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Treating industrial wastes in Colombia using water hyacinth

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Water hyacinth can absorb pollutants from domestic and industrial wastewater. It has been used in a treatment system outside an aluminium factory in Colombia for over 10 years now, and results show that the removal of many pollutants is over 90 per cent.

The treatment of domestic or industrial wastewater has always been a difficult problem to solve. The large investment required for water treatment plants is one of the main obstacles in developing countries to finding a satisfactory solution to this problem. Macrophytes (in this case, water hyacinth) have been used to treat wastewater, and in small communities and industries they have demonstrated efficiency in removing a large range of substances such as organic material, nutrients and heavy metals. This kind of biological water treatment process is

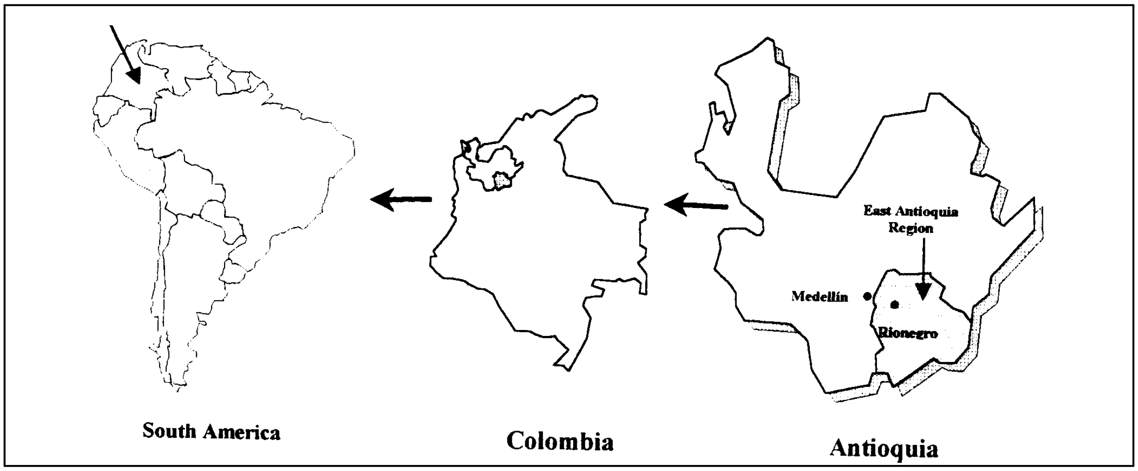

Figure 1 Location of the IMUSA factory in Rionegro, Antioquia, Colombia

The dense root system of water hyacinth allows it to absorb efficiently

Channels planted with water hyacinth

The outlet of treated water into La Mosca creek a normal practice in many countries in the struggle against pollution, and it is an ecological and economical option for treating wastewater in the tropical and subtropical regions of the world.

The use of macrophytes in Colombia

There is a wide range of water plants in Colombia, some of which are regarded as water weeds. There are 42 known families of dicotyledons, 30 families of monocotyledons, 6 families of pteridophytes, and 17 families of bryophytes.[1]

Although various species of water plants have been investigated for treating industrial and domestic effluents, *Eichhornia crassipes*, or water hyacinth, has been used the most because it is most efficient. It is a tropical plant that lives on the surface of standing waters. Its filamentous roots grow to a length of one metre or more, and it is through its extensive root system that it can absorb the impurities found in domestic wastewater, as well as heavy metals such as nickel, cadmium, lead, mercury, aluminium, and other industrial and agricultural pollutants such as phenol. *E. crassipes* can double its size in 10 days. Another macrophyte that has been tested is *Pistia stratiotes*, but it does not work as efficiently as *E. crassipes*, having less adaptation to low temperatures and lower levels of absorption through its shorter roots.

