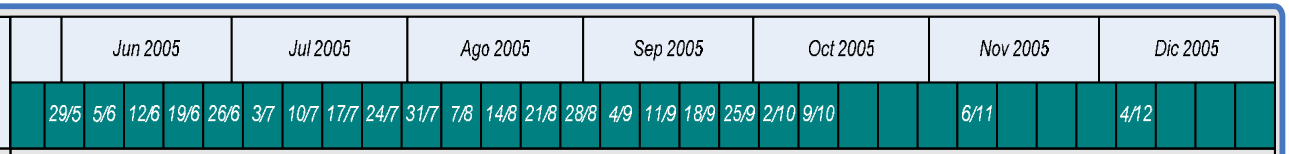
Chapter 6: Materials and methods

This thesis paper is theoretical in essence with a small experimental contribution. However, the aim in building a pilot plant for the photocatalytic degradation of pesticides using photo Fenton and photo Fenton-like processes is based on studies regarding the reaction kinetics. A general work plan for the elaboration of the thesis is presented, followed by the pilot plant work plan and experimentation.

6.1 General work plan

ID	Task Name	Start	Finish	Duration
1	Hydraulics literature research	23/05/2005	16/06/2005	3.8w
2	Building of hydraulic excel sheet	20/06/2005	30/06/2005	1.8w
3	Measuring of physical area and selection of system configuration	30/06/2005	02/08/2005	4.8w
4	AutoCad drawing to model the proposed system	02/08/2005	26/08/2005	3.8w
5	Pesticide research. (Literature, interviews, visits to fields)	25/08/2005	01/11/2005	9.8w
6	Advanced oxidation processes literature research	07/11/2005	01/12/2005	3.8w
7	Recommendations for improvement	23/12/2005	30/12/2005	1.2w



1. Basic hydraulics research was conducted. Equations describing pump power to drive a system and the factors affecting it were identified. Research involved literature sources and personal interviews to professors and hydraulic engineers.

2. A hydraulic Excel sheet was built for the automation of the calculations mentioned above.

3. Measures of available area were taken and several plant configurations were proposed. A design was chosen consulting with the project leaders at the IMTA.

4. An AutoCAD drawing of the system was built to illustrate the proposed design and as a guide for its future set up.

5. Research on pesticides was conducted through books, Internet and personal interviews. Up-to-date information regarding container management strategies was collected. Emphasis was set on the Mexican use of 2,4-D and atrazine and the way pesticide containers are handled. For this end, a personal interview with AMIFAC's PLAMEVA leader supplied the latest information on the industrial perspective regarding container handling. A visit to a local pesticide supplier complemented information on the routine of the pesticide market and disposal. Finally, visits to actual fields added information at the peasant level.

6. Thorough investigation of advanced oxidation processes was carried out to learn the reaction kinetics of Fenton and Fenton-like processes and link them to pilot plant working parameters. The use of figures of merit such as A_{co} was researched and adapted to the pilot plant operation. A figure-of-merit Excel sheet relating A_{co} to operation time was built to be used before operation.

7. Finally, recommendations for further research are offered. These are based on problem areas found on available pesticide information, degradation kinetics and figures of merit.

6.2 Pilot plant studies

6.2.1 Pilot plant work plan

Work was conducted following this outline:

1. Calculations for the power requirements of the pump were performed. For this end an Excel sheet was built to allow an easier visualization of the effects of different arrangements and to automate the numerical results. The Excel sheet also provides for a lower error probability in the calculation, since every time the program runs, it does so in exactly the same way, minimizing the "human error" probability.

2. Several possible configurations for the plant were proposed, based on available collectors and area. After revision with the thesis directors, a design was chosen based on high versatility, low cost and easy maintenance criteria.

3. Piping accessories were researched and the most adequate ones were chosen based on their high versatility, availability in Mexico, low cost, good supplier service and chemically resistant smooth material. Early research on the Internet was conducted. In it, available accessories were found and located. Visits to local hardware stores confirmed the availability of the preferred accessories in the city. Then, location of suppliers in Mexico was

conducted and contact established. Finally, testing of accessories was performed with glass tubing. This testing included resistance to pressure applied, leakage and adequate glass-accessory transition.

4. With the accessories selected and suppliers chosen, exact measures of the system were taken to build the physical base where the compound parabolic collectors will be mounted.

5. Operating time was decided using the area per order (A_{co}) figure-of-merit. A second Excel sheet was built for the quick calculation of A_{co} and its outcome was modified to result in a pilot plant working time.

