Energy &
Environmental Catalysis Lab

Electrochemistry and Electrochemical Water Treatment

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AEESP outreach project at the Beacon Institute for Rivers and Estuaries

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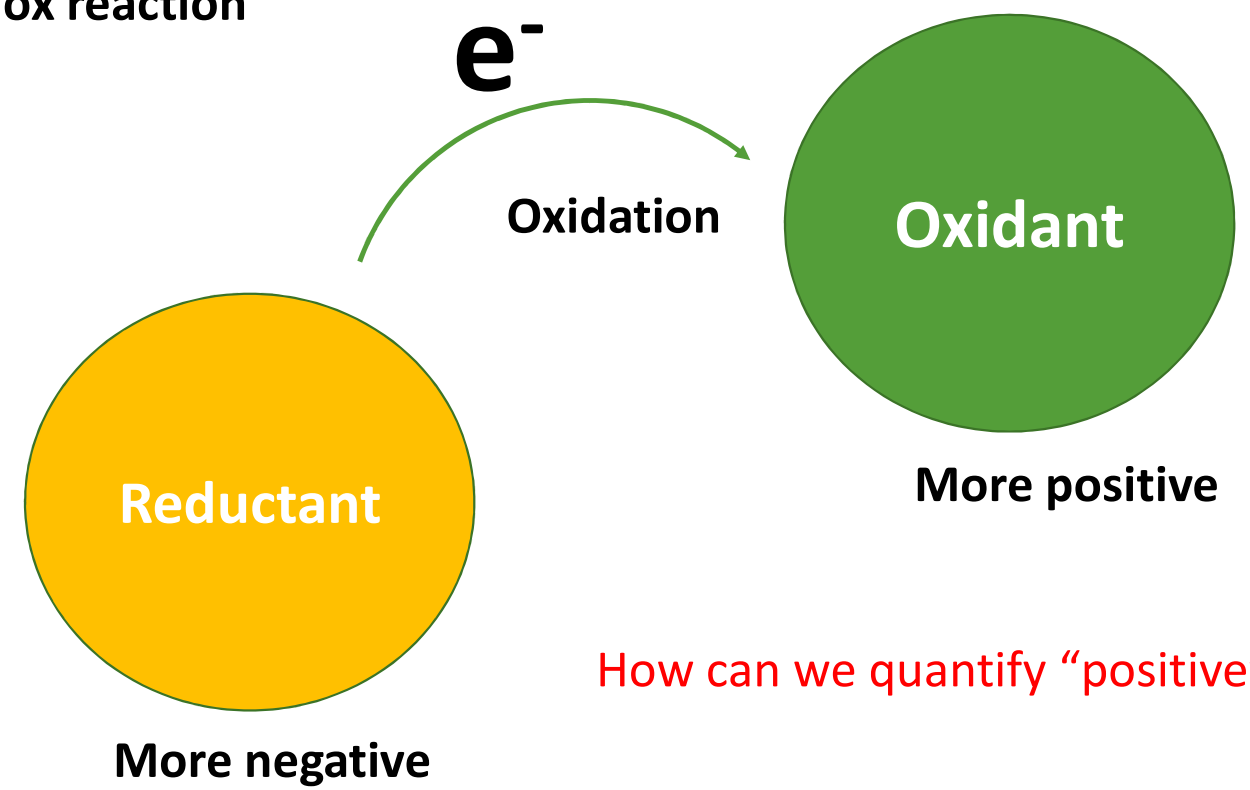
1. Introduction to Electrochemistry

- **Redox reaction**



How can we quantify “positive” and “negative”?