The IMUSA factory

IMUSA (Industrias Metálicas Unidas, S.A.), is a factory which has produced aluminium kitchen utensils since 1935. It is located in the eastern part of the department of Antioquia, Colombia, 40km from Medellin, 2137m above sea level and with an average annual temperature of 17 °C. Aware of their social and environmental responsibility, the factory owners built a wastewater treatment system in 1988 with advice from the departments of biology and chemistry of the Universidad de Antioquia, Medellin, Colombia.[2]

Channels were constructed in a zigzag shape, 500m long and with a surface area of 2 600m² (Figure 2). The average incoming flow is 1.78 l/sec and the outgoing flow is 1.10 l/sec. The retention time of the water is 14 to 21 days. The correct depth is an important part of the design, because it has been demonstrated that in shallow pools the removal of pollutants occurs in a shorter time than in deeper pools. Pools must therefore have a depth of between 0.2 and 0.9m. The flow rate and pollution load should determine the surface area of the pools.

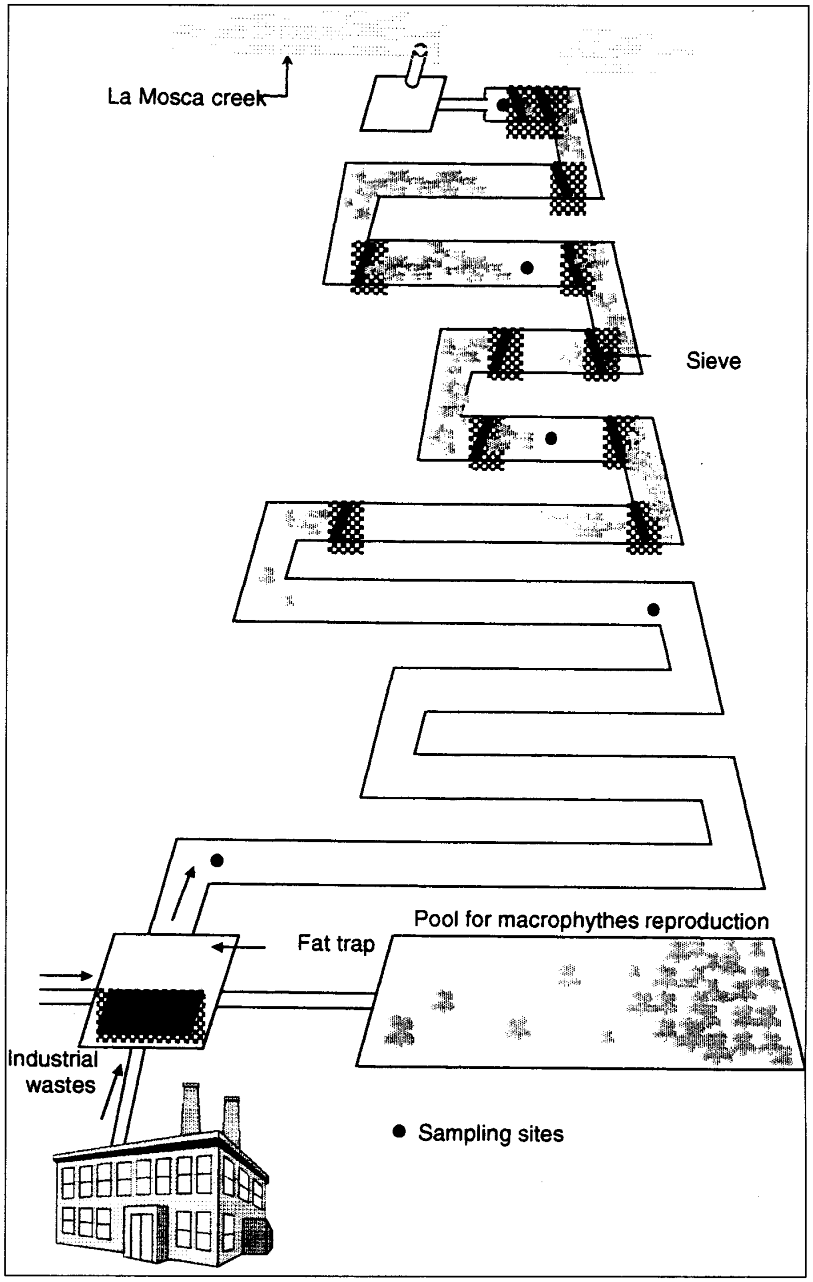

Figure 2 Layout of the channels outside the IMUSA factory

Every six months the channels are cleaned. All the plants are removed, packed and sent to the rubbish dump in Medellin. Once the channels are clean, new water hyacinth are planted again. Every two to three weeks a workman removes those plants that are already saturated by pollutants: these are easily recognized by their yellowish colour and withered appearance.

