

## STUDY ON THE FORMATION OF FLOATING ISLANDS IN THE INLE LAKE FROM BOTANICAL POINT OF VIEW

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### ABSTRACT

A 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, is presented. Six species of plants that are said to be the pioneers for the formation of floating inlands were analysed through their general morphology and anatomy of the submerged plant parts.

The chemical compositions of wild floating islands and floating water gardens, both in use and non-use, were also analysed with the aid of Atomic Absorption Spectrophotometer.

### INTRODUCTION

The<sup>1</sup> wealth of a country is measured by its natural resources. But there are some attributes created by nature only for a particular country or place and they are not similar for the whole world. They are to be expressed as natural luxuries. Inle Lake in Myanmar is one of them.

Inle Lake with its water catchments, floating islands, water gardens, flora and fauna is great interest and puzzle the foreigners and even the Myanmar people.

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Note: Designation at the time of the research is only used.

They seek knowledgeable answers to the mystery of the magnificent lake with surrounding mountain ranges. The lake itself is also a very important ecosystem supplying water to Lawpita hydropower station.

Innthas, whose unique culture and livelihood complements the scenic beauty of the lake, are native to the lake. It is so fantastic to see an Inntha with a bamboo hat standing on a boat with one leg rowing it.

The nature and structure of the wonderful ecological association of the lake should be made known to the scientists and researchers, laymen and at least to the puzzled foreigners. This paper is to present the structure of plants which build up the floating islands and contribute to their buoyancy.

## **LITERATURE REVIEW**

### **Inle Lake**

Geologists refer to the Inle Lake as tertiary (i.e. formed 350 – 400 millions years ago) in its origin and it occupies the deepest part of the Naung Shwe basin, which is about 40 miles long and about 8 miles wide and lies between the latitudes of 20° 10' and 20° 53' and the longitudes of 96° 50' and 96° 57'. The whole basin had once been occupied by a very large lake, much larger than the Indawgyi Lake, which is the largest natural lake now in Myanmar with an area of 55.9 sq.miles. According to Dr. Movius, Philadelphia University (1939) water level was 300 feet higher than the present level. Some thought that in the early stage the boundary of the lake reached to Shwe Nyaung, 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, and the floating islands about 27.96 sq. miles. The lake has become 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 Thamaikan, Heho and Naung Shwe which are separated from each other by the mountain ridges which split up and run into one another, though they will preserve the original north and south direction, thus encircling the flat-bottomed basins or valleys. Since the lowest levels for the basins are 4130', 3785' and 2880', it is evident that the drainage must be taking place from the Thamaikan Basin to Heho Basin or directly into the Naung Shwe Basin through the subterranean channels. Eventually all the three basins drain themselves into the Inle Lake, which also receives water from the eastern ridges through numerous swift streamlets. The southern side of the lake receives water from the Nampiluchaung, which flows through the Thamaikan Basin, which might have formed in prehistoric time, the Heho Basin, that appears to be drained within the prehistoric times probably during the time of the Bagan dynasty. According to legends there was a big stream flowing across the Naung Shwe Valley where Inle Lake now exits. The water drained from the three basins makes the formation of the Inle Lake (Nath, 1961).

### Water Sources of the Inle Lake (Irrigation Dept. Nyaung Shwe -1995)

Sr. no.	Streams from the eastern shore	Annual silting amount (acre ft)
1.	Nan-Si	20.8
2.	Su-Lin-Pan	12.8
3.	Lwe-Tant	8.0
4.	Taung-Pu	1.6
5.	Chaug-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
	<b>Total</b>	<b>229.6</b>

<b>Sr. no.</b>	<b>Streams from the western shore</b>	<b>Annual silting amount (acre ft)</b>
1.	Nam-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-Phan	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
	<b>Total</b>	<b>2036.8</b>

## Flora, Fauna and Water Quality

According to Nath (1961), there were about 12 species of aquatic plants throughout the highway from Nyaung Shwe to the northern shores of the lake.

Thant (1968) mentioned that 23 species of fishes were observed in the lake and also stated that the lake was 14 miles long and 7 miles wide. The depth of water was 12 ft in summer and rose up to 20 ft. in rainy season.

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

Organic matter	0.0161 %
Ca	0.0222 %
Mg	0.0279 %
Cl	0.0017 %
SO <sub>4</sub>	0.0017 %
HCO <sub>3</sub>	0.1030 %
Fe	0.48 %
Total N	0.7992 %
K	0.024 %
p <sup>H</sup>	7.38

## FORMATION OF FLOATING ISLANDS

So far studied, the present floating islands that occupy 27.96 sq. miles of the lake are soilless and, composed mainly of some plant species of families Gramineae and Cyperaceae. Among them are two Gramineae, *Phragmites karka* (Kyu-phyu) and *Phragmites communis* (Kyu-ni), three Cyperaceae, *Cyperus digitatus*, two unidentified species locally known as Sha-lone and Sha-pya and one Zingiberaceae,

*Hedychium coronarium* (Taw-Ngwe-Pan). The colonization of these plants does not take place at the same time but at different stages.

