



**1<sup>st</sup> Workshop on Eco-Tanning processes in Kenya and the East African Region**  
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# **Microbial recovery of Lime from beamhouse effluent**

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**By**

**Dr. George Okwadha**

**The Technical University of Kenya**

**School of Civil & Resource Engineering**



# Beamhouse operations

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- The steps in the production of leather between curing and tanning are collectively referred to as beamhouse operations.
- They include, in order, **soaking, liming, removal of extraneous tissues (unhairing, scudding and fleshing), deliming, bating or puering, drenching, and pickling.**



# Liming

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- Liming is one of the most important steps in beamhouse operations
- The hides are soaked in liming drums which contain a solution made of lime and sulphur compounds.
- The main purpose of this process is **to separate the hair from the hides.**



# Lime Recovery & Recycling

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- Can be done using bacteria
- Process is Microbial Carbonate precipitation
- Requires a facultative bacteria (exists in both aerobic and anaerobic environments)



# Microbial Carbonate Precipitation (MCP)

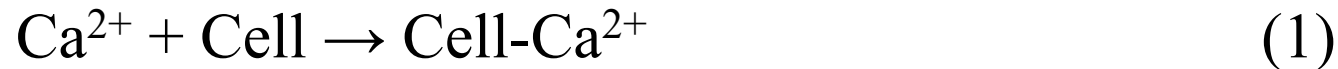
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- MCP occurs as a byproduct of common microbial metabolic processes such as
  - Photosynthesis
  - Sulfate reduction
  - Urea hydrolysis

# MCP by bacterial surface charge

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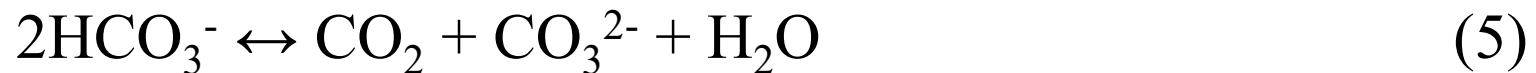
- Done by microbes with –ve net surface charge
- Remove divalent cations including  $\text{Ca}^{2+}$  &  $\text{Mg}^{2+}$  from the aquatic environment by binding them onto their cells surfaces (eqs 1-3)
- Become ideal crystal nucleation sites



# MCP by photosynthetic organisms

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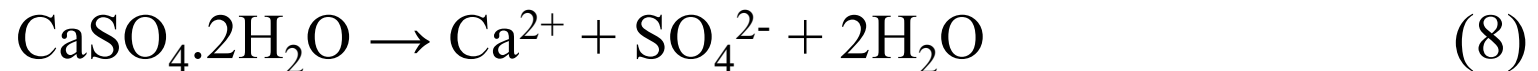
- Occur in aquatic environment
- Metabolic processes of algae and cyanobacteria utilize dissolved  $\text{CO}_2$  (eq. 4) which is in equilibrium with  $\text{HCO}_3^-$  &  $\text{CO}_3^{2-}$  (eq. 5)
- Removal of  $\text{CO}_2$  induces equilibrium shift (eq. 6)
- In a calcium rich environment,  $\text{CaCO}_3$  is precipitated (eq. 7)



# MCP by heterotrophic organisms

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- Abiotic dissolution of gypsum ( $\text{CaSO}_4^{2-} \cdot 2\text{H}_2\text{O}$ ) provides an environment rich in calcium and sulfate ions (eq. 8).
- In the presence of organic matter in an anaerobic environment, the sulfate reducing bacteria (SRB) reduce sulfate to  $\text{H}_2\text{S}$  and releasing the  $\text{HCO}_3^-$  ions (eq. 9).
- If  $\text{H}_2\text{S}$  degasses, pH increase occurs which favors  $\text{CaCO}_3$  precipitation (eq. 7)





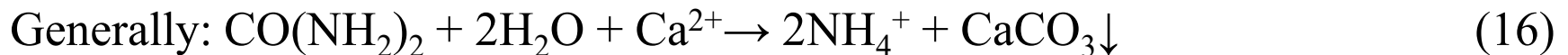
# MCP by Urea hydrolysis

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- Done by ureolytic bacteria -*Sporosarcina (Bacillus) pasteurii* (rest of the world) and *Bacillus Sphaericus* (mostly in Europe)
- These bacteria
  - Are Alkalophilic (growth between pH 6.5 and 9).
  - Are Facultative
  - Are non pathogenic
  - Uses urease enzyme to hydrolyse urea
  - Have high zeta potential

# MCP by Urea hydrolysis Cont'

- During urea hydrolysis
  - Urease enzyme hydrolyzes urea intracellularly to produce  $\text{NH}_3$  &  $\text{CO}_2$ .(eqs 10 & 11)
  - $\text{NH}_3$  released increases the pH (eq. 12-14)
  - In the presence of  $\text{Ca}^{2+}$  ions,  $\text{CaCO}_3$  is precipitated (eqs. 15&16)
    - $\text{CO}(\text{NH}_2)_2 + \text{H}_2\text{O} \rightarrow \text{NH}_2\text{COOH} + \text{NH}_3$  (10)
    - $\text{NH}_2\text{COOH} + \text{H}_2\text{O} \rightarrow \text{NH}_3 + \text{H}_2\text{CO}_3$  (11)
    - $\text{H}_2\text{CO}_3 \leftrightarrow \text{HCO}_3^- + \text{H}^+$  (pKa = 6.37) (12)
    - $2\text{NH}_3 + 2\text{H}_2\text{O} \rightarrow 2\text{NH}_4^+ + 2\text{OH}^-$  (13)
    - $\text{HCO}_3^- + \text{H}^+ + 2\text{NH}_4^+ + 2\text{OH}^- \leftrightarrow \text{CO}_3^{2-} + 2\text{NH}_4^+ + 2\text{H}_2\text{O}$  (14)
    - $\text{CO}_3^{2-} + \text{Ca}^{2+} \leftrightarrow \text{CaCO}_3$  ( $K_{\text{so}} = 3.8 \times 10^{-9}$ ) (15)





# Recovery of Lime

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- From equation 16, lime can be recovered, cleaned, dried and reused
- Coast Calcium is recovered??
- Optimal pH is 9
- Liming effluent pH is 11.3
- The process
  - Economically saves money
  - Promotes environmental sustainability



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**Thank you**

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