Pollutant uptake

The average results for the period 1990–2001 of pollutant uptake by water hyacinth are given in Table 1. It shows that the efficiency of the system is

Table 1 Mean values of physical-chemical parameters before and after treatment, analysed 1990–2001 at the IMUSA aluminium factory

Parameters (in mg/l unless specified	*Inflow*	*Outflow*	*% efficiency*
Volume (l/sec)	3.7	2.3	–
Temperature (°C)	22.5	21.0	–
Oxygen	1.5	2.5	66.66
Turbidity	60.0	2.8	95.33
Total dissolved solids	911.0	310.0	65.97
Suspended solids	89.0	1.0	98.87
Volatile susp. solids	27.0	1.0	96.29
pH	8.25	4.15	–
Total iron	2.6	1.25	51.92
Chlorides	275.0	55.0	80.00
Total phosphorus	0.34	0.02	94.11
Nitrites	0.19	0.05	73.68
Nitrates	0.03	0.008	73.33
Biological oxygen demand	35.6	9.08	74.49
Chemical oxygen demand	75.5	39.6	47.54
Detergents	3.287	0.74	77.43
Aluminium	54.2	10.7	80.25
Chrome	0.24	0.005	97.91
Copper	0.188	0.001	99.46
Nickel	0.215	0.001	99.53
Lead	0.378	0.008	97.88

over 90 per cent for the removal of heavy metals and 98 per cent for suspended solids. This could probably be increased with further research.

Water treatment systems based on macrophytes principally consist of a series of pools where plants grow, absorbing nitrates, phosphates and other pollutants over a specified period of time.

The purification mechanism is performed in the following way. Bacteria associated with plant roots oxidize the organic material. This oxidation is facilitated by oxygen transportation from the leaves to the roots. Nitrogen is absorbed by the plant roots and removed from the water by the action of microbes.

Phosphates and other ions are removed mainly by absorption by the plant and to a smaller extent through mineralization by micro-organisms and precipitation on the bottom of the channel. The removal of heavy metals is performed mainly via uptake by the plants.

If the wastewater does not contain heavy metal toxic elements (most domestic wastewater does not), the plants once dried and chopped are used as a food supplement for cattle (they contain about 25 per cent protein), or they can be used as an organic fertilizer. In the case of industrial wastes that contain toxic elements, the biomass can be used to produce methane via anaerobic composting. One hectare of hyacinth produces from 16 to 32t/day of biomass, from which 90 to 180m^3 of methane and 0.5t of fertilizer can be produced.

The application of the system for small communities

This system can be used for small communities of up to 5000 inhabitants, where the costs would be small compared to traditional systems, such as active sludge or oxidation pools. Although the removal of the pollutants is not 100 per cent, the very low cost of the system make it worthy of consideration, since 80 per cent or more of the pollutants are removed. For a population of 5000 inhabitants, approximately 1.2 hectares are needed to treat 680m^3/day (allowing 136 l/person/day) of residual waters with a flow of 78 l/sec. The retention time of the water is from 14 to 21 days.

Advantages and disadvantages

The *advantages* of the system are (1) low construction and maintenance costs, (2) the simplicity of maintenance and therefore its ease of application for small communities. The *disadvantages* are the need for a large surface area for the channels and the problem of the final disposal of the plants when they contain heavy metals and toxic substances. Marginal lands that are already polluted may be used for this purpose.

References

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