# Macrobotanical Remains in Archaeology: Preservation Modes and Method

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**Abstract:**

During excavation, archaeologists sometimes notice the presence of plant remains in the archaeological sediment. These more visible macrobotanical remains include wood, seeds, fruits and floral parts. Depending on the region and conditions, they can be preserved by various modes, including dessication, waterlogging and charring; the latter being the most common especially in modern Iraq.

Thanks to the development of research on this organic material, our knowledge on the way of life of ancient societies was greatly improved. They would be able to provide important knowledge about earlier vegetation, the plant exploitation including cultivation and domestication process as well as the diet. In addition, plant remains may help us to reconstruct activities and help us to interpret the function of spaces and/or structures. However, before being able to provide such information, the archaeobotanical study requires to apply strategies and methods from sampling to interpretation. Our paper presents these different steps.

**Keywords:** Archaeobotany , Flotation , Charred Plants , Mineralisation, Dry Sieving

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# بقايا النباتات الكبيرة في علم الآثار: أنماط وطرق الحفظ

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**الملخص:**

خلال التنقيبات، يلاحظ علماء الآثار أحيانًا وجود بقايا نباتية بين الرواسب الأثرية. تشمل هذه البقايا النباتات الكبيرة التي ترى بالعين المجردة كالخشب والبذور والفواكه وأجزاء من الزهور. وكل هذا يعتمد على الظروف المناخية للمنطقة، عند اكتشافها حيث يمكن الحفاظ عليها باستعمال طرق مختلفة، بما في ذلك التجفيف والتشبع بالمياه فضلا عن التفحم؛ والطريقة الأخيرة هي الأكثر شيوعًا في العراق.

حيث ظهرت دراسات حديثة بفضل التطور العلمي في البحث عن المواد العضوية، ومن خلالها تحسنت معرفتنا عن ماهية وطرق الحياة لدى المجتمعات القديمة بشكل كبير. اذ يمكنها تقديم معلومات مهمة حول مدى الغطاء النباتي في العصور القديمة، ومدى تطور المفاهيم الزراعية وعمليات التدجين فضلاً عن النظام الغذائي.. فضلا على ذلك، قد تساعدنا بقايا النباتات في إعادة بناء الأنشطة والحصول على تفاسير لوظائف المساحات والهياكل. للحصول علي المزيد من المعلومات، تتطلب الدراسة الأثرية تطبيق استراتيجيات وطرق مختلفة من خلال أخذ العينات المختلفة وتقديم التفاسير المختلفة لها، وهدفنا في هذا البحث هو معرفة الطرق المختلفة في الكشف عن النباتات الكبيرة المكتشفة خلال التنقيبات الأثرية ودراستها بصورة علمية دقيقة.

**الكلمات المفتاحية:** علم النبات الأثري، التعويم، النباتات المتفحمة، التمعدن، الغربلة الجافة.

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## Introduction

During archaeological fieldwork, archaeologists sometime notice changes in the colour or texture of the sediment. Dark burnt and white soft ashy layers are among the most easily recognisable deposits. They can be associated to a structure such as a hearth, oven or kiln and be spread within the site, in internal or external spaces. These specific layers have a high probability to contain plant remains, preserved by charring. Whereas other preservation modes exists in the world depending on the region and conditions of deposit (dessication, waterlogging), in Iraq plant remains are mostly recovered in the charred form. Additional modes of preservation in the region includes (bio) mineralisation and plant impressions.

Plant macroremains refers to items that are, in theory, large enough to be visible by eyes. However, since the earliest archaeological research carried out in Iraq, little attention was carried out on The retrieval of plant remains. The field of study, the archaeobotany, The study of plant remains is a relatively new field that originated towards the end of XIX$^{th}$ century and was developed by european researchers in western Europe, but also in Anatolia, Egypt and Peru. Plant remains include wood, seeds, fruits, tubers and other floral parts. Their analysis and identification may help archaeologists to understand and reconstruct activities carried out by the inhabitants of the site. Indeed, this organic material can provide information on 1) the vegetation that was surrounding the occupation, 2) the seasonality of the settlement (camp versus permanent village), 3) strategies of plant exploitation, and it especially highlights if people were gathering or cultivating plants and how and 4) the uses of the plants, as food, fuel, architecture, craft etc.

