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A Study on the Formation of Floating Islands of Inle-Lake from Botanical Point of View

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အင်းလေးကန်ရှိ ကျွန်းမျောများ၏ ဖွဲ့စည်းပုံကို ရုက္ခဗေဒရှုထောင့်မှ ခွဲခြားဖော်ထုတ်ပြီး၊ ဆန်းစစ်လေ့လာခြင်း

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Abstract

Preliminary survey on the formation of floating Islands and floating water gardens of Inle Lake both in use and non-use, conducted from the botanical point of view was presented. Six species of plants which were said to be the pioneers, leading to the formation of floating Islands were analysed through their general morphology and anatomy of the submerged plant parts. The chemical composition of wild floating Islands and floating water gardens both in use and non-use were also analysed with the aid of Atomic Absorption Spectrophotometer.

Contents

1. Introduction

Natural resources are one of the basic units when measuring the wealthiness of a country. But there are such properties created by nature only for a particular country or habitat and is not common through out the world, they are the natural luxuries.

Myanmar is a country, which attracts foreigners not only by the richness of its natural resources, but also by natural beauties. Among the most luxuriants ecological association, Inle lake is one of the most significant and productive ecological system supporting an immense variety of plants and animals and yielding great wealth for Myanmar through its occurrence of floating islands, floating water gardens, living style of the natives (Inthas) in the lake, rowing flatboats with one leg, which all these can be found only in Myanmar, and its role in storage and release of water which is the main source for the Lawpita hydropower station.

Foreigners who visited the Inle lake always raised questions on the water catchment, floating islands, water gardens, wild life nature . . . etc. Although they come from different places, the questions are the same and yet, knowledgeable answer is still lacking for so many decades. Thus, it become clear that some concrete information of the Inle Lake is and urgent necessity for the country.

In order to fulfil this requirement an attempt has been made to collect information on the historical and geological background of the lake, formation of the floating islands and chemical composition of both crude and cultivated islands were undertaken. To make the paper more complete, literature of previous and present work of some workers were also reviewed.

2. Literature Review

Inle lake

Geologist refer to the Inle Lake as tertiary in its origin and occupies the deepest part of the Yawnghwe basin, which has and average length of about 40 miles and about 8 miles wide and is between 20° – 10' and 20°-53' North latitude and 96° – 50' and 96°-57' East longitude. The whole basin had once been occupied by a very large lake, much larger than the Indawgyi Lake which is the largest and natural lake now, with and area of the open sheet of water 55.9 sq.mile. According to Dr.Movius, Philadelphia University (1939) water level was 300 ft higher than the present level. Some thought that in the early stage the boundaries of the lake reached to present Shwenyaung, Aungthabye areas, then it receded to the present position. The present Inle Lake is a remnant with an average length of 9.5 miles from North to South and 3.5 miles from East to West and its open sheet of water is about 23.42 sq.miles, the littral zone about 28.12 sq.miles and the floating islands about 27.96 sq.miles. The lake is very shallow and the deepest at present does not exceed 18 feet.

Geology and drainage

The area of Shan Plateau is divided into three structural basins, namely the Thamaikan basin , the Heho basin and Yawnghwe basin, which are separated from each other by the mountain ridges which split up and run into one another, though they still preserve the original North and South direction. Thus encycling the flatbottomed basins or valleys.

Since the lowest level for each of the basin is 4130', 3785', 2880', it is evident that the drainage must be taking place from the Thamaikan basin to Heho basin or directly into the Yawnghwe basin through the subterrenean channels. Eventually all the three basins drain themselves into the Inle Lake, which also receives water from the eastern ridges by numerous swift streamlets. The southern site of the lake is drained by the Nampiluchaung, which flows through the Thamaka basin which may have been drained in prehistoric times, the Heho basin which appear to be drained within the prehistoric times probably during the times of the Pagan dynasty. Traditions mentioned that before that date there was a big stream meandering across the Yaunghwe valley where Inle Lake now stands. The water drained from the three basins was responsible for the formation of the Inle Lake. (D.M.Nath, 1961).

