INDUSTRIAL WATER MANAGEMENT

WATER MANAGEMENT IN COFFEE PROCESSING

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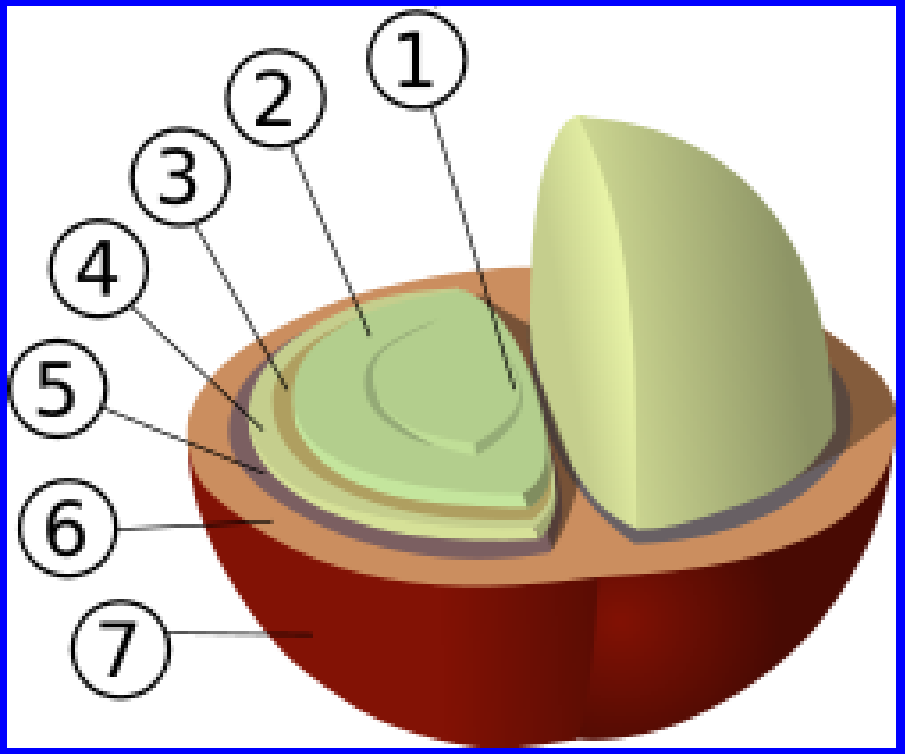
Water Management in Coffee

- *Water consumption*
- *Wet processing*
- *Wastewater sources*
- *Wastewater treatment*

Water Management in Coffee

140 litres of water

Coffee Berry



1: centre cut

2:bean (endosperm)

3: silver skin (testa, epidermis)

4: parchment (hull, endocarp)

5: pectin layer

6: pulp (mesocarp)

7: outer skin (pericarp, exocarp)

Coffee Processing

- *Dry Process*
  - *Cherries sorted and cleaned by winnowing or flotation*
  - *Cleaned cherries sun dried for 4 weeks*
  - *Machine-drying may be used to speed up the process after the coffee has been pre-dried in the sun for a few days*
  - *Dry process used for*
    - *95% of the Arabica coffee produced in Brazil*
    - *Most of the coffees produced in Ethiopia, Haiti and Paraguay,*
    - *Some Arabicas produced in India and Ecuador*
    - *Most Robustas*

Coffee Processing

- *Wet Process (mostly for Arabica)*
  - *Cherries sorted by immersion in water (good ripe fruit sinks)*
  - *Skin and some pulp removed by pressing through a screen*
  - *Mucilage and pulp is removed by wet or dry fermentation*
  - *Fermentation breaks down cellulose 12-36 hours*
  - *Washing*
  - *Drying*

Coffee Processing

- *Semi-wet process*
  - *Cherries de-pulped to remove the pericarp*
  - *Mucilage removed mechanically in upflow*
  - *Used in Colombia and Mexico to reduce water consumption*
  - *Semi-washed processing requires less time than washed processing but quality is inferior*

Coffee Processing

- *Becolsub*
  - *Developed in Columbia taken from Beneficio ECOLogicos SUB-productos*
  - *Reduces water contamination by up to 90% compared to wet processing*
  - *Pulping without water*
  - *Mucilage removed mechanically using <1m^3 water per tonne coffee*
  - *Mucilage is a potential by-product.*

Coffee Processing

- *The amount of water used in processing depends the process*
- *Recycling of water in the de-pulping process can drastically reduce the amount needed*
- *Without reuse consumption can be up to 20m³/tonne*
- *With reuse and improved washing techniques, consumption of 1 to 6 m³/tonne is achievable*

