Nutrient cycling in wetlands:

The diffusion of oxygen in saturated soils is 10,000 times slower than in unsaturated soils. A saturated soil will become anaerobic in a matter of hours (matter of days at the most) depending on
1) temperature
2) the amount of organic matter
3) the initial microbial community and
4) the amount of reducing compounds present (example: ferrous iron).

The general reaction is:

$$[CH_2O]_n + n\ H_2O = n\ CO_2 + 4n\ e^- + 4n\ H^+$$

where $[CH_2O]$ is organic matter. As plant material decays, electrons (H+) will be available in excess to react with already released organic compounds (like nitrogen). This process moves to a state that is more acidic.

O_2 disappears the fastest, followed by NO_3, and SO_3. At the same time Mn, Fe, NH_3, CH_4 and HS are released from the system. Oxygen reacts with electrons to produce water:

$$O_2 + 4\ e^- + 4\ H^+ = 2\ H_2O.$$

In the anaerobic state, both biological and electrochemical activities are found. There is a gradient in soils with an aerobic zone on top, an oxidizing layer, and an anaerobic zone on the bottom. As plant material decays, the carbon in the aerobic zone is broken up by microorganisms into dissolved organic carbon. In the anaerobic zone fermentation occurs. In this process, microorganisms convert dissolved organic carbon into lactic acid or ethanol. Methanogenic organisms work in the anaerobic zone to convert dissolved organic carbon into methane.

In both the aerobic and fermentation processes, CO_2 is generated. This involves the bicarbonate cycle: H_2CO_3 HCO_3 CO_3^-. This process also affects the pH of the water.

The production of methane is much more common in freshwater systems. In saltwater less than <1mg C is converted to methane per day. In freshwater (especially marshes) this number can be up to 440.

In the nitrification process, organic nitrogen becomes soluble and is converted to NH3 (ammonia) and then NH4OH (ammonium ion). This ion is used by plants or is washed away by runoff. Nitrosomonas is the species of bacteria responsible for the conversion of ammonia to nitrite, and Nitrobacter converts nitrite to nitrate. Rhizobia associations and algae also fix nitrogen to bring into the system. Plants can take up nitrate or ammonia forms of nitrogen.

Denitrification is the process that produces N2 (N gas). This gas is released when soil is disturbed, or is released slowly into the atmosphere. Wetlands are one of the only places where N2 is produced, this is important for the ecosystem.

The sulfur cycle involves the conversion of organic sulfur into H_2S that is stored in soil. H2S can also be released into the atmosphere or oxidized to sulfate in the aerobic zone. Sulfate is taken up by plants or washed away by runoff. H_2S production is low in saltwater and high in freshwater.

The phosphorous cycle starts with the decomposition of particulate phosphorous and then its conversion into soluble phosphorous. Soluble phosphorous can be taken up by plants and algae or absorbed by clay particles. Compounds found bound to soil are CaP, AlP, and FeP. This chemistry in the soil is the reason that higher concentrations of P are found in effluent than in influent. Constructed wetlands are not very good at decreasing P levels. A big debate over wetlands concerns their role in the environment. Are they sinks, sources, or transformers?