As part of my fluid mechanic engineering studies at INP-ENSEEIHT Toulouse, France, I worked on a long project called BEI ("Bureau d'Etudes Industrielles"). It is realized by third-year students in the Hydraulic and Fluid Mechanic department working with industrial partners. I worked with a classmate called Ségolène Clerc. Dominique Legendre and Arnaud Cockx, who currently do researches on two-phase flow, supervised this work. Our project shared resources with the O_2Star project. Five private and public companies and laboratories currently work on the O_2Star project: ITT W&WW, France Assainissement/Degrémont (Suez), IMFT (Fluid Mechanic Institute of Toulouse, France), INSA Toulouse (National Institute of Applied Sciences) and CEMAGREF. The purpose of the O_2Star project is the optimization of flow and oxygen transfers inside biological wastewater treatment reactors in wastewater treatment plants. In fact, wastewater treatment plants contain biological reactors which allow a secondary treatment of wastewater in order to eliminate carbon compounds. These compounds are dangerous for the environment because their degradation involves consumption of the oxygen dissolved into the water and necessary for the life of aquatic species. In order to eliminate these carbon compounds, the wastewater is brought with a mixture containing bacteria to degrade the organic matter in suspension. This involves an important aeration to create a bacteria activity. This aeration can be natural or artificial (by using diffusers) and some mixers are present inside the reactor in order to create stir.

Our project called "Modeling of oxidation ditches in wastewater treatment" was a study of the oxygen transfer in any aeration tank. The aim of this project was to create a simple tool to evaluate the oxygen transfer. This tool had to be functional and allow the user varying many parameters which characterized the oxidation ditch. It had to be useful for industrial in order to design and optimize the tank. The calculation of the oxygen transfer had to take into account the phenomenon of spiral flow, which appears in a cross section of the basin and changes significantly the residence time of air bubbles in the tank.

As I said before, I worked on this project with Ségolène Clerc, so we needed to share the tasks. As I had already worked on this project during my second-year internship, I took care of the bibliographic part because it was easier for me to find some documents. During this time S. Clerc made a timetable in order to respect delays in our project. After that, we both worked on the equations respecting the delays. Because I had some knowledge on how to build a website, I took care of it while S. Clerc made the two powerpoint presentations. To help us in our project, we often meet Dominique Legendre and Arnaud Cockx so that they could lead us in the right direction. To realize this project, we used Matlab in order to create the simple tool asked. We also relied on our knowledge in two-phase flow acquired during our studies at ENSEEIHT.

The project unfolded as follows : first we made some bibliographic researches to help us understanding the different phenomena appearing inside the oxidation ditch such as the spiral flow. After that, we studied the losses in the horizontal liquid flow. This study allowed us determining the horizontal velocity of the fluid depending on the aeration, the mixers and the basin characteristics. Next, we took care of the spiral flow phenomenon, it means the setting in motion of fluid in a cross section of the tank caused by the gas bubbles flow. We wrote the equations governing this phenomenon by projecting them on the section. The spiral flow modeling had a major importance in our study because this phenomenon strongly modifies the residence time of bubbles in the basin, and therefore the rate of gas. We were also interested by the transition phenomenon appearing just downstream and upstream the grid of diffusers. Indeed, the rate of gas does not reach instantaneously its maximum or minimum values and the transition zones had to be taken into account in the transfer of oxygen. Finally, all these studies were used to calculate the oxygen concentration in water. The oxygen inside water comes from air bubbles and the oxygen transfer mainly depends on the air diffusivity, the bubbles residence time, and the gas rate in the basin. So we implemented all these equations inside a Matlab program and started to get some results. To summarize the results, we drew some graphics by varying some parameters and looked at their influence.

During this project, we had to face problems like which kind of equations should be better for this modeling? Are our results valid?... To solve this problem, we met the supervisors of this project. D. Legendre had a look almost each week to see if we were in the right direction and we met A. Cockx twice : once at the beginning for the presentation of the project and he gave us some articles to read and we asked him to come another time to validate our results.

After several weeks of work, we obtained results . We created a simple tool – a Matlab program – which allowed calculating the oxygen transfer inside the tank. As it was asked, we managed to include in our modeling the spiral flow phenomenon. Our results showed the gas rate inside the tank depending of different parameters such as the size of the airlift, the size of the tank, the air flow rate, the size of the bubbles, the mixers thrust, some losses coefficient. That is why our program can be used for any tank, any grid of diffusers, any mixer, so any industrial will be able to employ this tool.

During all this project, we made some hypothesis, simplifications which make our work improvable. First, we only modeled the spiral flow in a cross section, however to take into account all this phenomenon, the spiral flow should be study also in the direction of the liquid flow. Another perspective can be the improvement of the roughness losses modeling due to the grid of diffusers. Moreover, we had never looked at the influence of the mixers on the flow.