Coffee Processing

Country	Process	Water use m^3/tonne cherry
India	Semi-washed, wet processing	3
Kenya	Fully washed, reuse of water	4-6
Colombia	Fully washed and environmental processing (BECOLSUB)	1-6
Papua New Guinea	Fully washed, recycling use of water	4-8
Vietnam	Semi wet and fully washed	4-15
Vietnam	Traditional, fully washed	20
India	Traditional, fully washed	14-17
Brazil	Semi-washed, mechanical demucilage	4
Mexico	Semi-washed, mechanical demucilage	3.4
Nicaragua	Traditional, fully washed	16
Nicaragua	Fully washed, reuse of water	11

Wastewater

- *Two sources of wastewater*
  - *Pulping (~55% of volume)*
  - *Washing (~45% of volume)*
- *Both wastewaters contain sugars which begin fermenting to ethanol and acetic acid causing reduction in pH from ~7 to ~3-4*

Wastewater

- *Pulping Wastewater*
  - *Raw wastewater high insoluble COD up to 50,000mg/l*
  - *After screening COD 5,000 – 9,000*
  - *TN 50 – 110mg/l*
  - *TP 9 – 15mg/l*
  - *Sugars, proteins, pectins,(polysaccharide carbohydrates), acids polyphenolics (tannins) and alkaloids (caffeine)*
  - *Fermentation begins and pH falls depending on length of contact time (min 4.2)*

Wastewater

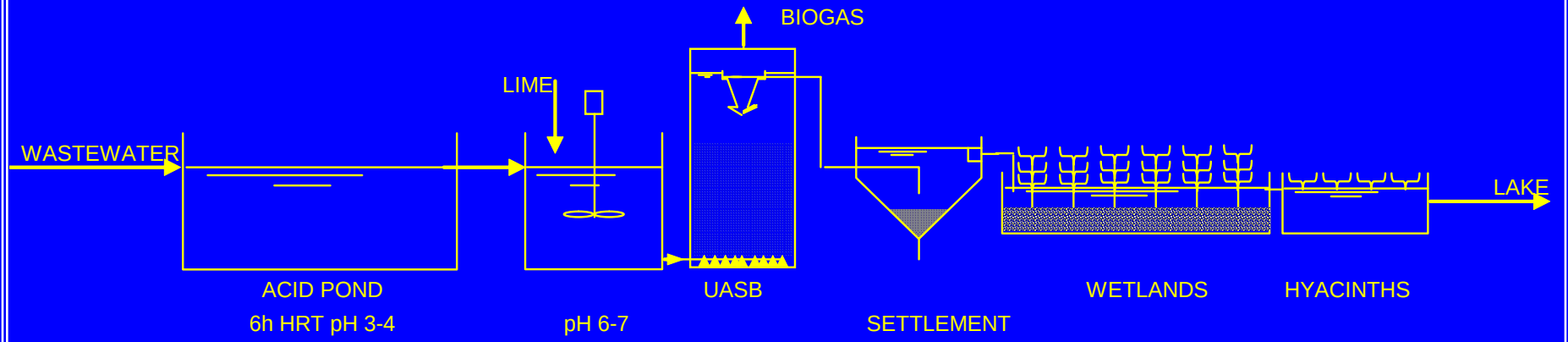
- *Fermentation/washing water*
  - *Washing of the fermented beans*
  - *Pectins, proteins and sugars.*
  - *Concentration falls as washing progresses*
  - *COD 7,000mg/l initial – 50mg/l final*
  - *TN 150mg/l initial – 40mg/l final*
  - *TP 16mg/l initial – 8mg/l final*
  - *pH 4 initial – 7 final*

Wastewater

- *Wastewater treatment*
  - *Coffee processing is a batch process so wastewater no constant*
  - *Pectin precipitates at low pH*
  - *For anaerobic treatment or constructed wetland pH 6.5 - 7.5*
  - *pH correction by $CaOH_2$ soulbilises pectins COD increases from an average of 3.7 g/l to an average of 12.7 g/l.*
  - *Flavonoids from the skin of the cherries increase colour*
  - *Polyphenolics and flavonoid compounds may be removed by aerobic fungi*

Wastewater

Khe Sanh Vietnam



	ACID POND	NEUT	UASB	SETTLING	WETLAND	HYACINTH	DISCH
pH	3.8	6.1	6.2	6.5	6.5	7.0	7.0
BOD	20,000	10,000	1,000	800	400	200	200

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Wastewater

- *Acid fermentation*
  - *Floating mucilage scum*
  - *Setting of solids*
- *Neutralisation*
  - *Produces calcium acetate*
- *UASB generates biogas*
- *Anaerobic settlement*
- *Re-aeration*
- *Wetlands planted with reeds*
- *Water hyacinth pond*