Information obtained through archaeobotanical analysis can (and should) be confronted to other material and fields of study to answer specific questions. As an example, if the plant remains can provide information about the crops consumed by an ancient community, the type of pottery associated to it may allow us to further investigate storage and/or cooking practices. Similarly, the study of lithic industry may provide additional information about plant harvesting strategies. Interdisciplinary allow archaeologists to cross and check data obtained from various disciplines. The archaeobotanical results can thus, be discussed and compared to other available data to reconstruct the history of an archaeological site. This paper, deriving from the master thesis of S.H. Agha carried under the direction of prof. A.KH. Kamil and R. Buxo Capdevila, The objective of this paper is to provide an overview of the fundamental principles of archaeobotany and to present the methodologies employed in the retrieval and identification of macrobotanical remains.

## 1. The macrobotanical remains

Plants can be divided into different groups or categories, depending on the scientific perspective (anatomy, botany etc). We can, for example, distinguish the vascular from the non-vascular plants ; the first one being subdivised into the gymnosperms and the angiosperms. But plants can also be classified into trees, shrubs and herbs according to the degree of lignification.

Plant macro remains are fossilized plants that are visible at a distance and that can be handled by hand. A macrofossil may range in size from 0.5 mm to an enormous trunk of a tree, there is a median size of 0.5 mm to 2.0 m. [1]

There are many types of plant macro remains, including fruits, seeds, wood, tubers, fibers, leaf fragments, etc. [2] Identifying fragmented fruit, nut, and large seed remains is therefore largely a matter of detailed study of comparative material. To recognize the charred Macroremains , To effectively compare and identify archaeological materials, it is necessary to char and fragment reference materials in a manner that closely matches the size and composition of the archaeological specimens.[3]

## a. Wood (and wood-like)

The term of « wood » usually refers to lignified plants. However, some plants such as the date palm are often considered as trees whereas, botanically speaking, they are not. [4]

Wood remains provide information about the vegetation surrounding a site at the time of its occupation, its exploitation and evolution including degradation related to human activities.[5]

The identification of charred wood is one of the primary tasks undertaken by paleoethnobotanists.[6] Through the charring process, certain characteristics that are typically helpful in identifying fresh wood, such as color and odor, are eliminated.[7] Wood can be used as construction material to build houses but also ships, as fuel and to produce objects (such as hunting or agricultural tools, vessels, etc). However, the recovery of wood can also reflect wood management associated to cultivation activities.[8]

## b. Seeds, fruits, underground storage organs and floral parts

Seeds are reproductive structures. The seeds of the gymnosperms are naked whereas those of the angiosperms are enclosed and protected by an ovary.In angiosperm seeds, there are three major components: the embryo, the endosperm, and the seed coat (testa). Archaeological seeds may not preserve all distinguishing characteristics. Charring, for example, can alter the size and shape of the seeds, or the seeds may be broken. Seed coats provide important diagnostic characteristics, such as color for uncharred seeds, texture, attachments, and scars. The ability to recognize and distinguish seeds significantly declines when the protective outer layer of the seed, known as the seed coat, is either lost through charring or eroded in dried-out materials.[9] Typically, when large seeds are found, they often present a fragmented challenge. To successfully identify charred specimens, it becomes crucial to deliberately char and fragment comparable materials that resemble the archaeological samples. Additionally, a thorough examination of distinct tissue features is required[10] The accurate identification of archaeological seeds to botanical taxa is largely based on comparing archaeological specimens to known varieties of seeds.[11]

Forthermore the Fruit is a matured ovary and its attaching parts. Depending on fruit structure, the ovary wall, or pericarp, can be soft, fleshy, leathery, rigid, or thin. [12] Fruits derive from the development of the ovary and can consequently only be produced by angiosperms. [13] Seed arrangement in fruit can also vary. Certain fruits exhibit the characteristic of a solitary seed that is united with the wall of the ovary.[14] Other fruits contain multiple seeds. While archaeologists occasionally discover intact whole fruits, it is more typical to find fragments of edible portions of the fruit.[15]Additionally Nuts are hard and bony fruits that are indehiscent, one-celled, and one-seeded. There are some nuts that are covered by a leathery husk, such as those in the hickory family. There may be archaeological evidence of husk fragments, hard pericarps, and embryos of nuts. [16] Identifying many roots and tubers based on their form and structure can be challenging due to the variable nature of these characteristics. However, the degree of preservation and fragmentation of macro remains can further limit the success of identification.[17] When preservation is through charring, recovering tuber or root peelings is very unlikely, because such remains are quite fragile. However, it is possible to find finds both in dry and waterlogged preservation settings. [18] It was also attempted to detect tuber exploitation via tool useware and residue analysis [19]