1. Introduction to Electrochemistry

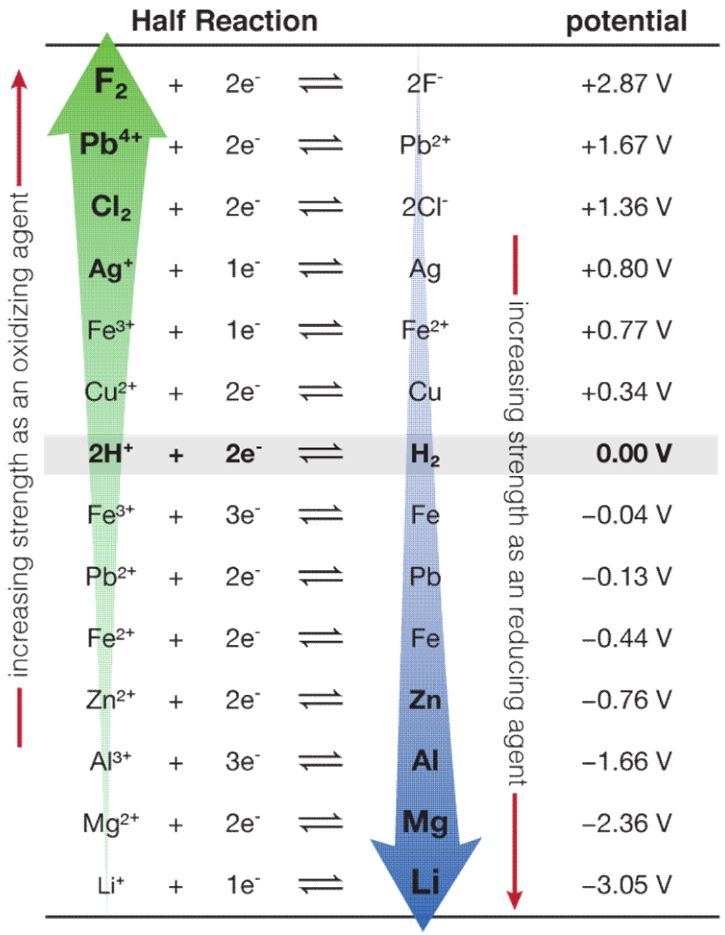
- **Standard Reduction Potential (Redox Potential)**

Standard reduction potential is written in a form of

$$Ox + e^- \rightarrow Red$$

They are constants describing how oxidative/reductive reactions could be.

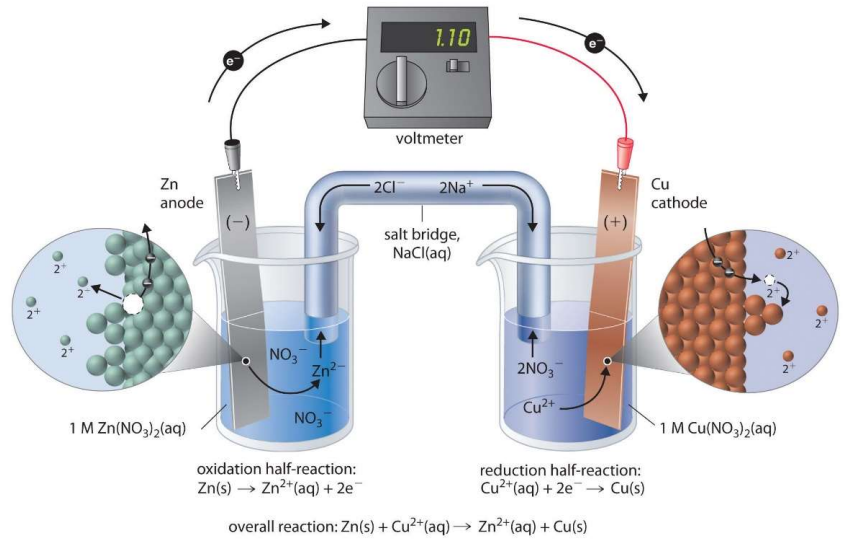
More positive value means more oxidative.