Water Catchment Sources of the Inle Lake
(Irrigation dept. Nyaungshwe-1995)

Sr.No	Streams from the Eastern shore	Annual siliting amount (acre/ ft)
1.	Nan-Si	20.8
2.	Sure-Lin-Pan	12.8
3.	Lwe-Tant	8.0
4.	Taung-Pu	1.6
5	Chaung-Chauk	4.0
6.	Tha-Pye-Pin	3.2
7.	Chaung-Sauk	14.4
8.	Tha-Le-Oo	20.8
9.	Nyaung-Gyi	11.2
10.	Kho-Pan-Kone	3.2
11.	Ye-Pu	25.6
12.	Me-Za-Li	17.6
13.	Ye-Poke	44.8
14.	Da-Li	8.0
15.	Kan-Pa-Ni	3.2
16.	Han-Me-Zin	30.2
Total		**229.6**

Sr.No	Streams from the western shore	Annual siliting amount (acre/ ft)
1.	Nan-Lat	844.8
2.	Tha-Na-Kha	4.5
3.	Ye-Pe	217.6
4.	Nyaung-Win	2.4
5	Thi-Kone	7.2
6.	Ye-Oo	2.4
7.	Tha-Than	8.0
8.	Than-Taung (or) Kalaw Chaung	409.6
9.	Inn-Tain (or) Bi-Lu-Chaung	499.2
10.	Sein-Kar-Myauk	28.0
11.	Ma-Gyi-Sake	12.8
Total		**2036.8**

According to D. M. Nath(1961), it was stated that there are about 12 species of aquatic plants throughout the high way from Yaunghwe to the northern shores of the Lake.

Khin Thant (1968) mentioned that there are 23 species of fishes observed in the Lake and also stated that the Lake is 14 miles in length and 7 miles in breadth. The depth of water is 12 ft in summer and rise up to 20 ft. in rainy season.

National Health Depth.(1968) analysed the water of Inle Lake and mentioned that it consists of –

Organic Matter	0.0161%
Ca	0.0222
Mg	0.0279
Cl_2	0.0017
SO_4	0.0017
Si	0.0010
HCO_3	0.1030
Fe	0.48
Total N	0.7992
K	0.024
P^H	7.38

3. Formation of the Floating Islands

So far studied, the present floating islands which occupy 27.96 sq.miles of the Lake are soiless islands, composed mainly of some Graminae and Cyperaceae. Among them are two Graminae, *Phragmites karka* (Kyu-phyu) and *Phragmites communies* (Kyu-ni), three Cyperaceae, *Cyperus digitatus*, two unidentified species locally known as Sha-lone and Sha-pya and one Zigiberaceae, *Hedychium coronarium* (Taw-Ngwe-Pan). The colonization of these plants did not take place at the same time but in differing stages.

According to the information obtained from some local natives (Inthas) Sha-lone and Sha-pya are the pioneer plants followed by Graminae after a few years later. Finally the arising of Taw-Ngwe-Pan reveals that the floating Islands has reached to a mature state and can therefore be transformed into the water gardens. All these changes took at least 10 to 15 years, the Inthas said. By that time the thickness of the submerged portion is about 4-5 feet in depth, composed of running stems, roots, rhizomes and hair – like numerous adventitious roots tightly interwoven as a thick compact mass which serves as a mattress for the water gardens. The anatomical structure of these underwater parts clearly reveals waxy thick cuticle and suberinize or cutinize epidermis, large air cavities and wide hollowed pith, by which these character make the plants much lighter for buoyancy and can survive for more than 10 years in water without decomposition.

The Inthas said that when *Colocacia antiquorum* (Pein Yar) emerge this designates that the floating islands is no longer in use, because the roots and rhizomes of *Colocacia* destroy the compact mass of mattress which leads to the destruction of buoyancy, and consequently no more cultivation can be made on it.

Floating Water Gardens

When the floating Islands reach to a mature state i.e. over 10-15 years, the aerial plant parts were cut off from the base leaving only the under water portion. Then, it was again cut into slices of about 4' x 600' and move to the place where it will be transformed into a nursery bed for cultivation. The remainders of the decay aerial portion was burnt out, black silt from the bottom of the lake was carried in flat boats and spread over it to the extent the bed is not sunk but still floating. When there is enough soil for a bed, the gardens were anchored by bamboo poles. A great variety of fruits, vegetables, ornamental flowers were raised on the water gardens. Among them, tomato is the major crop of Inthas which supply not only to the neighbouring areas but also throughout the Southern Shan States and even right down to Yangon and Mandalay, famously known as "Inn Khayanchin Thee". The water gardens can be use up to about 15 years, so long as the submerge mattress can hold its buoyancy, it was learnt.