## 1.1The preservation modes and states in Iraq

In normal conditions, organic material would desintegrate through time. [20] Specific favorable conditions must be met for plant remains to be preserved in archaeological deposits.[21] Natural and cultural processes have a significant impact on the preservation state of archaeobotanical material. Each preservation mode alters differently the plant remains and the preservation potential of plants varies from species to species.[22]

### 1.1.1 Charring

From an archaeological standpoint, charring is perhaps the most beneficial outcome for a seed, even though it may appear counterintuitive. Charring renders a seed highly resistant to decomposition as charred plants become inedible to insects, animals, bacteria, and fungi..[23] Charred plant remains survive in most environments, and charring (carbonisation) is the most frequent mode of preservation encountered on archaeological sites in Iraq. In most cases, open fires such as in hearths, parching ovens or house fires, exposed plant remains to high temperatures leading to their carbonisation. [24] The fire can be accidental or voluntary. [25] The organic molecules in the plant are transformed into charcoal by this heating (when there is a restricted supply of oxygen). [26]Carbonised plant remains can persist in most conditions because charcoal is unaffected by bacteria, fungus, or other organisms that break down organic matter. Consequently, plant materials that are utilized as fuel, discarded into fires, or handled in close proximity to open flames have a higher probability of undergoing charring.[27]

Charring can alter the morphology and the morphometry of the plant part. It can led to a shrinkage (size decrease) or conversely contribute to create puffy macrobotanical remains. The identification of plant specimens significantly decreases when they are fragmented or when the seed coat is damaged or poorly preserved. Furthermore, different plant parts and taxa exhibit distinct responses to charring. The hard nutshell fragments (for example pistachio fruit endocarp) are usually better survive charring than fragile seeds like oily seeds of flax or poppy (that tend to explode when exposed to fire).[28]

### 1.1.2 (Bio-)mineralisation

In classical archaeological contexts, mineralization is a frequently encountered preservation method, with calcium-phosphate replacement being the predominant form observed.[29] This kind of preservation is accomplished by adding minerals to the cell walls or by filling the cell voids with inorganic materials. Mineralization using calcium carbonate (CaCO 3), silica, or phosphate is the most frequent.[30] The prevalence of these conditions is most notable in latrine deposits, where the majority of the assemblages consist of plant remains that were consumed and subsequently excreted by humans. These deposits offer exceptional evidence of diet. However, the distribution of such assemblages in the classical world is highly localized due to the specific microenvironment necessary for calcium-phosphate preservation.[31] Mineralization occurs when inorganic substances take the place of the organic content in plant remains. Several plants' seed coats and fruit shells naturally undergo mineralization. These mineralized plant parts occasionally endure in archaeological deposits without requiring additional external preservation methods.[32]

## 1.2 Recovering techniques

### 1.2.1 Sampling strategies

In Archaeobotany, usually archaeologists use different methods for sampling according to regions, sites, period and specialists.[33] Given that charring can arise from both intentional and unintentional burning, it may seem reasonable to adopt a sampling approach that focuses exclusively on contexts displaying evidence of burning.[34] Nevertheless, solely sampling hearths or visibly ashy deposits does not consistently lead to the retrieval of a macroremains sample that accurately represents the broader context in practice.[35] It is possible to clean hearths periodically, limiting their usefulness. Once charred material has been dispersed or relocated from its original primary deposition context to secondary contexts, it becomes challenging to visually identify and extract samples from it.[36] In most excavation situations, it is not feasible to recover plant macroremains of all sizes from every cubic meter of excavated soil. Even if all soil is sieved through a water separator system, selecting a mesh size that allows for efficient processing can still lead to the unintentional loss of small remains.[37] For all size grades of macroremains, bulk sieving is impractical; instead, samples of the excavated soil should be Gathered for the purpose of flotation or meticulous sieving. [38]Sampling allows for a reduction in the number of samples collected for analysis, leading to an expedited processing time. This is achieved by processing smaller volumes of sediment during the sampling procedure, rather than processing entire contexts.[39] [40]