increasing strength as an oxidizing agent

Half Reaction					potential
F_2	+	$2e^-$	$\rightleftharpoons$	$2F^-$	+2.87 V
Pb^{4+}	+	$2e^-$	$\rightleftharpoons$	Pb^{2+}	+1.67 V
Cl_2	+	$2e^-$	$\rightleftharpoons$	$2Cl^-$	+1.36 V
Ag^+	+	$1e^-$	$\rightleftharpoons$	Ag	+0.80 V
Fe^{3+}	+	$1e^-$	$\rightleftharpoons$	Fe^{2+}	+0.77 V
Cu^{2+}	+	$2e^-$	$\rightleftharpoons$	Cu	+0.34 V
$2H^+$	**+**	**$2e^-$**	**$\rightleftharpoons$**	**H_2**	**0.00 V**
Fe^{3+}	+	$3e^-$	$\rightleftharpoons$	Fe	−0.04 V
Pb^{2+}	+	$2e^-$	$\rightleftharpoons$	Pb	−0.13 V
Fe^{2+}	+	$2e^-$	$\rightleftharpoons$	Fe	−0.44 V
Zn^{2+}	+	$2e^-$	$\rightleftharpoons$	Zn	−0.76 V
Al^{3+}	+	$3e^-$	$\rightleftharpoons$	Al	−1.66 V
Mg^{2+}	+	$2e^-$	$\rightleftharpoons$	Mg	−2.36 V
Li^+	+	$1e^-$	$\rightleftharpoons$	Li	−3.05 V

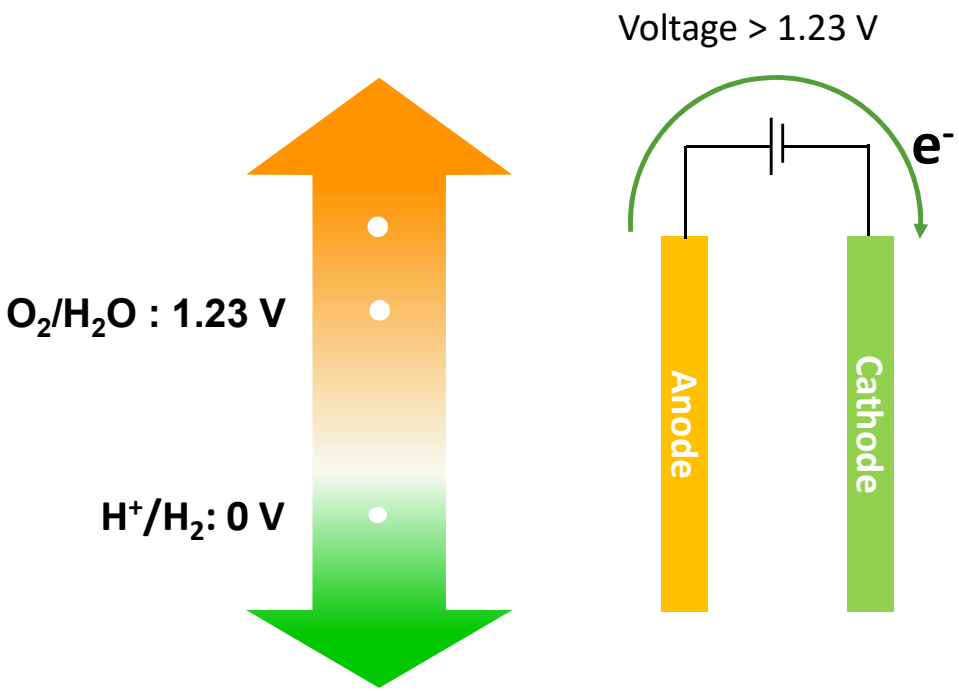
increasing strength as an reducing agent

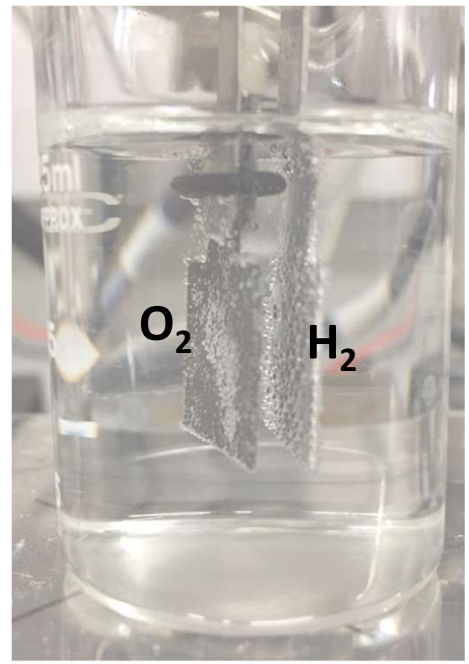


Ref: Principles of General Chemistry (v. 1.0)

1. Introduction to Electrochemistry

- Electrochemistry is the art to guide the flow of electrons





Experiment #1: tap water electrolysis

Procedure: Fill the beaker with 25 mL tap water. Apply 4 V between anode (mesh) and cathode (plate).

