix-like programming environment and it consists of three subsystems viz., LiteFS, LiteShell and Kernel. The user interacts with IoT devices from LiteShell using Unix like commands. The Kernel executes these commands and LiteFS File System provides support to file and directory related operations[37]. LiteOS has an 8MHz CPU and occupies only 128K bytes of program flash, and 4K bytes of RAM. Several advanced platforms such as MicaZ and TelosB support LiteOS[97].At the Kernel level, LiteOS implements priority based and round-robin scheduling. LiteOS dos not have any in-built networking protocol stacks but it supports plug-and-play routing stack[98]

	Paper	[93]	[99]	[100]	[101]	[102]	[98]	[9]	[91]	[6]	[103]	[104]	[3]
Discussed Features	Architecture	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO	NO
	Programming Model	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO
	Scheduling	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Memory Management	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Resource Sharing	YES	YES	YES	YES	YES	YES	YES	NO	YES	YES	YES	YES
	Real-time Application Support	YES	YES	YES	YES	YES	NO	NO	NO	YES	NO	YES	YES
	Portability	NO	YES	NO	NO	NO	YES	YES	NO	NO	NO	YES	YES
	Upgradability	NO	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Energy Efficiency	NO	YES	NO	NO	NO	YES	YES	NO	NO	NO	NO	YES
	Resource constrained Computing	NO	YES	NO	NO	YES	NO	NO	NO	NO	NO	NO	YES
	Failure handling	NO	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Simulation Support	NO	NO	NO	NO	NO	NO	NO	YES	NO	NO	NO	NO
	Communication Protocol Support	NO	YES	YES	NO	YES	NO	NO	YES	NO	YES	NO	NO
	Supported platforms	NO	NO	YES	NO	YES	NO	NO	NO	NO	NO	YES	NO
	Networking Technologies	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES	NO
	Licence	NO	NO	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 3: Comparison of Survey Papers with respect to the features studied

ARM mbed: ARM mbed is single-threaded, event-driven and modular Operating System. It has good connectivity and low footprint of 5K static RAM, and around 38K flash[48].

Yocto: With a layered architectural design, The Linux Foundation collaborative , Yocto Project is a platform to create customized OS for IoT networks. It has an excellent support for Raspberry Pi or the BeagleBone, or MinnowBoard. Yocto Project output can be transferred to other platform orto another platform. Usually Yocto uses 2GB RAM per virtual core and allows for easy re-use of code

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Apache Mynewt: Apache Mynewt requires 8KB of RAM and 64 KB of ROM. It's kernel takes up only 6KB. Communication protocols typically take up 50-100KB of ROM

Contiki: Contiki is a platform that provides software and hardware for Wireless Sensor Networks. Adam Dunkels created Contiki in 2002. Contiki platform has a pre-emptive multithreading architecture and an event-driven programming model, which uses Protothreads, Contiki requires only 2KB of RAM and 40KB of ROM. The Contiki OS features Cooja, a network simulator[94]

Brillo: Brillo is a new Android-based embedded OS for IoT launched in 2016 by Google Being a power frugal System, it should work with even the most basic hardware. Only 128Mb of storage and 32MB of Ram is Brillo's memory footprint. Brillo is accompanied with the full stack application framework with complete secure protocol stack called Weave. It is Open Source Version of Android OS, which is scaled down to suit resource constrained devices. Brillo supports connectivity like Wifi and BLE. It also supports the Thread protocol used in Google's Nest Devices and Android Things. .

Android Things: In 2018 Google Launched its first Operating System built for IoT, called Android Things. To handle the communication with peripherals and drivers, This OS has Android Things Library which supports industry standard protocols such as GPIO, I2C,,PWM , UARTand SPI.. Google dropped Android Things project in January 2021 and completely shutdown its console.[62]

Erika Enterprise: Started in 2002 by Evidence Srl, ReTiS Lab, Italy, Erika Enterprice is a Real Time OS with a support for multicore architecture. It is suitable for all kinds of micro controllers ranging from 8 to 64bits. It also supports hypervisors such as JailHouse and scaled up in 2018 by adding AUTOSAR and Graphical Editor and thus making it ready for the Vehicular Adhoc Networks. The Erika Enterprise OS contains single image Kernel shared among various CPUs. Usually in embedded OS, multi-processor resource policy(MSRP) allows, tasks on a core to share single protocol stack. But being a multicore architecture Erica Enterprise needs a flexible spin-lock model.

OpenTag: Open Tag is a minimal exokernel, open-source RTOS. Exokernel is used to have a direct contact with the system architecture. This OS was developed in C programming language, having Exokernel system architecture; it has event driven programming and pre-emptive scheduling model. It is implemented with DASH7 protocol stack. It provides dynamic memory management and deep sleep mode for power management. DASH7 is a wireless standard designed for low-power and low-latency communication. OpenTag is a full featured exo-kernel with large API and Library. On MSP430 boards OpenTag entails 16-24KB ROM (Flash) and 2KB RAM[73].