Moreover the sampling strategy sould be in agreement with the project research ans the nature of preservation . When there are several temporal components at a site, In order to optimize temporal contrasts, it is feasible to select a smaller subset of sediment samples for analysis.[41]

Comparing Collections of artifacts and remains from all hearth features or samples taken from the floors Over a period of time is possible. For single-component sites, it is possible to select samples that offer the greatest insights into the varying utilization of space. In essence, it is easier to choose a smaller subset of samples (potentially analyzing 25% or less of the total samples) for analysis rather than attempting to predict the optimal sampling contexts during the ongoing excavation process.[42] Archaeobotanical samples are typically collected using three techniques: "pinch" or composite sampling, column sampling, and point sampling. [43]

When excavating horizontally intricate regions that demand context-specific botanical information, it is advisable to take samples at shorter intervals and from more precisely defined areas. It is crucial for the sampling process to promptly adapt to changes in excavation strategy or conditions. Moreover, I suggest avoiding composite sampling over areas exceeding one meter in size; if the units are larger, they should be subdivided accordingly. Each sediment sample should be placed in a new plastic bag, promptly sealed, and labeled with relevant provenience details such as the grid number. [44] Between samples, Ensure that the sampling tool (such as a trowel or a similar instrument) is properly cleaned.

During sampling, it is important for each sampling unit to maintain a consistent depth when cutting into the floor, avoiding any intrusion into lower strata. When excavating substantial pit features, dissecting them into sections enables the study of profiles, which helps guide sampling efforts and enhances the chances of obtaining botanical samples that accurately reflect the original purpose or function.[45]

In conclusion, here are some pointers for effective archaeobotanical sampling:

(1) Collect sediment samples of standardized sizes for the purpose of flotation or fine-sieving. [46]

(2) Handle the sediment collected for flotation or fine sieving with care. Ensure that the samples are taken from sediment that has already passed through bulk screens, while being cautious not to force the sediment through the screen.

(3)Use sediment bags with two tags. In cases of moist sediment, paper tags placed inside flotation sample bags degrade rapidly. Writing information on the outside of plastic bags with an ink marker fades quickly when exposed to sunlight.

(4)Evaluate the condition of the sediments. If the flotation samples are wet, leave the plastic bags open to allow the sediments to dry during processing. In instances of large wet samples, it may be necessary to spread them out or subject them to water sieving.

(5) Float or fine sieve the sediment samples, aiming to keep pace with the fieldwork. While the recovery of macroremains often lags behind

excavation, it is advisable to commence sediment processing early in the field season.[47]

### 1.2.2 Processing

Small seeds, on the other hand, are frequently difficult to detect with the naked eye, especially if they are waterlogged in dark organic sediment.[48]

Archaeological sites provide three methods for recovering macro remains: direct retrieval from the site itself during excavation, utilization of excavation screens, and application of water-based recovery techniques such as flotation or fine-sieving.[49] Considering the significant variation in preservation conditions both within and between sites, it is crucial to formulate a comprehensive recovery plan that aligns with long-term excavation objectives. Sampling strategies must account for factors such as the quantity and distribution of samples, sample volume, and appropriate recovery techniques. These decisions depend on various factors, including the specific characteristics of the archaeological site, the sediment type, the expected preservation methods, the research inquiries at hand, and the available resources.[50]

Generally Dry-sieving (dry screening), manual and machine-assisted flotation are commonly employed in Iraq for plant material recovery.

#### a. Dry Sieving

Dry Sieving (Screening) is one method for dealing with this problem. Dry screening is now a common method in commercial and academic excavations, allowing for the systematic recovery of tiny objects such as lithics, pottery sherds, bone, and shell.[51] However, because the majority of seeds and other plant pieces are so tiny (2 mm), if the screen aperture size is too high, botanical material may be lost. Plant remains may be crushed or have their distinctive traits removed when handled with stones and other thick materials. Dry screening is sometimes the most practical way to retrieve macro remnants, though.[52] During extremely dry conditions, bacterial activity is reduced, resulting in dried/desiccated plant remains (e.g., in a desert environment).[53]

Using water in other ways to extract macrobotanical remains weakens them. In spite of the fact that the plant material appears very well preserved, wetness greatly accelerates tissue breakdown and decomposition. Water can even explode carbonized plant remains from arid areas. **(figure.1)**. [54] [55]