Observation:

Bubbles evolved from anode and cathode.

Question:

What is happening in the beaker?

Why the required voltage to split water is larger than 1.23 V?

Experiment #2: Experiment #1: saltwater electrolysis

Procedure:

Fill the beaker with 25 mL tap water amended with ¼ tsp of table salt.

Apply 4 V between anode (mesh) and cathode (plate).

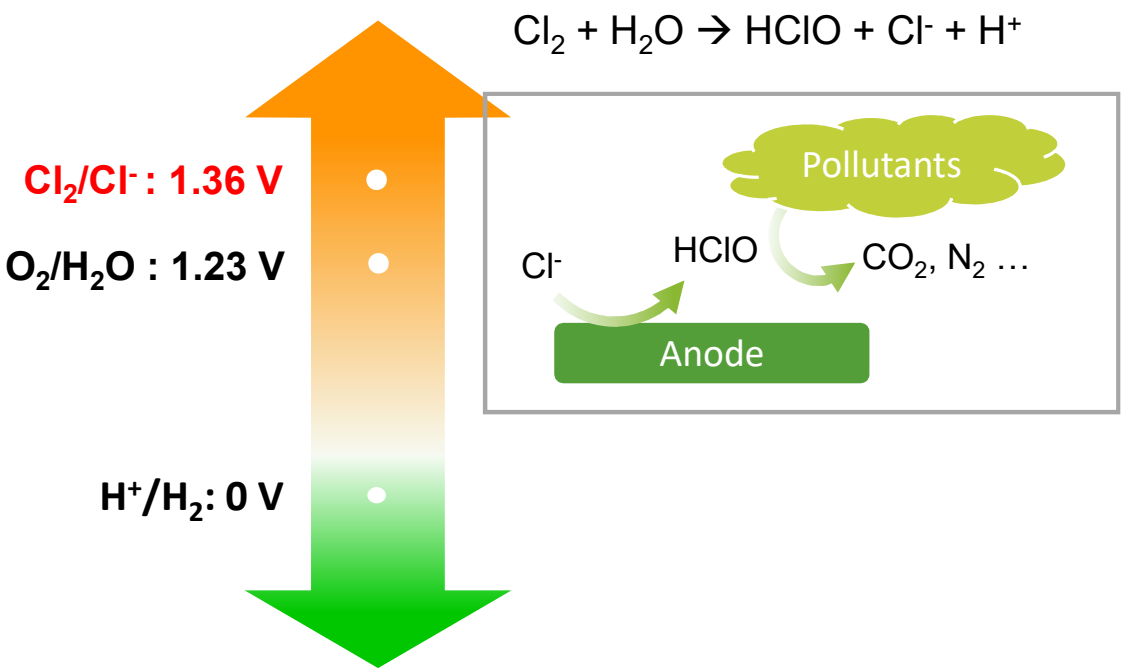
Observation:

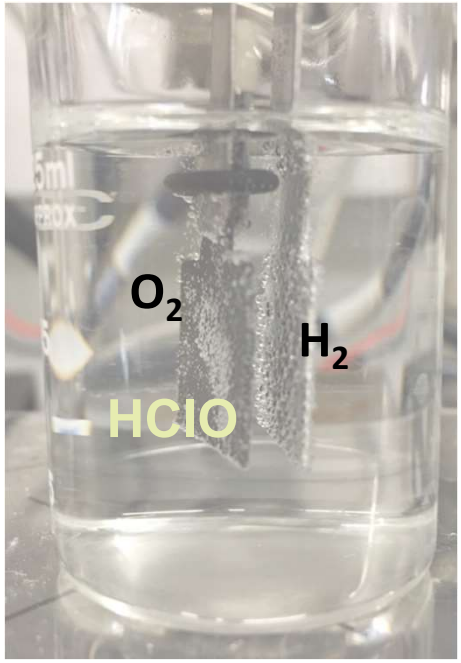
1. Increase of current;
2. Bubble evolved from anode and cathode;
3. Smell

Questions:

Why the current increases?