µClinux: µClinux is a open source project developed by D. Jeff Dionne and Kenneth Albanowski in 1998. The name µClinux is pronounced as "you-see-linux". But the name actually is the combination of the Greek Alphabet µ(mu) which stands for Micro, the English Capital C which is the abbreviation for Controller and the word Linux tells us the fact that µClinux is derived from the Linux 2.0/2.4 kernel and inherits some features of Linux which are suitable for embedded OS. This OS supports Motorola 68, ARM, Sparc, MIPS, Altera and NEC architectures. It is specifically aimed at CPUs without MMU (Memory Management Unit) and requires 32 MB and the size of bootable image starts from 0.8 MB.

MicroC/OS-III: This is an open-source project developed by Micrium, Inn and designed by Jean J. Labrosse. µC/OS-III is the acronym for Micro-Controller Operating Systems Version 3. It has a microkernel architecture and its highly portable and scalable. Its maximum ROM footprint is 24KB and only 1KB Ram is adequate to use it in microcontrollers and DSPs. µC/OS-III uses pre-emptive Round-Robin scheduling and is multitasking OS[105].

NutOS: Nut/OS is a modular, open source, real-time operating system with simple RTOS Kernel which provides services to run Ethernut, the TCP/IP stack. The Ethernut software network stack is called Nut/Net.[85] It provides a prevalent API for various protocols. It is easily configurable and highly scalable. It features Co-operative multithreading and dnamic memory management. The memory footprint of Nut/OS is 128/256k bytes Flash memory and 4K bytes on-chip EEPROM[86].

Windows IoT: Windows 10 IOT is a proprietary operating System developed by Microsoft. It is released in 3 different versions and Windows 10 IoT Core was first released by Microsoft in August 2015. The Core version is a light-weight version of Windows 10 and is optimised to run o small constrained devices with a memory foot print of at least 256 MB of RAM memory and 2 GB of storage memory. Windows 10 IoT Core embedded devices need a minimum processing power of 400MHz and Windows 10 IoT OS uses pre-emptive scheduling with a Hybrid kernel Architecture.

CONCLUSION

Whenever an existing technology botches up, an innovative and advanced idea pops up and that technology starts trending. For the subsistence and development of a technology, its vital software part has to be improved and made more reliable. The augmentation of Internet of Things is making the smart homes more secure, smarter and reliable. OS support is vital in facilitating the development and subsistence of IoT. In this paper, we first investigate the various IoT OS projects and its contributors. we provide a comprehensive study of the most used and state-of-art closed source OSs for IoT.. Then, we provide an extensive overview of the survey papers on IoT OSes, where the various features of OS are studied in detail, based on the established designed and development aspects such as architecture and kernel models, memory management, scheduling, power consumption, security, development and programming model.[106]. The future work is to study the Security aspects of smart home networks.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

References:

[1] G. L. P. Ashok, P. S. Akram, M. S. Neelima, J. Nagasaikumar, and A. Vamshi, "Implementation Of Smart Home By Using Packet Tracer," vol. 9, no. 02, 2020.
[2] P. Sethi and S. R. Sarangi, "Internet of Things : Architectures , Protocols , and Applications," vol. 2017, 2017.
[3] M. Silva, D. Cerdeira, S. Pinto, and T. Gomes, "Operating Systems for Internet of Things Low-end Devices : Analysis and Benchmarking," *IEEE Internet Things J.*, vol. PP, no. XX, p. 1, 2019.
[4] S. Bansal and D. Kumar, "IoT Ecosystem: A Survey on Devices, Gateways, Operating Systems, Middleware and Communication," *Int. J. Wirel. Inf. Networks*, vol. 27, no. 3, pp. 340–364, 2020.
[5] P. P. Ray, "A survey on Internet of Things architectures," *J. King Saud Univ. - Comput. Inf. Sci.*, vol. 30, no. 3, pp. 291–319, 2018.
[6] F. Javed, M. K. Afzal, S. Member, M. Sharif, and B. Kim, "Internet of Things (IoTs) Operating Systems Support , Networking Technologies , Applications , and Challenges : A Comparative Review," *IEEE Commun. Surv. Tutorials*, vol. 20, no. c, pp. 1–39, 2018.
[7] A. Dunkels, "Contiki - a Lightweight and Flexible Operating System for Tiny Networked Sensors."
[8] R. T. E. L. Barry, *Mastering the FreeRTOS ™ Real Time Kernel*. .
[9] F. Jaskani, S. Manzoor, M. Amin, M. Asif, and M. Irfan, "An Investigation on Several Operating Systems for Internet of Things," *EAI Endorsed Trans. Creat. Technol.*, vol. 6, no. 18, p. 160386, 2019.
[10] R. K. Panta, S. Bagchi, and S. P. Midkiff, "Zephyr: Efficient incremental reprogramming of sensor nodes using function call indirections and difference computation," *Proc. 2009 USENIX Annu. Tech. Conf.*, pp. 411–424, 2019.
[11] A. Nyffenegger, "Connecting constrained devices to the cloud using Zephyr A prototype with nRF Connect Bachelor Thesis," 2020.
[12] A. Elvstam and D. Nordahl, "Operating systems for resource constraint Internet of Things devices : An evaluation," 2016.
[13] Y. K. Lee, Y. Kim, and J. N. Kim, "Implementation of TLS and DTLS on Zephyr OS for IoT Devices," *9th Int. Conf. Inf. Commun. Technol. Converg. ICT Converg. Powered by Smart Intell. ICTC 2018*, pp. 1292–1294, 2018.
[14] P. Levis *et al.*, "TinyOS: An Operating System for Sensor Networks," in *Ambient Intelligence*, vol. 00, 2005, pp. 115–148.
[15] P. Thomas, K. Kuladinithi, M. Becker, P. Trenkamp, and C. Goerg, "Performance Evaluation of CoAP using RPL and LPL in TinyOS," pp. 2–6, 2012.
[16] R. Dor *et al.*, "Student installation of TinyOS," pp. 1–7, 2014.
[17] P. Levis *et al.*, "TinyOS : An Operating System for Sensor Networks."
[18] P. Levis and N. Lee, "TOSSIM : A Simulator for TinyOS Networks," pp. 1–17, 2003.
[19] P. Levis, N. Lee, M. Welsh, and D. Culler, "TOSSIM : Accurate and Scalable Simulation of Entire TinyOS Applications."
[20] P. Levis, "TinyOS : An Open Platform for Wireless Sensor Networks Moore ' s Law," 2007.
[21] E. Baccelli, O. Hahm, M. Wählisch, and M. Günes, "RIOT : One OS to Rule Them All in the IoT To cite this version : RIOT : One OS to Rule Them All in the IoT," 2013.
[22] E. Baccelli *et al.*, "RIOT: An Open Source Operating System for Low-End Embedded Devices in the IoT," *IEEE Internet Things J.*, vol. 5, no. 6, pp. 4428–4440, 2018.
[23] T. Eichinger, "The friendly operating system for the IoT," 2017.
[24] P. Kietzmann *et al.*, "Connecting the World of Embedded Mobiles : The RIOT Approach to Ubiquitous Networking for the IoT," no. 2.
[25] K. Roussel, Y. Q. Song, and O. Zendra, "RIOT OS paves the way for implementation of high-performance MAC protocols," *SENSORNETS 2015 - 4th Int. Conf. Sens. Networks, Proc.*, pp. 5–14, 2015.
[26] B. Karaduman, M. Challenger, R. Eslampanah, J. Denil, and H. Vangheluwe, "Platform-specific Modeling for RIOT based IoT Systems," *Proc. - 2020 IEEE/ACM 42nd Int. Conf. Softw. Eng. Work. ICSEW 2020*, pp. 639–646, 2020.
[27] T. Wroldsen, "A Real Time Operating System for embedded platforms," no. May, 2004.
[28] P. Kugler, P. Nordhus, and B. Eskofier, "Shimmer , Cooja and Contiki : A New Toolset for the Simulation of On-node Signal Processing Algorithms," 2013.
[29] F. Österlind, "A Sensor Network Simulator for the Contiki OS," 2006.
[30] T. Paul, G. S. Kumar, and A. C. Os, "Safe Contiki OS : Type and Memory Safety for Contiki OS," pp. 2009–2011, 2009.
[31] S. Bhatti *et al.*, "MANTIS OS: An Embedded Multithreaded Operating System for Wireless Micro Sensor Platforms," *Mob. Networks Appl.*, vol. 10, no. August, pp. 563–579, 2005.
[32] H. Abrach *et al.*, "Mantis," *Network*, no. October, pp. 50–59, 2003.
[33] H. Abrach *et al.*, "MANTIS : System Support For M ultimod A l N e T works of I n-situ S ensors Technical Report CU-CS-950-03 Department of Computer Science MANTIS : System Support for M ultimod A l N e T works of I n-situ S ensors," no. April, pp. 1–15, 2003.
[34] M. Rangan, "Mos (Mantis Os)," 2005.
[35] Q. Cao, T. Abdelzaher, J. Stankovic, and T. He, "The LiteOS Operating System: Towards Unix-Like Abstractions for Wireless Sensor Networks," in *2008 International Conference on Information Processing in Sensor Networks (ipsn 2008)*, 2008, pp. 233–244.
[36] T. V. Chien, H. N. Chan, and T. N. Huu, "A comparative study on operating system for Wireless Sensor Networks," *2011*