## b. Manual Flotation

The foundation for flotation equipment is grounded on the principle that combusted botanical elements possess a lower density (1 g/mL) than that of water.When sediment is shaken in water, charred plants rise to surface for collection with a skimmer or mesh container.[56] In order to capture the minute components of plant remains, commonly referred to as the light fraction, a mesh of 0. 5 mm or smaller is conventionally utilized. The archaeological practice of retrieving artifacts involves segregating stone tools, ceramics, bone, and other materials with higher density than water, resulting in their individual retrieval.[57] Bucke flotation is a basic and easy-to-build system. To facilitate the collection of heavy materials, a mesh screen is affixed to the bottom of a bucket after cutting it off. The sediment-filled bucket is then emptied into a tub filled with water. Using a fine mesh hand-sieve, the lighter fraction is sieved from the water's surface.[58] [59] (**figure 2)**.

### c. Flotation Assist by Machine

Machine-aided systems, in contrast to manual techniques which depend on hand-agitation or bilge pumps, commonly utilize a type of hydrodynamic force generated by a gasoline-powered pump.

The Ankara Machine (**figure 3**), commonly referred to as the water separator, is regarded as one of the earliest systems to have been conceptualized and created. The methodology employed involved the utilization of water pressure derived from an elevated reservoir to effectively cleanse non-floating artifacts, disintegrate sediment, and rinse charred plant remains into a distinct flot box that was deliberately coated with fine mesh. [60].

The SMAP[61] device has the capability to send water directly to the primary container without requiring a raised holding structure. Additionally, it has the added benefit of being easily transportable.[62] Various SMAP tanks in use for processing clay sediments. Settling tanks collect and remove sediment from the flotation tank's outflow, recycling clean water. Useful in limited water and conservation situations.[63]

"Water pressure alone does not constitute the sole means of agitation for samples. " Froth flotation apparatuses employ air pressure, generated by compressed air and/or a frothing agent, to induce the formation of bubbles for the purpose of dispersing and segregating sediment into distinct light and heavy factions (**figure 4**).[64]

## 1.2.3 Analysis

### a. Sorting (large and small mesh)

During excavation, a field laboratory is required for both sample storage and post-processing tasks. The field lab should ideally feature capabilities for first analysis of light fraction samples, as well as space for sorting items collected in heavy fraction residue.

The field lab accommodates a variety of additional activities, and excavators and trench supervisors frequently work there in the evenings.[65]

Basic Sorting Procedures and Equipment: Counts, weights, and frequently measures or other characteristics of items according to taxonomic grouping are recorded while analyzing plant remnants recovered by flotation or a related, fine-mesh recovery technique.[66]

Selection of Samples: All samples known to be from secure stratigraphy can be studied where relatively few seeds have been recovered. However, bulk flotation of richer sites, such as those in the Near East, can yield hundreds of samples ranging from a few seeds to thousands of seeds.[67]

Sorting Methods: When a sample has both light and heavy fractions, they are typically studied individually, however the numerical data can be merged when reported. Each sample (or light and heavy fraction) is weighed to the closest 0.01 g before being passed through a series of nested geological sieves, resulting in "splits" of similar-sized particles.[68]

Individuals sorting through samples should be able to recognize and collect artifacts such as lithics, pottery sherds, and animal bone because heavy fraction residues may include them. (**Figure 5-6**), [69]

**b. Identification:**

Diagnostic characteristics, such as color (for uncharred specimens), texture, attachments and scars morphologies allow to identify plants parts. While photographs and drawings can serve as useful visual aids, they cannot replace or substitute the original material itself. Comparative material (*herbarium*, seed bank) is required in order to check the identification of the plant remains. Observing comparative specimens enable the archaeobotanists to gain an understanding of the diagnostic characteristics and how it can be distinguished from other similar specimens.[70] Sometimes, experimental charring allows to create reference collection of specimens preserved in similar conditions. This comparative material helps to understand the effects or damage induced by the specific conditions.[71] It is essential to conduct complete sample analysis and identification in a laboratory that has access to a physical reference collection. However, for individuals who require on-site work, there are now printed and digital seed atlases available to assist in the process.[72] The identification of plants necessitates a considerable duration of experiential learning and thorough acquaintance with the subject matter. Considering the uncertainties associated with the preservation of archaeobotanical specimens, and the intricate and laborious process of distinguishing and categorizing them, it is imperative to design a comprehensive sampling methodology at the outset of a research initiative.[73]

**Conclusion**

In summary, this paper highlights several key points regarding archaeobotany and its significance in understanding ancient societies:

1. Multifaceted Information Source: Archaeobotany offers a wealth of information to delve into and reconstruct the daily lives of ancient civilizations.
2. Interdisciplinary Insights: The interpretations drawn from archaeobotanical data are intricately linked to broader archaeological inquiries encompassing ecological, social, economic, and political aspects.
3. Historical Neglect: Historically, archaeobotany did not receive the attention it merits, which explains the limited investigations in the field.