Why there is a funny smell?





- Chloride was oxidized to hypochlorous acid, a powerful oxidant/disinfectant.

Experiment #3: Electrochemical Water Treatment

Procedure:

Fill the beaker with 25 mL tap water, then add ¼ tsp of table salt and one drop of food dye (any color).

Apply 4 V between anode (mesh) and cathode (plate).

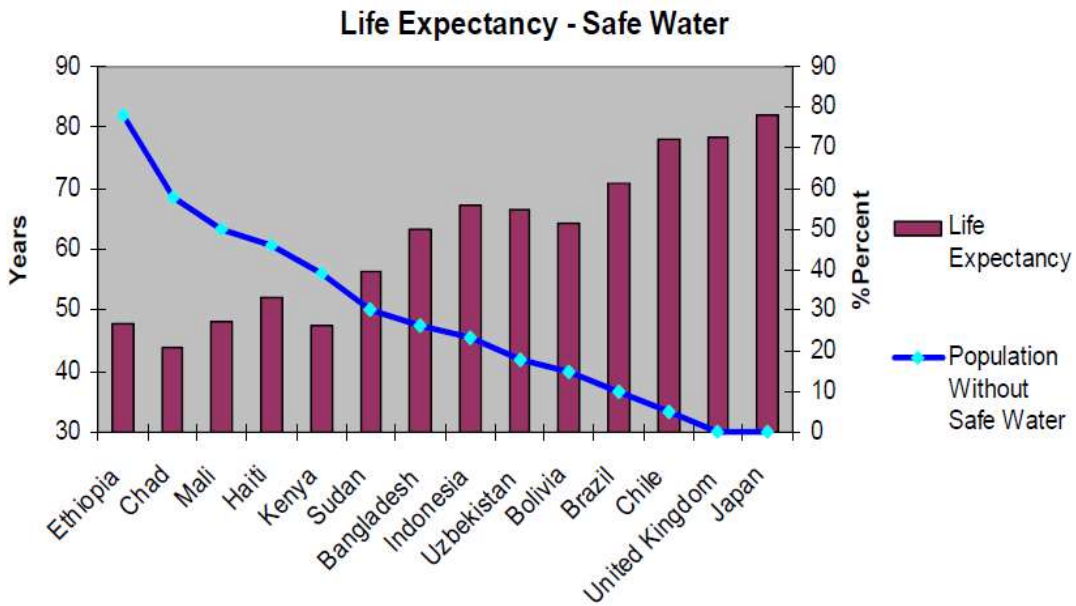
Observation:

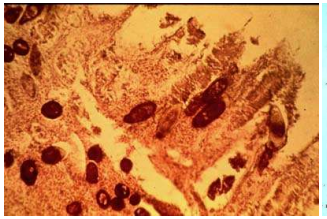
Gradual discoloration of dye-spiked water.

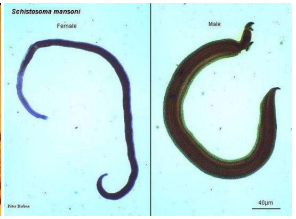
Question:

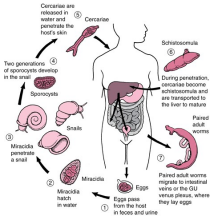
How was the water treated?

The importance of Disinfection









How can we inactivate tiny bugs?

