The construction and operating costs of conventional water treatment systems often are cost-prohibitive. They involve highly mechanized systems and require a minimum inflow that exceeds the water treatment needs and economic possibilities of small population centers. Natural low-rate biological treatment systems tend to be lower in cost and less sophisticated in maintenance although they require the use of relatively large land areas.

The three main natural treatment systems are:

Upland natural wastewater treatment systems
Wastewater stabilization ponds
Wetland wastewater treatment systems (Macrophyte treatment)

Macrophyte treatment:

They are ponds which incorporate aquatic plant species. Macrophytes take up large amounts of inorganic nutrients (especially N and P) and heavy metals as a consequence of the growth requirements. The harvested plants might be fed to cattle, used as a green manure, composted or converted into biogas.

Floating Aquatic Macrophyte Systems

Several genera are used, including *Salvinia, Spirodella, Lemna* and *Eichornia* (water hyacinth) In tropical regions, water hyacinth can produce more than 250 kg/ha d (dry weight). Floating macrophyte species can be easily collected. In colder regions, these floating species do not reach a large size, and their production of biomass is limited, which reduces their absolute water treatment value.

Emergent Macrophyte Treatment Systems

The growth rate and pollutant assimilative capacity of emergent macrophytes such as *Phragmites communis* and *Scirpus lacustris* are limited by the culture system and wastewater loading rate. More than 50 % of the nutrients are stored in below-ground portions of the plants, difficult to harvest to achieve effective nutrient removal. However, because emergent macrophytes have more supportive tissue than floating macrophytes, they might have greater potential for storing the nutrients over a longer period. Consequently, frequent harvesting might not be so necessary to achieve maximum nutrient removal.

1. System of emergent superficial-flow macrophytes:

In superficial-flow systems, contaminants are eliminated through reactions that take place in water and upper zone of contact. Little wastewater circulates through the roots, which limits their water treatment capacity.

2. System of emergent subsuperficial-flow macrophytes:

As in the previous system, a layer of gravel or soil is used, through which water circulates by gravity. Its most important drawback it the rapid clogging up of the terrain with time by roots, rhizomes, and sedimented solids.

3. A new method: artificially floating macrophyte filters

This wastewater treatment system, developed by the School of Agricultural Engineering of Madrid, is based on emergent macrophytes that naturally root to the soil, but in this case are converted into artificially floating macrophytes. Since they float, these species form a dense mat of roots and rhizomes that occupy the entire volume of the collector (pond or

canal), thus forcing all the water to circulate through the matted vegetation, which supports microorganisms that degrade organic material.

This new method combines the advantages of floating and emergent macrophyte systems, eliminating or reducing the drawbacks of these systems. To date, *Typha, Phragmites, Sparganium, Scirpus* and *Iris* have been used especially.

The advantages of the FMF system are:

- Easy installation and minimum energy demand
- Greater effectiveness: the entire volume if wastewater circulates through the treatment mesh (annual absorption rate 180 g N/ m^2 and 27 g P/ m^2) (*Typha latifolia*)
- Harvesting does not destroy the system
- Production of a large amount of biomass. 13 kg/m^2 year of dry matter (*Typha latifolia*)
- It absorbs hydraulic peaks because the filter volume acts as a laminator
- Little noise and low visual impact

At present, a Floating Macrophyte Filter is being used experimentally in Spain at Madrid, Reus, Fuerteventura and Alicante airports. The first one for 500 inhabitant-equivalents. Another project is now finished in Villacañas (Toledo). The project included the construction of a 550 m long channel for treating nutrient-laden water from a primary and secondary water treatment plant in order to improve the quality of the water in a protected wetland area.

Fundación Global Nature is now managing a LIFE-Environment project (European Commission) in Lorca (Spain), to demonstrate the effectiveness of a wastewater treatment system using floating macrophyte filters (FMF). Here, about 35.000 inhabitants, live in small, dispersed population centers or in single-family homes. Most of the dispersed population centers have sewage lines, but no water treatment stations. 1.100 pig farms also cause severe environmental problems due to the lack of adequate purine.

7 filters are now finished: 3 in small isolated centers (150-500 inhabitants), 2 in single-family homes, one in an Interpretation Center and another one in a pig farm.