According to the information of some local natives (Innthas) Sha-lone and Sha-pya are the pioneer plants followed by Gramineae after a few years later. Finally the arising of Taw-Ngwe-Pan reveals that the floating island has attained a mature state and can therefore be transformed into the water gardens. It is said that all these changes took at least 10 to 15 years. By that time the thickness of the submerged portion is about 4-5 feet 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 suberized or cutinized epidermis, large air cavities and wide hollowed pith make the plants much lighter for buoyancy and can survive for more than 10 years in water without decomposition.

The Innthas said that the emergence of *Colocacia antiquorum* (Pein Yar) designates that the floating island can no longer be used, 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 Gardens**

When the floating islands reach to a mature state, i.e. over 10-15 years, the aerial plant parts are cut off from the base leaving only the under-water portion. Then, it is again cut into rectangular block of about 4' x 60' and moved to the place where it will be converted to a cultivated land. The remainders of the decayed aerial portion are burnt down; block silt from the bottom of the lake is carried by flat boats and spread over it up to such a volume of soil that the boat is still floating. When there is enough silt for a bed, the gardens are anchored by bamboo poles. A great variety of fruits, vegetables, ornamental flowers are cultivated on the water gardens.

Among them, tomato is the major crop of Innthas which is exported not only to the neighboring areas but also throughout the southern Shan State and even right down to Yangon and Mandalay, famously known as "Inn-Khayanchinthee." The water gardens can be used up to about 15 years, so long as the submerged mattress can hold its buoyancy.

### **Old Water Gardens or Abandoned Water Gardens**

The samples of the abandoned water gardens are soft, black, humus-like in structure and, therefore there is no longer holding buoyancy. They gradually sink to the bottom of the lake or have sunk down along the bamboo poles.

### **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 veins and smooth margins with acute tips, base sheathing. Spikelets clustered with numerous reddish flowers.

#### Anatomy

Transverse section of the root reveals the following distinct characters: -

- (1) Single layer of epidermis with strongly thick cuticle.

- (2) Ground tissue composed of large suberized parenchyma cells, 4-6 sided, tangentially elongated and flattened, cells arranged in radial rows serially, thickness 350-600  $\mu\text{m}$ , silicified bodies present on the cell walls.
- (3) Sclerenchymatous pith encircled by the six large metaxylem cells.

2. Scientific Name - *Unidentified*  
 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 transverse section  
 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  $\mu\text{m}$  thick, cells 4-6 sided, radially arranged, (ii) The remaining area occupied by large air cavities, traversed by deformed 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 inches in diameter; bracts usually longer than umbel. Spikes corymbose, shortly penduncled. 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 layers 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 cells.

### Transverse section of the rhizome

The section reveals the following distinct characters:

- (1) Heavily suberized or cutinized epidermal cells.
- (2) Underlying collenchymatous tissue 5-6 layered, followed by 3-4 layers of sclerenchyma cells the remaining parenchyma contain numerous oil cells.
- (3) Small numerous vascular bundles partially or wholly enclosed by sclerenchymatous cells.

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|----|-----------------|---------------------------|
| 4. | Scientific Name | - <i>Phragmites karka</i> |
|    | Myanmar name    | - Kyu, kyu-phyu           |
|    | Family          | - Gramineae               |

## **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 that float 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 stems reveal 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  $\frac{3}{4}$  of the diameter.

The section undertaken reveals the following distinct characters

(1) 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 flattered
- (iii) followed by aerenchyma cell 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 peripheral small bundles enclosed by the sclerenchymatous sheath and large bundles lie at the innermost region, oval in outline with two large metaxylem and enclosed by sclerenchymatous 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  $\frac{3}{4}$  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 adventitious roots

Similar structure to Kyu-phyu except the following differences

- (1) heavily thickened cuticle about 20  $\mu\text{m}$  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 coronariun*  
 Myanmar Name - Ngwe-pan  
 Family - Zingiberaceae

## **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 color.

### 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 phloem 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.

## CHEMICAL ASPECTS

### Determination of Extractable Nutrients

Specimens of wild floating islands, upper and lower layers of the water gardens and abandoned 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 elements containing in the soil by the following table.

Element	Soil	Wild floating island	Upper layer of water garden	Lower layer of water garden	Abandoned 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.

## DISCUSSION AND CONCLUSION

Studies on the formation of floating islands reveal five main points as follows:

- (1) floating islands are soilless and composed of plants only;
- (2) the most dominant plants on the mature floating islands are found to be plant species of Gramineae 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 impregnated with cutin and suberin that are impermeable to water; sclerenchyma cells are in 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  $\frac{3}{4}$  of the sections serve as the main cause for buoyancy.

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

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