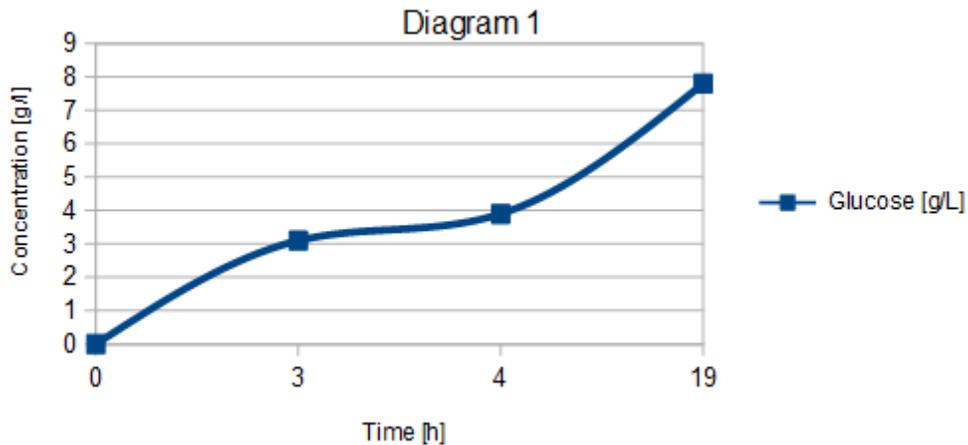


Average result of 15 work groups about the experiment of paper-waste to bioethanol

1. Step: Hydrolysis of Cellulose by Enzymes

15 work groups invested 30 g of waste paper and 700 ml of buffer for hydrolyzing the paper with the enzymes cellulase and cellulbiase. During 19 hours of hydrolysis the glucose concentration in grams per liter was measured in an optical test at the wavelength of 510 nm.

Diagram 1 shows the produced glucose during hydrolysis.



Time	0	3	4	19
Glucose [g/L]	0	3.1	3.9	7.8

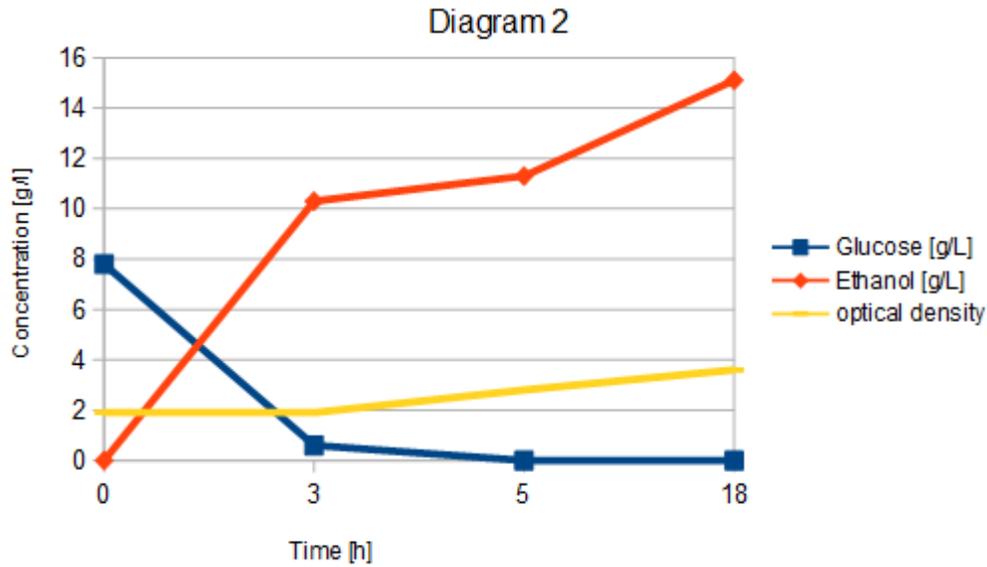
Results:

The glucose concentration is rapidly increasing during the first 3 hours and slower during the fourth hour. Over night the enzymes are still working and after 19 hours the glucose reached a maximum level of 7.8 g/L so round about 40% of the invested paper was hydrolyzed into glucose.

2. Step: Anaerobic Fermentation of Glucose to Ethanol

After hydrolysis the 15 work groups filtered the hydrolyzate for separating the glucose solution from the paper debris. In a 1 L vessel we added to 500 ml of the glucose solution 500 ml of fermentation buffer which contained all the nutrients the yeast needed for the anaerobic fermentation.

Diagram 2 shows the glucose-, ethanol concentration and the optical density of the yeast cells during the 18 hours fermentation. Glucose concentration was again measured in an indirect optical test at 510 nm. Ethanol concentration was measured indirectly at 340 nm and optical density of the yeast cells at 600 nm.



Time	0	3	5	18
Glucose [g/L]	7.8	0.6	0	0
Ethanol [g/L]	0	10.3	11.3	15.1
optical density	1.9	1.9	2.8	3.6

Results:

Diagram 2 shows a very fast decrease of glucose concentration during the first 3 hours to near by 0 g/L. Ethanol concentration is increasing during the first 3 hours as well very fast and over night it reached the maximum level after 18 hours of 15.1 g/L. Optical density increased during the 18 hours of fermentation from 2 to 3.6. That means the amount of cells increased by 80%.

Step 3: Distillation

In the 3. step the 15 work groups distilled 300 mL of the fermentation solution. The groups got 3 to 5 mL of a 95% solution of ethanol.

Step 4: Transformation of Ethanol to Electricity in a Fuel Cell

After the dilution of the distilled ethanol solution to 15% with water the solution was given in a fuel cell. Immediately the windmill was turning around driven by an engine.