4. Recovery Methods: The paper explores various methods for recovering plant remains in diverse states, underscoring the importance of standardization while recognizing the need for flexibility to adapt techniques to the unique characteristics of each site.
5. Evolution of Techniques: Weakness recognition within the field has spurred the development of innovative recovery techniques in paleoethnobotany.
6. Diverse Plant Uses: Examining the complete spectrum of plant materials brought to ancient sites for purposes such as sustenance, fuel, construction, and toolmaking yields invaluable insights into ancient societies.

These points collectively emphasize the significance of archaeobotany as a multidimensional tool for exploring and comprehending the complexities of past civilizations.

# Figures

**(figure.1)** Dry sieving process

(https://zagoraarchaeologicalproject.org/2013/10/04/archaeological-sieving/)

(**Figure 2)** Manual flotation machine

(http://clarissacagnato.weebly.com/macrobotanical-analysis.html)

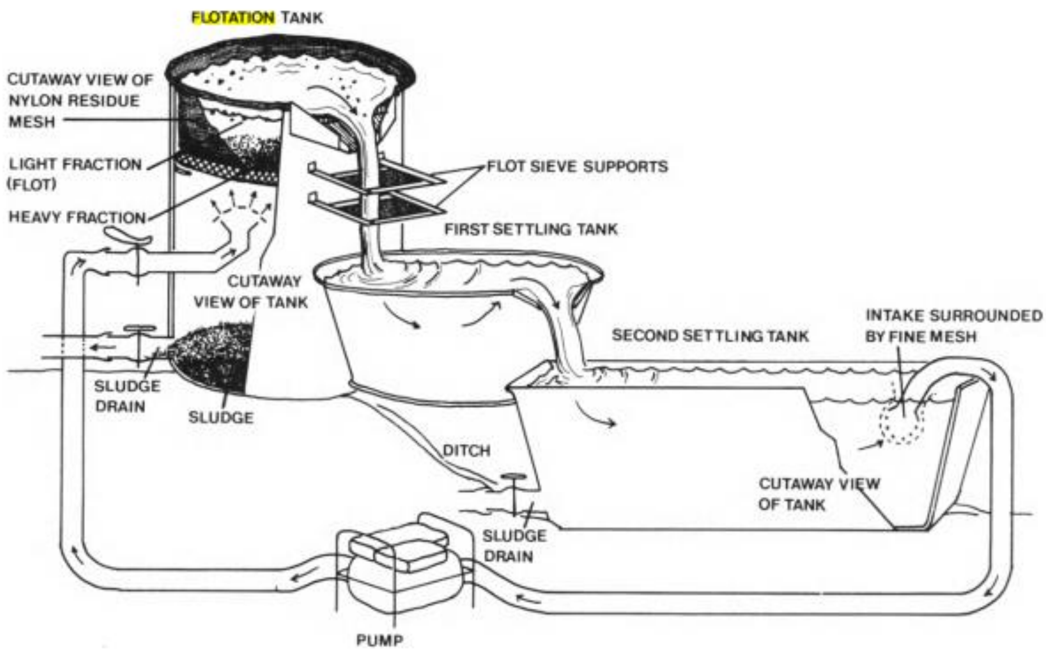


**Figure 4**: Flotation System (Ankara Machine)

(Deborah M. Pearsall, *Paleoethnobotany: A Handbook of Procedures* (San Diego: Academic Press, 1989), 57.)

**Figure 4**: Flotation assist by machine

(The photo by researcher)


(**figure 5**) sorting heavy residues process

(The photo by researcher)

(**figure 6**) sorting light residues process

(https://www.penn.museum/blog/museum/archaeobotany-in-the-gardens-of-emily-dickinson-clues-collections/)

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