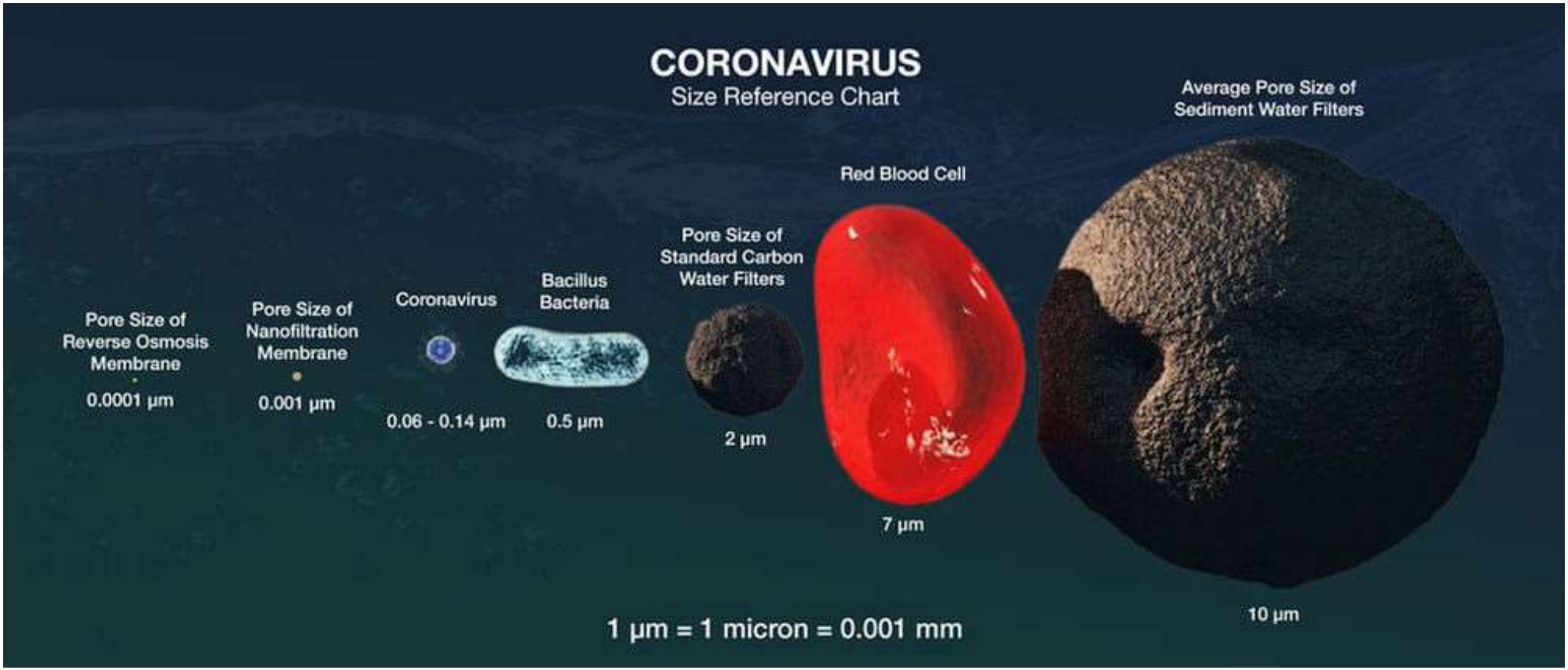
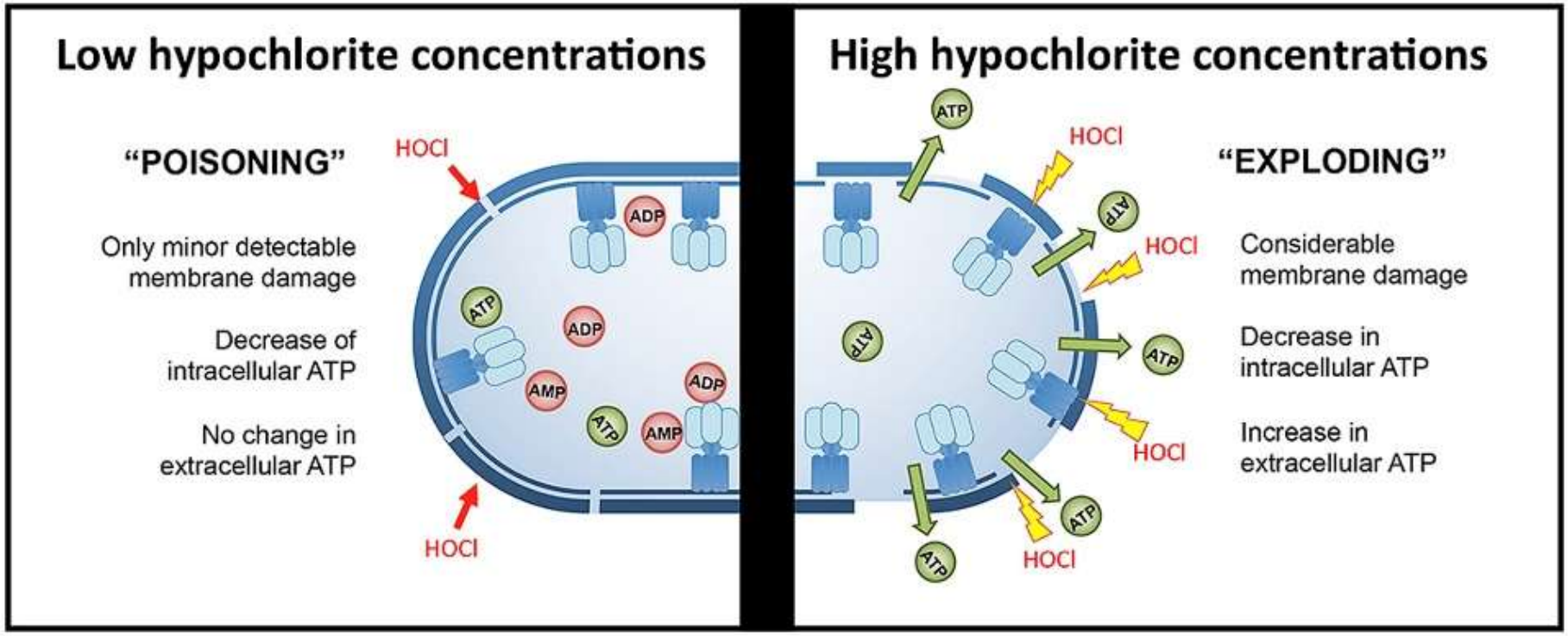