Int. Conf. Adv. Comput. Sci. Inf. Syst., pp. 73–78, 2011.
[37] V. Vanitha, V. Palanisamy, N. Johnson, and G. Aravindhbabu, "LiteOS based Extended Service Oriented Architecture for Wireless Sensor Networks," *Int. J. Comput. Electr. Eng.*, vol. 2, no. 3, pp. 432–436, 2010.
[38] *LiteOS User ' s Guide*. 2011.
[39] "The LiteOS Operating System Kernel 2.0.1," 2011.
[40] N. Melot, "Study of an operating system: FreeRTOS," 2009.
[41] T. Errors, "Getting Started with FreeRTOS on megaAVR® 0-series," pp. 1–29.
[42] C. Sabri, L. Kriaa, and S. L. Azzouz, "Comparison of IoT constrained devices operating systems: A survey," *Proc. IEEE/ACS Int. Conf. Comput. Syst. Appl. AICCSA*, vol. 2017-Octob, pp. 369–375, 2018.
[43] S. Martin, "Arm Mbed – AWS IoT System," no. January, 2018.
[44] A. R. M. Limited, A. R. M. Limited, T. Instruments, C. C. Studio, and T. Instruments, *EM BED D ED SY STEM S : INTRODUCTION TO ARM ® CORTEX -M MICROCONTROLLERS Volume 1 Fifth Edition June 2014 Jonathan W . Valvano Fifth edition 2nd printing*. 2014.
[45] N. Sudheer, "Hardware Implementation of Mbed to Mbed Through Controller Area Network Using ARM Cortex Core," vol. 2, no. 8, pp. 2491–2498, 2013.
[46] P. Primiceri, P. Visconti, A. Melpignano, G. Colleoni, and A. Vilei, "Hardware and software solution developed in arm MBED environment for driving and controlling DC brushless motors based on ST X-Nucleo development boards," *Int. J. Smart Sens. Intell. Syst.*, vol. 9, no. 3, pp. 1534–1562, 2016.
[47] D. Ibrahim *et al.*, *Introduction*, vol. 1999, no. December. 2018.
[48] Rob Toulson and T. Wilmshurst, *Fast and Effective Embedded Systems Design Applying the ARM mbed*. 2017.
[49] M. Swain and A. K. Srivastava, "Design of embedded Linux based voice calling device," *Int. J. Appl. Eng. Res.*, vol. 10, no. 15, pp. 35095–35102, 2015.
[50] H. Khandelwal, P. Mankodi, and R. Prajapati, "Enhancement of automation testing system using Yocto project," *Proc. Int. Conf. Electron. Commun. Aerosp. Technol. ICECA 2017*, vol. 2017-Janua, no. April 2017, pp. 697–700, 2017.
[51] B. Linux, "Working with Yocto to Build Linux," 2018.
[52] S. Rifenbark, "Yocto Project Overview and Concepts Manual," *Yocto Proj.*, 2018.
[53] A. P. Navik and D. Muthuswamy, "Dual band WLAN gateway solutions in Yocto Linux for IoT platforms," *Internet Things Glob. Community, IoTGC 2017 - Proc.*, pp. 1–3, 2017.
[54] A. Biswas, D. Biswas, S. S. Chauhan, and A. Borwankar, "Smart home equipment control system with raspberry Pi and Yocto," *Proc. World Conf. Smart Trends Syst. Secur. Sustain. WS4 2020*, pp. 553–558, 2020.
[55] N. X. P. Semiconductors, "Real-time Edge Yocto Project User Guide Overview," 2021.
[56] D. Moseley, "Why the Yocto Project for my IoT Project?," *Embedded*, 2017.
[57] A. Kurniawan, *Raspbian OS Programming with the Raspberry Pi*. 2019.
[58] G. R. Viswanath, J. A. Sadiq, V. R. Priya, and A. Professor, "Scrutiny Mechanism By Raspbian," *Int. J. Sci. Res. Eng. Dev.*, vol. 2.
[59] W. Harrington and W. Harrington, *Learning raspbian : get up and running with Raspbian and make the most out of your Raspberry Pi*. 2015.
[60] G. Howser, "Raspberry Pi Operating System," *Comput. Networks Internet*, pp. 119–149, 2020.
[61] I. I. Pătru, M. Carabaş, M. Bărbulescu, and L. Gheorghe, "Smart home IoT system," *Netw. Educ. Res. RoEduNet Int. Conf. 15th Ed. RoEduNet 2016 - Proc.*, 2016.
[62] L. Jordan and P. Greyling, "Android Projects."
[63] S. Arslan, O. Dagdeviren, and G. Kardas, "An IoT LDR Bulb Application with Android Things Operating System for Smart Cities," *Proc. - 2019 Innov. Intell. Syst. Appl. Conf. ASYU 2019*, pp. 1–5, 2019.
[64] V. V. R. Dantu, V. V. S. Sai Dasaradha, and P. Sasikumar, "Unified Automotive Location Tracking Using Android Things (IoT)," *Wirel. Pers. Commun.*, vol. 120, no. 1, pp. 63–79, 2021.
[65] T. Cho, H. Kim, and J. H. Yi, "Security Assessment of Code Obfuscation Based on Dynamic Monitoring in Android Things," *IEEE Access*, vol. 5, no. X, pp. 6361–6371, 2017.
[66] S. Arslan, O. Dagdeviren, and G. Kardas, "An IoT LDR Bulb Application with Android Things Operating System for Smart Cities," *Proc. - 2019 Innov. Intell. Syst. Appl. Conf. ASYU 2019*, no. January 2020, pp. 1–5, 2019.
[67] A. Avanzini, P. Valente, D. Faggioli, and P. Gai, "Integrating Linux and the real-time ERIKA OS through the Xen hypervisor," *2015 10th IEEE Int. Symp. Ind. Embed. Syst. SIES 2015 - Proc.*, pp. 218–224, 2015.
[68] S. Afshar, M. P. W. Verwielen, P. Gai, M. Behnam, and R. J. Bril, "An implementation of the flexible spin-lock model in ERIKA Enterprise on a multi-core platform," no. 2016, 2022.
[69] S. M. N. Balasubramanian, S. Afshar, P. Gai, M. Behnam, and R. J. Bril, "A dual shared stack for FSLM in Erika Enterprise A dual shared stack for FSLM in Erika Enterprise," 2017.
[70] Evidence, "ERIKA Enterprise Manual," 2012.
[71] P. Pagano *et al.*, "ERIKA and open-ZB: An implementation for real-time wireless networking," *Proc. ACM Symp. Appl. Comput.*, no. May 2014, pp. 1687–1688, 2009.
[72] S. Afshar, M. Behnam, R. J. Bril, and T. Nolte, "Flexible spin-lock model for resource sharing in multiprocessor real-time systems," *Proc. 9th IEEE Int. Symp. Ind. Embed. Syst. SIES 2014*, pp. 41–51, 2014.
[73] J. Norair, "Introduction to DASH7 technologies," *Dash7 Alliance Low Power RF Tech. Overv.*, pp. 1–22, 2009.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