Old Water Gardens (or) Non- use Water Gardens

The samples of the non-use water gardens reveals, soft, black humus–like nature, therefore no longer holding its buoyancy. They gradually sink to the bottom of the lake or being sink down by the aid of bamboo poles.

4. Botanical Aspect

1. Scientific Name - *Machaerina*
   Myanmar Name - Sha-lone
   Family - Cyperaceae

General Description

Morphology

A tall perennial herbaceous plant; leaves, about 5-6 feet, long, slender, with parallel faces and rounded margins with acute tips, base sheathing. Spikelets clustered with numerous flowers, reddish colour.

Anatomy

Transverse section of the root reveals the following distinct characters:-
(1) Single layer of epidermis with strongly thick cuticle. (2) Ground tissue compose of large suberinize parenchyma cells, 4 -6 sided, tangentially elongate and flattened, cells arranged in radial rows serially, thickness 350-600 μm, silicified bodies present on the cell walls. (3) Sclerenchymatous pith enclincled by the six large metaxylem cells.

2. Scientific Name - *Unidentify*
   Myanmar Name - Sha-Pya
   Family - Cyperaceae

General Description

Morphology

A tall perennial herbaceous plant; leaves, about 6 feet, long, slender, with acute tips; Sheathing at the base, reveals semi circular outline in t.s. Inflorescence not observed.

Anatomy

In transverse section (1) Epidermal cells not clearly observed because of the deposition of brownish substances. (2) The ground tissue composed of 2 types of cells (i) underlying parenchyma cells about 150 μ thick, cells 4-6 sided, radially arranged, (ii) the remaining area occupied by large air cavities, transversed by deform parenchymatous strands (3) Wide sclerenchymatous pith encircled by 9-10 metaxylem cells.

3. Scientific Name - *Cyperus digitatus*
   Myanmar Name - Nwa – Mye – Yin, Hti- Myet
   Family - Cyperaceae

General Description

Morphology

Glabrous, stem triquetrous. Leaves as long as the stems. Umbel 8-24 inch in diameter, bracts usually longes than umbel. Spikes corymbose, shortly peduncled. Spikelets variable in size, golden yellow rufous or brown.

Anatomy

Transverse section of the root reveals the following distinct characters: (1) numerous unicellular smooth walled hairs arise from the discontinuous epidermal cells. (2) Ground tissue composed of outermost 5-6 layered of parenchyma cells polygonal, compact; the middle portion of isodiametric aerenchyma cell contain large single crystal in each cell; innermost parenchyma cells about 6 layered, cells mostly rectangular. (3) Vascular bundles about 9 encircling the sclerenchymatous pith

Transverse section of the rhizome

The section reveals the following distinct characters (1) Heavily suberize (or) cutinize epidermal cells. (2) Underlying collenchymatous tissue 5-6 layered, followed by 3-4 layer of sclerenchyma cells the remaining parenchyma contain numerous oil cells. (3) Small numerous vascular bundles partially all wholly enclosed by sclerenchymatous cells.

4. Scientific Name - *Phragmites karka*
   Myanmar Name - Kyu, Kyu-phyu
   Family - Graminae

General Description

Morphology

Stem very tall; leaves perennial, panicle erect, branches wide spreading, leaves lanceolate - linear, spikelets about 18 cm long; glume 3, rarely more than ½ inch, flowering stems 1-3; style bifurcating.

Anatomy

Transverse section of the running stem

Naturally the running stems which floats on the water surface are very long, with distinct nodes and internodes ranging 5.5- 6.0 cm apart with numerous adventitious roots arise from the nodes. Running stem reveals yellowish green or pale green and a diameter of 0.5 – 1.5 cm, surface glabrous and waxy, internally the stem composed of large air – cavity which occupies $^{3}/_{4}$ of the diameter.

The section undertaking reveals the following distinct characters - the ground tissue composed of;- (I) collenchyma cells 1-2 layered, contain abundant minute crystals walls strongly thick (ii) parenchyma cells 2-3 layered containing abundant crystals, shape ovoid to ellipsoid, tangentially flattened (iii) followed by aerenchyma cells with air cavities (iv) continuous sclerenchymatous sheath 3-5 layered (v) followed again by aerenchymatous cells. (2) Numerous vascular bundles arranged in two rings, the periphral small bundles enclose by the sclerenchymatous sheath and large bundles lies at the innermost region, oval in outline with two large metaxylem and enclosed by sclerencymatous sheath.