Photo credit: https://abcdust.net/how-large-is-a-corona-virus-virion-compared-to-the-mp10-2-5/

How can we inactivate tiny bugs?

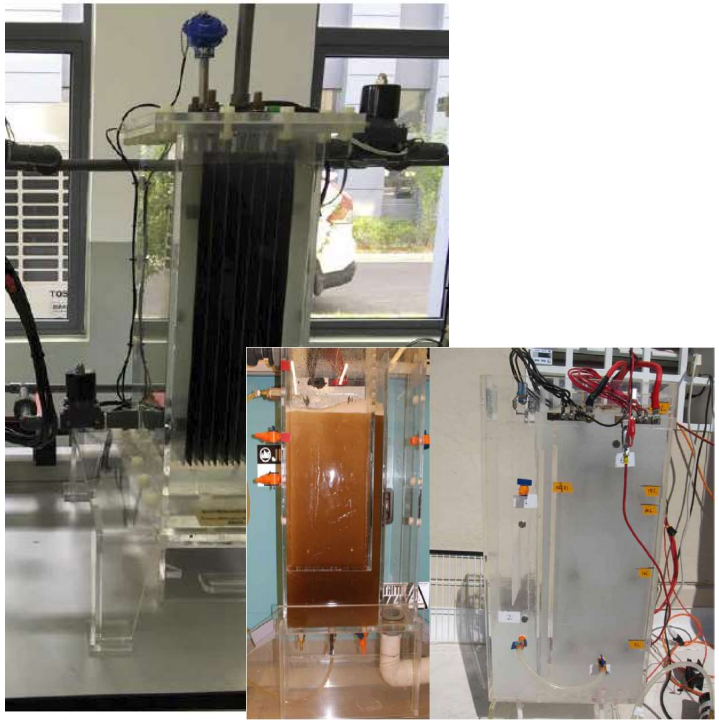


Reference: https://doi.org/10.1016/j.watres.2016.05.087

Examples of electrochemical water treatment

- Our team at Clarkson is developing full-scale electrochemical water treatment unit for:

Sewage disinfection
(in collaboration with Caltech)



Harmful algal bloom mitigation
(in collaboration with NYDEC and ResET Water)