[74] A. Vegendla, H. Seo, D. Lee, and H. Kim, "Implementation of an RFID Key Management System for DASH7," *J. Inf. Commun. Converg. Eng.*, vol. 12, no. 1, pp. 19–25, 2014.
[75] G. Started, "AN 2119 Getting Started with uClinux for STR71x," no. February, pp. 1–19, 2005.
[76] M. Wang and F. Liu, "Research & implementation of uCLinux-based embedded browser," pp. 504–508, 2008.
[77] S. Martin, "uClinux CoreCommander BSP User Guide," vol. 2009, no. January, 2009.
[78] E. Dodiu, A. Graur, and V. G. Gaitan, "Hard-soft real-time performance evaluation of linux rtai based embedded systems," *Elektron. ir Elektrotechnika*, no. 8, pp. 51–56, 2010.
[79] J. J. Labrosse and W. Road, *µC/OS-III*. .
[80] W. H. Li, J. Y. Zheng, and C. Yu, "Data acquisition system based on uC/OS-III embedded system," *Adv. Mater. Res.*, vol. 619, pp. 85–89, 2013.
[81] L. Peng, F. Guan, L. Perneel, and M. Timmerman, "Behaviour and performance comparison between FreeRTOS and µC/OS-III," *Int. J. Embed. Syst.*, vol. 8, no. 4, pp. 300–312, 2016.
[82] J. J. Labrosse, *µC/OS-II - The Real-Time Kernel - User's Manual*. 2015.
[83] M. Payer, "Implementation of a Bluetooth Stack for BTnodes and Nut/OS Version 0.9," 2004.
[84] M. Strobl, N. Balbierer, and A. Schingale, "Rapid Prototyping Embedded Systems Using Ethernut Boards," no. February, 2012.
[85] "Nut/OS Software Manual."
[86] M. Considerations, "Nut/OS."
[87] I. M. Culic and A. Radovici, "Extending the wyliodrin platform for windows 10 IoT core," *Netw. Educ. Res. RoEduNet Int. Conf. 15th Ed. RoEduNet 2016 - Proc.*, 2016.
[88] J. M. C. Gómez, J. R. Gómez, J. C. Mondéjar, and J. L. M. Martínez, "Non-volatile memory forensic analysis in windows 10 IoT core," *Entropy*, vol. 21, no. 12. 2019.
[89] A. C. Petrini and V. M. Ionescu, "Implementation of the huffman coding algorithm in windows 10 IoT core," *Proc. 8th Int. Conf. Electron. Comput. Artif. Intell. ECAI 2016*, 2017.
[90] P. Sabanal, "I NTO T HE C ORE : I N - DEPTH E XPLORATION O F W INDOWS 10 I O T C ORE."
[91] A. Al-sakran, M. H. Qutqut, F. Almasalha, H. S. Hassanein, and M. Hijjawi, "An Overview of the Internet of Things Closed Source Operating Systems," *2018 14th Int. Wirel. Commun. Mob. Comput. Conf.*, pp. 291–297, 2018.
[92] C. Bell, *Windows 10 for the Internet of Things*. 2016.
[93] A. Yaqoob, M. A. Ashraf, F. Ferooz, A. H. Butt, and Y. Daanial Khan, "WSN Operating Systems for Internet of Things(IoT): A Survey," in *2019 International Conference on Innovative Computing (ICIC)*, 2019, pp. 1–7.
[94] T. Borgohain, U. Kumar, and S. Sanyal, "Survey of Operating Systems for the IoT Environment," *ArXiv*, vol. abs/1504.0, 2015.
[95] E. Baccelli *et al.*, "RIOT : an Open Source Operating System for Low-end Embedded Devices in the IoT," vol. 4662, no. c, pp. 1–12, 2018.
[96] E. Baccelli, O. Hahm, and M. Gunes, "RIOT: One OS to Rule Them All in the IoT," 2012.
[97] Q. Cao, T. Abdelzaher, and J. Stankovic, "The LiteOS Operating System : Towards Unix-like Abstractions for Wireless Sensor Networks," pp. 233–244, 2008.
[98] P. Gaur and M. P. Tahiliani, "Operating Systems for IoT Devices: A Critical Survey," in *2015 IEEE Region 10 Symposium*, 2015, pp. 33–36.
[99] K. Parveen, A. Ali, and G. Asadullah, "Survey on Operating Systems for the Applications of the Internet of Things Introductio n," pp. 9–16, 2016.
[100] A. Jeghal, H. Aberbach, S. Abdelouahed, and H. Tairi, "A Comparative Study Between Operating Systems (Os) For The Internet Of Things (Iot) A Comparative Study between Operating Systems (Os) for the Internet of Things (IoT)," no. November 2019, 2017.
[101] N. Al-taleb, "A Study on Internet of Things Operating Systems," *2019 IEEE Int. Conf. Electr. Comput. Commun. Technol.*, pp. 1–7, 2019.
[102] C. Sabri, K. Lobna, and S. L. Azzouz, "Comparison of IoT constrained devices operating systems : A Survey," 2017.
[103] A. Musaddiq *et al.*, "A Survey on Resource Management in IoT Operating Systems," *IEEE Access*, vol. 6, pp. 8459–8482, 2018.
[104] E. Baccelli, O. Hahm, E. Baccelli, and O. Hahm, "Operating Systems for the IoT – Goals , Challenges , and Solutions Operating Systems for the IoT – Goals , Challenges , and Solutions," no. January, 2013.
[105] M. Lv *et al.*, "WCET analysis of the µC/OS-II real-time kernel," *Proc. - 12th IEEE Int. Conf. Comput. Sci. Eng. CSE 2009*, vol. 2, no. 2007, pp. 270–276, 2009.
[106] O. Hahm, E. Baccelli, H. Petersen, and N. Tsiftes, "Operating Systems for Low-End Devices in the Internet of Things : a Survey," vol. 3, no. 1, pp. 1–16, 2016.

