No water to waste: b

When waste waters are not well purified they can seriously damage surface and ground water. They can also endanger human and animal health. Staff of the Songhai training centre for sustainable agriculture describe how biological treatment can produce water which is safe for the environment and at the same time yields useful products.

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Waste water is a real public health and environmental problem in our countries. It is not unusual for this water to flow into ponds and ground water without any prior sanitary treatment. It then causes a serious danger: not only can it hinder animal life in these ecosystems (the availability of oxygen is no longer ensured through the enhanced activity of bacteria), but it also favours the development of pathogens or vectors of diseases like typhoid fever, poliomyelitis, hepatitis, dysentery, cholera or bilharziasis (Charbonnel 1989). In addition, valuable energy is dispersed into the environment through the nutrients in the water and is thus lost for renewed use.

Biological waste-water treatment is based on a process of cleaning the water by means of aquaculture with water hyacinth (*Eichhornia crassipes*), water lettuce (*Pistia stratiotes*) and the water fern *Azolla anabaena* in symbiosis with the bacterium *Anabaena azollae*, water fleas (*Daphnia magna*) and fish.

Purification at Songhai

The objective of biological purification of waste water is to transform the nutrients released by the bacteria in the water into biomass which can be put into a biogas tank. Biogas does not smell and has many practical uses.

At the Songhai centre, purification takes place in a series of watertight concrete basins receiving a continuous flow of waste water from the showers and latrines used by our students, and from the slurry of the biogas production. The basins are serially connected through descending overflow channels that discharge surplus water into the next basin. We have a Chinese type of biogas digester of 7 m^3 capacity.

Basin 1: water hyacinth

The first basin is covered by water hyacinths. Here, bacteria trigger two processes. First, under anaerobic conditions at the bottom of the basin, the biomass is digested and pathogenic bacteria, larvae and eggs of parasites are destroyed. Some biogas and minerals are released.

Second, at the surface, aerobic biological activity completes the degradation of organic wastes. The available elements in the water, dissolved or in suspension (brought to the surface by gas bubbles), are used by the water hyacinths for their metabolic activity (photosynthesis). Using light, they fix carbon and water from the atmosphere. This leads to a high concentration of energy. Through photosynthetic activity of the plants, enough oxygen for growth of bacteria is released around the roots and leaves that are in contact with the water (Charbonnel 1989). In turn, the bacteria release nutrients which the plants need.

Plants are harvested twice a week. Zhang Zhuan-Ta et al (1985) reported that water hyacinth under similar conditions in China contained 20.3% crude protein, 22.6% ash, 1.8% fat, 1.2% carbohydrate, 13.8% fibre and 2.9% phosphorous.

Basins 2, 3 and 4: water lettuce

Purification continues in the three succeeding basins filled with water lettuce, according to the same principle as for the water hyacinth. According to the same Chinese source, water lettuce can contain 19.4% crude protein, 35.6% ash, 3.0% fat, 0.7% carbohydrate, 4.8% fibre and 0.8% phosphorous. Plants are harvested every day.

When Charbonnel studied the performance of water lettuce basins, he found that the effluent has considerably lower values for specific parameters than the influent (see Table 1).

Basin 5: azolla

In the fifth basin nitrogen in the water is reduced. The azolla fern captures solar energy to fix carbon dioxide, while the bacterium *Anabaena azollae* fixes nitrogen. Plants are harvested twice a week.

Zhang Zhuan-Ta et al (1985) give the following composition for azolla in water-treatment basins: crude protein (25.0%), ash (17.3%), fat (3.1%), carbohydrate (1.2%), fibre (11.5%) and phosphorus (1.0%).

Last basin: fleas and fish

In a small separate pond (not supplied by the water being cleaned) water fleas and fish are bred. Water fleas take up organic matter and abundantly available phytoplankton. In 24 hours 12 to 20 water fleas can filter one litre of water (Sevrin, no date). In dried form, they have the following composition: humidity (10.8%), carbohydrate (12.5%), dry matter (89.2%), calcium (3.0%), total nitrogen (9.1%), phosphorus (1.2%), magnesium (traces) and fatty substance (10.4%).

Biogas

Biogas is a product of anaerobic decomposition of organic matter from either animal or plant origin. This fermentation takes place in a tank or methane digester. The organic matter we feed to the tank daily is a mixture of 10 kg of droppings (from pigs, quails and chickens) and 7 kg of aquatic plants that are first chopped and macerated for 24 hours. After fermentation, the remaining slurry flows into a storage basin and then into the water hyacinth basin.