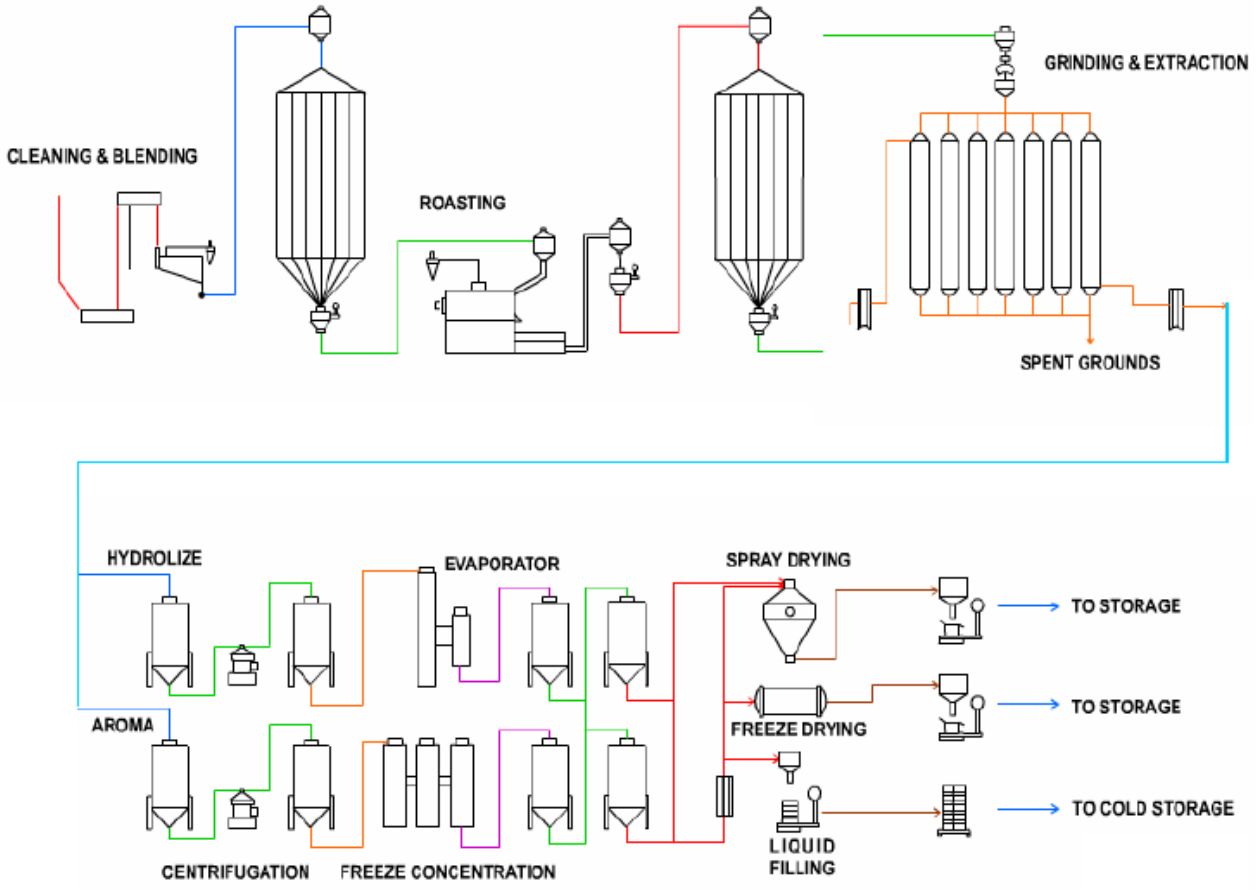
Instant Coffee

- *Roasting*
  - *rotating cylinders at165 °C 8–15 minutes*
  - *fluidized bed 1-4 minutes*
- *Grinding to 0.5–1.1mm*
- *Extraction with water in 5-10 percolation columns at 155 to 180 °C*
- *Coffee solution to about 15-30%*
- *Drying*
  - *Freeze drying*
  - *Spray drying*

Instant Coffee

- *Spray drying*
  - *5–30 seconds 270°C*
  - *Moisture content in 75-85% out 3-3.5%*
- *Freeze drying*
  - *Rapid freezing*
  - *Drying under vacuum*
  - *Condensation of water vapour*

Instant Coffee



Instant Coffee

- *Wastewater*
  - *Batch processing*
  - *Extraction wastewater*
    - *coffee grounds COD 10,000mg/l*
    - *High colour*
  - *Cleaning in place water*
    - *Alkaline detergents COD 1,000mg/l*

Instant Coffee

- *Spent coffee grounds adsorb a range of heavy metals including*
  - *Cadmium*
  - *Lead*
  - *Copper*
  - *Zinc*
- *Can be used for wastewater treatment*