Asia Pacific Journal of Research

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Asia Pacific Journal of Research
A peer reviewed international Journal
IMPACT FACTOR : 6.58
Print -ISSN -2320 - 5504
Online-E-ISSN - 2347 - 4793

ANTIMICROBIAL ACTIVITY OF THE AQUEOUS EXTRACT OF MENTHA PIPERITA PLANT

K.Shridhara Prasad

Associate Professor of Chemistry

Department of Chemistry, Dr.G.Shankar Govt.Women's First grade College and P.G.Study Centre, Ajjarkad, Udupi-576101. Karnataka, India

Email:kspr65@yahoo.com;Ph: +91-9449969818

ABSTRACT

In vitro evaluation of antibacterial activity of Mentha piperita against four bacterial strains Pseudomonas Putida, salmonella typhi, Pseudomonas aeruginosa, Bacilius licheni formis, at 10, 20 and 30 µl concentration. Maximum zone of inhibition activity was observed in Pseudomonas aeruginosa at all tested concentration with inhibition zone of 0.9, 1.5 and 1.8 cm at 10, 20 and 30 µl concentration respectively as compared to synthetic antibiotic Streptomycin of 2.0 cm inhibition zone, followed by Pseudomonas Putida, Salmonella typhi. Least inhibition was observed in Bacilius licheni formis at all tested concentration.

Keywords : *Mentha Piperita, antibacterial activity, Pseudomonas aeruginosa, antibiotics*

INTRODUCTION

Biologically active compounds from natural sources have always been a great interest for scientists working on infectious. Higher and aromatic plants have traditionally been used in folk medicine as well as to extend the shelf life of foods , showing inhibition against bacteria, fungi and yeast .The genus Mentha Piperita belonging to family Lamiaceae includes large number of species that differ widely in their characteristics and ploidy level. Mentha species are perennial and could be multiplied both by reproductive and vegetative means .Members of this family posses great pharmacological and commercial significance (Zhang J.et al 2002).Mentha Piperita is a perennial plant that is found in various countries of the world both as cultivated and wild. It has been documented in the literature that Mentha piperita(fig.1) is used internally as a tea, tincture ,oil or extracts , and applied externally as a rub or liniment. The distinctive smell and flavor, a characteristic feature of Mentha Piperita is due to the naturally occurring cyclic terpene alcohol called menthol. Menthol is prescribed as medication for gastrointestinal disorders, common cold and musculoskeletal pain.The mint plants are rich sources of iron and magnesium,which play important role in human nutrition (Arzani et al., 2007). Botanists consider it as an astringent, antiseptic, antipyretic ,antispasmodic, ant catarrhal, antimicrobial, rubefacient, stimulant, emmenagogue and anti-aging properties (Thongson et al,2004).However ,to the best of our knowledge, no serious efforts have been made to test the antibacterial properties of Mentha piperita so far.In the present study we established antibacterial activity of Mentha piperita against pathogenic bacteria .The study confirms that the leaf extracts possess strong antibacterial properties against various pathogenic bacteria.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

Fig 1 .Mentha Piperita (Pudina Plant)

MATERIAL AND METHODS:

Plant Material

Mentha Piperita was obtained commercially from a local garden Hassan and identified by a botanical taxonomist of Botany and Microbiology, Government Science College. The leaves were washed under running tap water, followed by sterilized distilled water and dried at room temperature in dark, then grinded to powder using an electrical blender.

Preparation of Extracts

The plant material collected was healthy and free from any deformalities. The collected plant material was brought to the laboratory for further processing. The plant material was break into small pieces and then blended into powder by mixture blender .The powder is then passed from the sieve with pore size of 1 mm to get the equal size particles. The powder was kept aseptically in air tight container from moisture free place. For the extraction , the selection of solvents is done with care to meet extractability and regulatory criteria. About 25 g of powder is accurately weighed and transferred to the conical flask containing 200 mL distilled water and shaken well and powder mixed properly in water.The flask containing the mixture of powder and water is put on room temperature on aseptic condition for 7 to 8 days, extract and filtered using muslin cloth followed by Whatman filter paper.The filtered liquid material is centrifuged at 4000 rpm for 5 min and the pure extract was obtained in the form of supernatant. Thus obtained pure extract was stored at 4^{o} C as a stock solution for further work.