Element	*Influent value mg/l*	*Effluent value mg/l*
Ammonium N	10-30	< 75
P	40-80	< 10
BOD_5	200-240	< 70
Na	3-4	2
K	1	1
Ca	1-3	1.5
Mg	10-13	9

SP = suspended particles
BOD_5 = biochemical oxygen demand for 5 days
COD = chemical oxygen demand

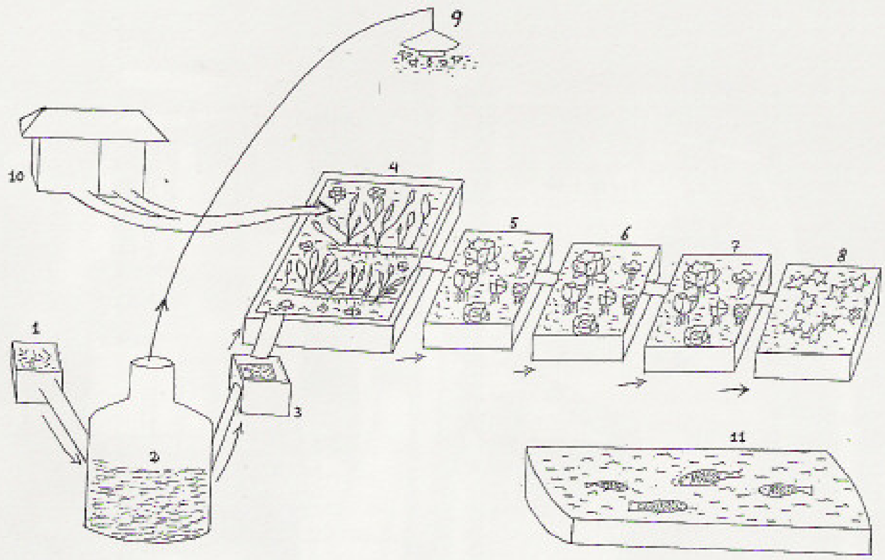
Table 1:
Performance of water lettuce basins

Analysing treated water

At Songhai we are mainly interested in the practical aspects of the treatment and, as we have started this fairly recently, we have not been able to do extensive laboratory analyses. According to Charbonnel's (1989) manual on lagooning of macrophytes, there are several methods to verify the level of water purification. In a laboratory, chemical analysis can be made of pH, COD (chemical oxygen demand), BOD_5 (biochemical oxygen demand for 5 days), and SP (suspended particles). In addition, biological analysis focusing on the zooplankton, phytoplankton and pathogens can reveal interesting data on the effects of the treatment.

However, on-the-spot observation can also indicate the level of purification reached. Cleaned water should no longer appear turbid.

iological purification



1 Feeding basin for biogas tank
2 Digester tank
3 Storage for out-flowing slurry
4 Basin with water hyacinth (9.6 m², 62 cm deep)
5 Basin with water lettuce (3.51 m², 42 cm deep)
6 Basin with water lettuce (3.61 m², 45 cm deep)
7 Basin with water lettuce (3.00 m², 30 cm deep)
8 Basin with azolla (30.80 m², 38 cm deep)
9 End use of gas
10 Toilets and showers
11 Pond with fish and water fleas

Aquatic plants can also be valuable indicators: the green colour of their leaves fades with depletion of N, P and K in the water. A practical rule of thumb is that the level of purification is considered satisfactory when the length of the roots of the water lettuce equals or exceeds the diameter of the plant. Our own observation of the water lettuce in the last basin teaches us that the water meets this requirement.

Plenty of useful products

The value of the biomass can be assessed in different ways. With an average daily input of 17 kg of organic matter into the digester, enough gas is produced to keep our young chicks warm with two burners on low flame all day and to cook three meals a day for our 50 students. At present we still import water hyacinths from the nearby lagoon.

It is difficult to know how much gas is really produced, since we have no gas meter. But theoretically, it can be calculated that about 4.7 m^3 of gas is produced per day. This is based on the fact that the droppings yield 4.5 m^3 gas, and the aquatic plants yield (= 0.6 kg dry matter) produces some 0.2 m^3 gas.

Crops irrigated with the effluent show a very positive response. A mixture of hay with 1 kg molasses and 2 kg purified effluent from the last basin is relished by ruminants.

Water hyacinths can take up pathogens and retain them in their roots; this makes it dangerous to feed them directly to animals. It is better to use them to produce biogas or compost. However, the roots of the water hyacinths mixed with water from the effluent, can be used for feeding the water flea larvae which are rich in protein and are tasteful feed for poultry and fish.

Water lettuce can be directly incorporated into animal feed because it does not take up pathogens. It can be consumed fresh or dried and can be added to pig feed. Fish like carp and tilapia are also eager consumers (Charbonnel 1989). Fresh azolla has a high water content (93-95%) and is difficult to store. Dried in the sun it can be stored much longer, but its organoleptic qualities seem to be affected. Azolla can complete the diet of fish, pigs, poultry (chickens, ducks, geese), ruminants, rabbits and even humans (Hove 1989). Adult water fleas are very rich in protein and considered the best fodder for the fish.

Wide-scale adoption?

This treatment system can be adapted to various regions of the globe, since most of the aquatic plants are cosmopolitan. Biological purification of waste water is a practical and environmentally sound system with low operation costs. Considering the present challenge of desertification we face in Benin, this system should be propagated, since biogas could replace firewood. This system could help solve the urban and rural waste problem and contribute to the necessary cleaning of waterways as well. Energy gained via biomass production is neutral with respect to the CO_2 balance, a topic of worldwide concern today.

All our visitors seem to be convinced of the advantages of this system. Yet it is still difficult to extend it more widely, because the investment costs for constructing the basins are too high for farmers. Sometimes, the absence of sufficient livestock for providing enough dung is a limiting factor. Nevertheless, some small projects in Benin and Togo have been inspired by our system. The media in Benin and Nigeria have also shown interest. Still, for successful extension of the system, much more official assistance is needed.

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