6.2.2 Pilot plant experimentation

6.2.2.1 Materials and equipment

The *Instituto Mexicano de Tecnología del Agua* (IMTA) bought from Ecosystems: Environmental Services S.A. (Barcelona, Spain) the compound parabolic collectors (CPCs).

The CPC consist of a series of borosilicate glass tubes mounted on highly reflective anodized-aluminum ray collector parables. The structure is a box containing the parables with a glass tube in the middle of each. The dimensions of the CPCs are of 1. 54 m long by 1.97 m wide, and is schematically presented in figure 6-1. At the time of writing this report, the CPC's had not arrived to the Institute yet.

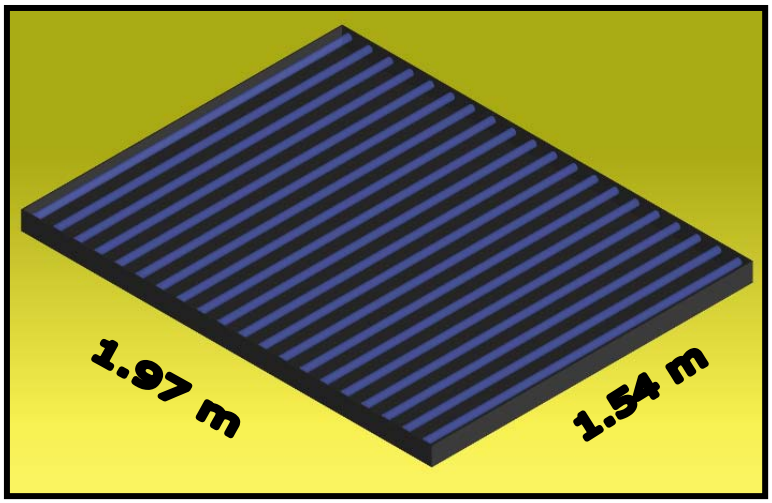


Figure 6-1. Scheme of a compound parabolic collector

For the experimental runs, three glass tubes, internal diameter 2.54 cm and length 50 cm were used to test PVC couplings (5.6 cm long, 3.33 cm internal diameter and 0.4 cm wide). Viton® O-rings were used. An Ahmsa TB180 lathe engraved canals on the couplings for O-ring fitting. A centrifugal pump provided water at 117, 679.8 Pa or 1.161 atm (12 m of water column).

6.2.2.2 Method

PVC couplings were carved with the Ahmsa lathe to make canals to fit the o-rings. First, a single incision on each side of the coupling was made and fitted with an o-ring. Two glass tubes were attached and connected to the water pump (Fig 6-2). The pump sent water and the far end of the second tube was hand sealed to keep the water inside (Fig 6-3). During the process both tubes were hand held to sustain the pressure. Visual inspection checked the connection for leaks and firmness (Fig 6-4). Secondly, couplings were carved two canals on each side and two o-rings used (Fig 6-5). Again, two tubes were connected to the water and flow began. Visual inspection was again used for leaks and firmness. The last step consisted in

attaching the three tubes, hand holding the end ones. Inspection on the two middle fittings was conducted.

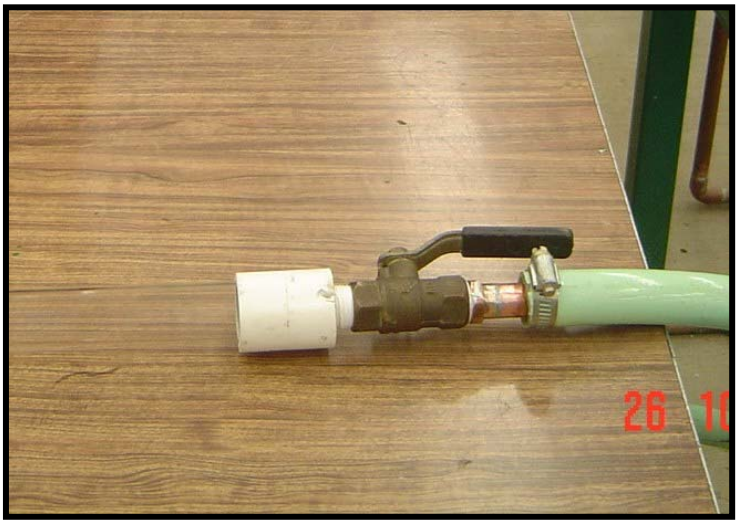


Figure 0-2. Connection to the water pump

Figure 0-3. Hand holding of the end of the tube to maintain pressure in the system.

Figure 0-4. Visual inspection of PVC fittings between two glass tubes.

Figure 6-5 PVC coupling with two canals to fit O-rings