Isolation of Test Organisms

Pure cultures of the test organisms used for antimicrobial study were obtained from the Dept of Biotechnology, Oxford college of engineering , Bengaluru . All the test organisms were cultured on nutrient agar slant. The cultures were maintained by sub-culturing periodically and preserved at 4^{o} C prior to use .The gram negative bacterial strain Psedomonas Putida and Salmonella Typhi and gram positive bacterial strain included Pseudomonas Aeruginosa, B.licheni Formis.

Determination of Antimicrobial Activity

The antimicrobial activity of the leaf extract was determined using agar well diffusion method (Odeyemi and Fagbohum, 2005) with slight modification of perez. Nutrient agar was inoculated with the given microorganisms by spreading the bacterial inoculums on the media. Wells (5 cm diameter) were punched in the agar with cork borer and filled with plant extracts. Control wells containing neat solvents(negative control) and standard antibiotic solution (positive control) viz.,Streptomycin (25mg) were also run parallel in the

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

sample plate. The plates were incubated at 27° C or 37° C for 24 hr and the inhibition zones were measured with the help of inhibition zone scale.

RESULTS

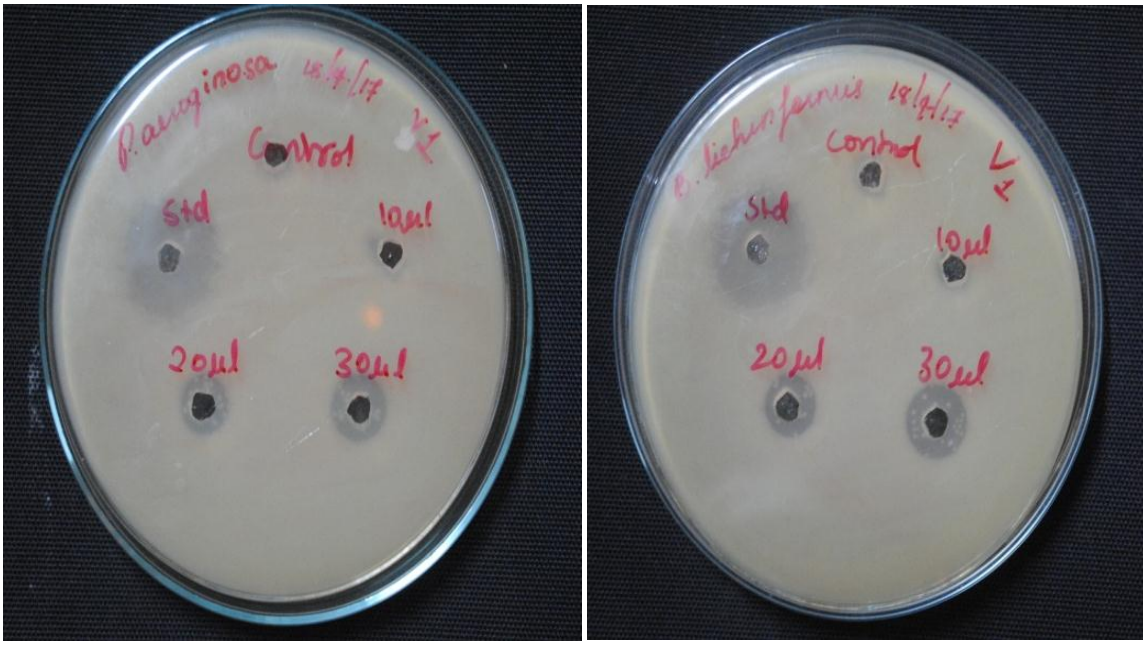
In the present investigation ,the aqueous extract of Mentha Piperita was most effective in controlling bacterial activity against all the isolates tested. The extract was highly significant in inhibiting the bacterial growth of Pseudomonas Aeruginosa with inhibition zone of 0.9, 1.5 cm at 10, 20 µl and at concentration of 30 µl bacterial inhibition was about 1.8 cm, it is almost competitive to standard Streptomycin of 2 cm inhibition. Salmonella Typhi has better control at 10 and 20 µl concentration with inhibition zone of 1.3 cm in both, while at concentration of 30 µl Pseudomonous Putida has less growth over the Salmonella Typhi with inhibition zone of 1.6 and 1.5 cm respectively. The least inhibition was observed in Bacilius licheni formis with inhibition zone of 0.7, 1.1 and 1.3 cm. The results were shown in fig. 2 and tabulated in table 1.