Transverse section of adventitious roots

(1) Epidermis composed of extremely large rectangular cells radially longer than tangential, cells isodiametric. (2) underlying sclerenchymatous cells, one layered; followed by a single layer of large, rounded, parenchyma cells and large air cavities which occupied $^{3}/_{4}$ of the section. (3) Vascular bundles lies at the periphery of the pith.

5. Scientific Name - *Phragmites communis*
   Myanmar Name - Kyu ni
   Family - Graminae

General Description

Morphology

Stems 6-10 ft; leaves linear acuminate bases broad withering in winter; panicles 6-18 inches, branches not widely spreading, brownish purple, bracts very slender, smooth hairy; peduncles silky hair at the very base of the panicles.

Transverse section of the root

Similar structure to Kyu-phyu except the following difference (1) heavily thickened cuticle about 20 μm in thickness (2) 2-3 layered of exodermis (3) underlying large air cavities traversed by strands of bead-like parenchyma cells (4) parenchymatous pith (5) vascular bundles about 10 located at the periphery of the pith.

6. Scientific Name - *Hedychium coronarium*
   Myanmar Name - Ngwe-pan
   Family - Zigiberaceae

General Description

Morphology

A tall plant about 6 ft with branched underground fleshy rhizome. The leaves emerge from the rhizome as two distinct ranks, distichous, the blade linear to elliptic, large. Inflorescence compact spike; flower solitary subtended by a conspicuous bract, bisexual, zygomorphic, perianth in two series, pure white in colour.

Anatomy

Transverse section of the root reveals the following distinct characters:

(1) Numerous unicellular hair arise densely from the epidermal cells. Exodermis present, shape and size similar to epidermis. (2) Underlying tissue parenchymatous, mostly large and rounded, arrange compactly at the periphery and loosely below; presence of prismatic crystals. Secretory cells appear as bright dots abundantly present in the parenchymatous pith cells. (3) Bundler numerous; Xylem and pholem arrange alternately, encircling the pith. Underlying the bundles are large rounded schizogenous cavities, number as much as bundle.

Transverse section of the rhizome

(1) Prismatic crystals occur in some epidermal cells. (2) Composed of compact parenchyma cells, rounded to ovoid, thin-walled, cells large, crystals in various forms, and minute bright dots occur in almost of the cells. Oil cells present, scarce. (3) Numerous vascular bundles scattered in the ground tissue.

4. Chemical Aspects

Determination of extractable nutrients

Specimens of wild floating islands, upper and lower layer of the water gardens and used water gardens were analysed by the aid of Atomic Absorptive Spectrophotometer. The percentage of three major elements, Nitrogen, Phosphorus and Potassium were found out and the comparison was made with the element contain in the soil by the following table.

Element	Soil	Wild Floating Islands	Upper layer of water Garden	lower layer of water Garden	Used water Garden
N	0.02-0.2%	1.3%	1.4%	1.6%	0.6%
P	0.02-0.5%	0.0007%	0.0004%	0.0007%	0.0001%
K	0.05-3.5%	0.016%	0.2%	0.011%	0.02%

The comparison reveals clearly that the percentage of nitrogen was 6-8 times higher in the floating island than in the soil; phosphorus was extremely less and the amount of potassium did not show much difference.

6. Discussion and Conclusion

Studies on the formation of floating islands clearly reveals five main points, i.e., (1) floating islands are soil less islands composed of plants only (2) the most dominant plants on the mature floating islands are found to be Graminae and Cyperaceae (3) the submerged portion is a thick dense mass of running stems, adventitious roots and rhizomes of the above plants which are tightly interwoven, forming as a compact mattress, (4) anatomically the transverse section reveals thick waxy cuticle; epidermal cells with thick outer walls which are infiltrated by cutin and suberin that are impermeable to water, and waterproof the cells; Sclerenchyma assumes a cylindrical arrangement either beneath the epidermis directly or exodermis. All these anatomical characters are the facts which prevent to a certain period from decomposition and (5) large air cavities and aerenchyma cells occupying $^{3}/_{4}$ of the sections serve as the main source for buoyancy.

Chemically, the wild floating islands and the water gardens both use and non-use consists of nitrogen content 6 to 8 times higher than in the soil, phosphorus was extremely less, and not much difference in potassium levels.

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