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The Chinampa: An Agricultural System That Utilizes Aquatic Plants

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INTRODUCTION

The most intensive system of agricultural production in Middle America is marsh farming or the farming of muddy-bottom wetlands. In Mexico the system is called a "chinampa".

The chinampa, developed over 2,500 years ago, utilizes a technique known to the early inhabitants of the Mexico City Valley before the arrival of the Mexican culture. An interesting example is the then important Middle American city of Teotihuacan, where inhabitants used aquatic plants in fields which had been reclaimed by draining marsh land. The mural of Tepantitla, dated 400 to 600 A.D. depicts *Nymphaea mexicana,* an aquatic plant known as "atlacuatzon", as an important part of the chinampa system.

THE CHINAMPA

The purpose of this paper is to describe the aquatic vascular plants related to the chinampa system in the Mexico City Valley. Biotic and abiotic samples were systematically collected in the different habitats of a chinampa using conventional techniques for limnological studies. This preliminary study was done in Xochimilco and Mixquic, two areas south of Mexico City frequently visited by tourists and local residents.

The chinampa is established in shallow lagoons where the terrain is raised in ridges or small islands limited by three or four canals. There are two types of these canals: the main or "acalotes", are more than 5 m wide and 1.5 to 4 m deep, and the secondary canals or "apantles", measuring 1 to 3 m wide and 1 m deep.

The growth and development of Mexico City has had a detrimental influence on the aquatic environments of the Mexico City Valley, as a result of water usage, pollution, and drainage projects. For example, several hydrophytes such as *Typha* species, *Scirpus lacustris, Potamogeton foliosus,* and *Nymphaea mexicana* have disappeared from the old lake area of Xochimilco and Mixquic. These species in past epochs comprised the "cesped" or lawn, that is, the mixture of hydrophytes used in the building of chinampas.

Presently, new chinampas are no longer built in Xochimilco and Mixquic because the reduction of the canal system no longer allows sufficient space. Some chinampas are being reclaimed that were abandoned or deteriorated through a rise in water levels.

Modification of the terrain for the farming of muddy-bottom wetlands begins in the shallower areas with little water movement. Man simply accelerates the process of natural succession that takes place, speeding succession by planting a fence of branches with the common willow, *Salix bonplandiana.*

The different stages leading from swamp or marsh to chinampa were better characterized in antiquity. The first stage was made up of submersed hydrophytes or floating plants such as; *Potamogeton lucens, P. foliusus, P. pectinatus, Nymphaea mexicana, Najas flexilis, Zanichellia* *palustris, Sagittaria macrophylla, Utricularia vulgaris, Ceratophyllum demersum, Myriophyllum brasiliense,* which in present chinampas are replaced with *Potamogeton pectinatus* (relicts), *Jaegeria bellidiflora, Ceratophyllum demersum, Nymphaea mexicana* (relicts).

The second stage was characterized by an abundance of emergent hydrophytes, principally cyperaceae; *Scirpus americanus, S. lacustris, Cyperus esculentus, C. hermaphroditus, Eleocharis acicularis, Typha latifolia, Typha angustifolia, Juncus effussus, Sagittaria macrophylla* and *Pistia stratiotes* as a free-floating element. Today, the dominant species in this stage are; *Lemna gibba, L. minor, Spirodela polyrhyza, Wolffia columbiana, Eichhornia crassipes* and species of emergent hydrophytes such as; *Polygonum amphibium, P. persicarioides, P. lapathifolium, Lilaeopsis occidentalis, Berula erecta, Limnobium laevigatum, Eleocharis palustris, Scirpus americanus,* and *Hydrocotyle ranunculoides.* Gradually the soil level rises through the accumulation of sediments and fundamentally from the detritus of hydrophytes from the first two stages. At this point the final stage begins in the transformation of the marsh to a chinampa. Currently, the dominant vegetation is an american bulrush *Scirpus americanus,* accompanied by; *Hordeum jubatum, Paspalum humbldtianum, Echinocloa holciformis, E. cruzgalli, Polygonum punctatum, Rumex crispus, R. obtusifolius,* and *E. palustris.* Interestingly, scarcely fifty years ago the floristic composition at this final stage of the wetlands was dominated by species of *Typha* and *Scirpus.* At this point the farmers or "chinamperos" begin raising the terrain above the water table by means of layers or mats formed from the previously mentioned species ("tules" = cattails and rushes), willow branches, and corn stalks called "canuela" or "little cane". The extinction of the species called collectively "lawn" or "cesped", and the appearance of others normally considered as aquatic weeds, provide an interesting example of the natural solution found by the chinampa farmers in this part of the Mexico City Valley. The "lawn" presently used by the farmers or "chinamperos" to raise the level of the marsh or swamp and leave the ground ready for planting, is made up of the following species; *Eichhornia crassipes, Limnobium laevigatum, Lilaeopsis occidentalis, Lemna gibba, L. minor, Wolffia columbiana, Hydrocotyle ranunculoides* and *Scirpus americanus.*

The most abundant salts in the chinampas are bicarbonate of sodium and magnesium, sodium and magnesium chloride and calcium sulphate. It is evident that there exists a process of salinization in the aquatic environment. Sodium values of 0.5 g/l are regularly found in main canals. This point is important because salinity represents a high degree of risk in any cultivated soil. This problem again illustrates how the primitive chinampa technique has lasted effectively through the centuries as the answer to salinity probelms is solved by proper management of organic matter.

The wet and dry weights of the more common species in the canals indicate the great quantity of water retained in their tissue and the significant contribution to the sediments of vegetable carbon, which is the main component of the muds or organic soils used to fertilize the system.

The totally decomposed portion of organic matter (humus) helps solubilize certain salts that could be found as precipitates, and in this way they can be reused as humates of potassium and ammonium. The reaction of humus with sodium is completely opposite. Humus buffers the salt effect by making sodium insolube. This results from the liberation of certain organic acids which give a slightly acid character to the sediments during decomposition. The lowered pH prevents the formation of sodium humates.

The organic matter found in mud from the bottom of the canals is under anaerobic conditions. Nitrogen, in the form of ammonium, cannot be assimilated by land plants. When this mud is scooped up and spread on the ground it oxidizes rapidly forming nitrates, which are available for growth of cultivated plants.

Generally, these muds have optimum properties required for plant growth; humidity, excellent texture, and good cation exchange capacity. A soil pH of 6 to 7.8 in the water avoids phosphorus precipitation and favors the formation of dicalcic phosphate which is easily assimilated by plants.

The use of these muds is a technique employed for centuries in chinampa farming. It offers the possibility of producing uninterruptedly a great variety of crops. An average of four crops a year can be harvested with yields of up to 90 metric tons of Swiss chard per hectare, 25 metric tons of spinach per hectare, or four tons of corn per hectare. The chinampas are an old yet still important aspect of agriculture in Middle America.