Table 1. Antibacterial Activity of Aqueous Extract of Mentha Piperita against Bacterial species

Bacteria	Zone of inhibition (cm) Concentration			
	Plant extract			Synthetic antibiotics
	10µl	20 µl	30 µl	Streptomycin
Salmonella Typhi	1.3	1.3	1.5	2.0
Pseudomonous Putida	0.8	1.2	1.6	2.0
Pseudomonas Aeruginosa	0.9	1.5	1.8	2.0
Bacilius Licheni Formis	0.7	1.1	1.3	2.0

Fig 2. Antibacterial Activity of Leaf Extract

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793



DISCUSSION:

Plants have formed the basis of sophisticated traditional medicine system and natural products make an excellent leads for new drug development (Newman et al, 2007). In addition to these properties, it has also been used appetite stimulant, a treatment for gastro intestinal infection and to lower blood sugar in diabetics. Its use for the treatment of certain types of cancer and viral infections has also been reported (Abascal et al, 2003). The obtained results from the present investigation suggest the presence of an active principle which is effective in significant inhibition of tested microbes. The present work shows that compounds from Mentha Piperita leaf extracts contain the effective active constituents responsible for eliminating the bacterial pathogens and also the present study reveals that more phenols were present in the tissue cultures plants followed by field grown plants, Same types of results were observed in Bacopa Monnieri.

As the work for the development of herbal medicines is in progress worldwide, the present report will help in the isolation of new products/drugs . It can be concluded that active chemical compounds presnt in Mentha Piperita should certainly find place in treatment of various bacterial infections. The use of this plant in the treatment of sore throat, mouth or throat irritation is validated scientifically supported by the results obtained in this work.

ACKNOWLEDGMENTS

Authors are highly thankful to the Principal and Head , Dept of Botany and Microbiology,Government Science College, Hassan for providing laboratory facility and infrastructure. Authors are thankful to Department of Biotechnology,Oxford college of Engineering Bengaluru for providing bacterial cultures for the study.

REFERENCES:

1.Abascal , K. and Yarnell, E. (2003). Herbs and drug resistance,Herbal gram ,The journal of the American Botanical Council, 237-241.

2.Arzani, A, Zein Ali H, Razmjo K (2007) ,Iron and magnesium concentrations of mint accessions (Mentha app). Pl. Physio. Bioch., 45, 323-329.

3.De N, and Ifeoma, E (2002).Antibacterial effects of components of the bark extracts of Neem (Agadiracta indica, A. Juss). Technol. Dev.8,23-28.

ISSN (Print): 2320-5504
ISSN (Online): 2347-4793

4.Newman, D.J., Cragg, G. M and Snader , K.M (2000). The influence of natural products upon drug discovery .Natural product Res, 17,215-234.

5.Odeyemi, A. T and Fagbohun, E. D (2005). Antimicrobial activities of the extracts of peels of Dioscorea cyensis L. J. f. Appl. And Environ. Sci.1,37-42.

6.Perez,M.Pauli and P.Bazerque, (1990) An Antibiotic Assay by Agar Well Diffusion Method, Acta Biological et Medica Experimentalis, Vol.15(1), 113-115.

7. Tejavathi.D and N.N. Rao(1998), Comparative Studies between Normal and Tissue Cultured Plants of Bacopa monnieri (L.) Pennel, In: I. A. Khan and A.Khanum,Eds., Role of Biotechnology in Medicinal and Aromatic Plants, Ukaaz Publications, Hyderabad, 239-247.

8.Thongson, C., Davidson, P. M ., Mahakarnchanakul, W., & Weise, J (2004). Antimicrobial activity of ultrasound-assisted solvent-extracted spices. Letters in Applied Microbiology, 39 (5), 401-406.

9 Zhang J. Sun L., Yin J., SuH, Ch Liao, Yanch (2002),Control of ZnO morphologyvia simple solution route, Chem.Mater, 14, 4172-4177.

Editorial board:

Chief Editor:

Board Members:

About College

Dr G Shankar Government Women's First Grade College & PG Study Centre, Ajjarkadu, Udupi was founded by the Government of Karnataka with an aspired vision to "empower women so as to achieve excellence and imbibe virtues of discipline, commitment to social values and willingness to contribute to the well-being of society." In addition to its unique stamp of being the only women's government college in the district, the institution is also first-choice educational hub of the rural and economically disadvantaged students. The phenomenal growth of the institution could be assessed from the fact that the college that started in the year 2003-04 with a meagre strength of 93 has risen to 2178 students in 2021-22.

112 of our students secured ranks in various university exams. Our students have represented the institution in a diverse set of state and national sporting and cultural competitions.

Truly, the institution is a forerunner of female education. With five Under-Graduate and five Post Graduate Courses on offer, the institution provide sample and smooth transitional scope to students from UG to PG in the same academic ambience. In addition, being a recognized IGNOU Study Centre and NPTEL-Local Chapter, the institution offers plethora of certificate courses to add to their vistas of knowledge. In collaboration with Unnathi Foundation, Bangalore, and Ramakrishna Hegde Skill Development Centre, Udupi, the institution also imparts Soft Skills and Communicative Skills Training Programme to students. As part of its commitment to knowledge-sharing, the institution has regularly hosted seminars, workshops, training programmes and conferences. In addition, with fourteen PhD holders, of which four of them are recognized Research Guides of various universities, the institution is making a mark as a portal of research in higher education. Named after Dr. G. Shankar, entrepreneur and philanthropist who has donated a substantial amount for the construction of classrooms, the college is an excellent example of stakeholders' participation in the development of the college. Ideally located (Udupi District, Karnataka State) in the district headquarters, it is one of the fast-emerging colleges of the district. The institution has tremendous scope for growth in the coming years and the institution is committed to achieve greater excellence in the days to come.