



**Subject: Volta pile as an archetype of FCH**

**General goal:** understanding of energy-conversion phenomena in electrochemical cells

**Specific goals (knowledge):**

- Volta pile converts the “chemical energy” directly into electricity
- The process relies in oxidation and reduction of atoms/ ions on electrodes
- Each chemical element, including oxygen and hydrogen has a proper place in Volta’s series
- FCH is based on the same principle as Cu/ Zn pile, but uses gases and not metals

**Specific goals (social competences):**

- Electrochemical piles, after more than 200 years from the discovery remain the principle “energy source” for cell phones, tablets, and also cars (as Pb battery) – the knowledge how to use (and dispose) them is useful
- Converting the Volta pile to H/O pile is not conceptually difficult: an experiment even for children
- “Fuel cell” means that the chemical elements can be delivered continuously, differently from metal electrodes in Volta pile

**Experimental equipment:**

- Eurocents, Al kitchen foil, soft toilet paper, salt
- New and used “finger” batteries (AA type)
- Voltmeter with wires and crocodile clips
- Possibly - low-voltage 0-5 V (and 1 A) power supplier
- Possibly – pairs of Zn/ Cu plates (for “human battery” experiment)

**Working methods:**

1. Lecture by the teacher and/or FCHGo staff, and answering questions (1 lesson unit)

2. Experiments with electrolysis and Volta piles (1/2 lesson)

3. Discussion with students and resumé (1/2 lesson)

### Forms of work

- panel lesson (45 minutes)

- hands-on activity and discussion (45 minutes)

### Lesson scenario (2x45 minutes)

Teacher activity	Student activity
<i>Introduction (10 minutes)</i>	
<p>“Fuel cells are emerging technology, but they were invented in 1839, during experiments on the electrolysis of water. And those experiments were possible thanks to Volta’s electrochemical pile.”</p>	<p>In every cell-phone there is pile. Can you read the voltage on the rear side?</p>
<ul style="list-style-type: none"><li>• What do you know on “sources of energy” in your cell phones? And batteries in watches and clocks?</li><li>• What types of “batteries” you know?</li><li>• Where, in opinion, the energy “produced” in the battery come from?</li></ul>	<p>- Students give examples</p> <p>- “Free-hand” answers of students.</p>
<i>Main activity (35 minutes)</i>	
<p>- Teacher shows presentation “Volta’s pile” [2] dealing with :</p> <ul style="list-style-type: none"><li>• The historical path between Galvani and Volta to define the source of electricity in experiments with Galvani frogs</li><li>• First attempt of Volta to organize the “electricity sources” into series, as an example of innovative idea</li></ul>	<ul style="list-style-type: none"><li>- Students make notes, and photos (Daniell pile, Galvani experiments)</li><li>- Students give examples of known types, shapes and applications of Volta’s pile</li></ul>

<ul style="list-style-type: none"> <li>• Details of functioning (elementary processes) of Zn/ Cu pile</li> <li>• Daniell pile, with separated anode and cathode regions, as a prototype to semi-cells in FCH</li> <li>• Volta's electrochemical series of elements, and the place of O and H in it. The definition of the "reference electrode" – that resembles much the anode in FCH,</li> </ul>	
<p>Break (10 minutes) – possible observing the equipment</p>	
<p><i>Laboratory activity (25 minutes)</i></p>	
<p>-Simple hands-on experiment with Volta piles</p> <p>- "Human battery": "Lick carefully your left palm then keep the red (Cu) plate, do not touch the wire; now lick the right palm and keep the grey (Zn)." The circuit is closed by a voltmeter (see Thesaurus file).</p> <p>"If you invite these five girls to a party you can run the cell phone with the battery!"</p> <p>Analyze what potential is produced by a single pair, and what should be produced according to the Volta's series. Identical limitations regard the efficiency of FCH .</p>	<p>1) wrap half of the 5 eurocent coin with Al foil and put it on the tip of your tongue: you have repeated the way in which Volta measured "voltage" without a volt-meter.</p> <p>2) make a pile of Fe / Cu plates, with every second pair separated by a piece of paper wetted with brine (salty water) – measure the voltage with a voltmeter vs the number of pairs; identify the positive and negative pole; refer to Volta's series</p>
<p>- work in pairs: "measure Volta's potentials between different metallic objects (like an Al pencil-sharpener and its blade, and so on. (10 minutes)</p>	<p>- students discuss and compare their observations</p>

<i>Conclusions (15 minutes)</i>	
<p>- Questions:</p> <ul style="list-style-type: none"> <li>• What have you learned today?</li> <li>• What is principle of work of Volta pile?</li> <li>• Does the “electrical energy” compare from null?</li> </ul>	<p>- Student answer in a linear order: give examples of applications of electro-chemical piles. Remember that 200 years it was an expensive and useless invention.</p>
<p>Question to be answered individually: “Do we know everything on the electro-chemistry?” “Who got the Nobel prize in chemistry in 2019?”</p>	<p>-Students search in internet different types of “piles” or “batteries”.</p>

#### **Home work**

*- Search at home some used batteries: copy the information on their construction, check details in internet.*

*- Make a trial of home-made electrolysis: fill the glass with water and drop inside a “finger” battery (AA). Observe bubbles. Add some salt to water. Check for the bubbles – identify the effective negative and positive pole of the pile. Compare between new and used pile. Write down conclusions*