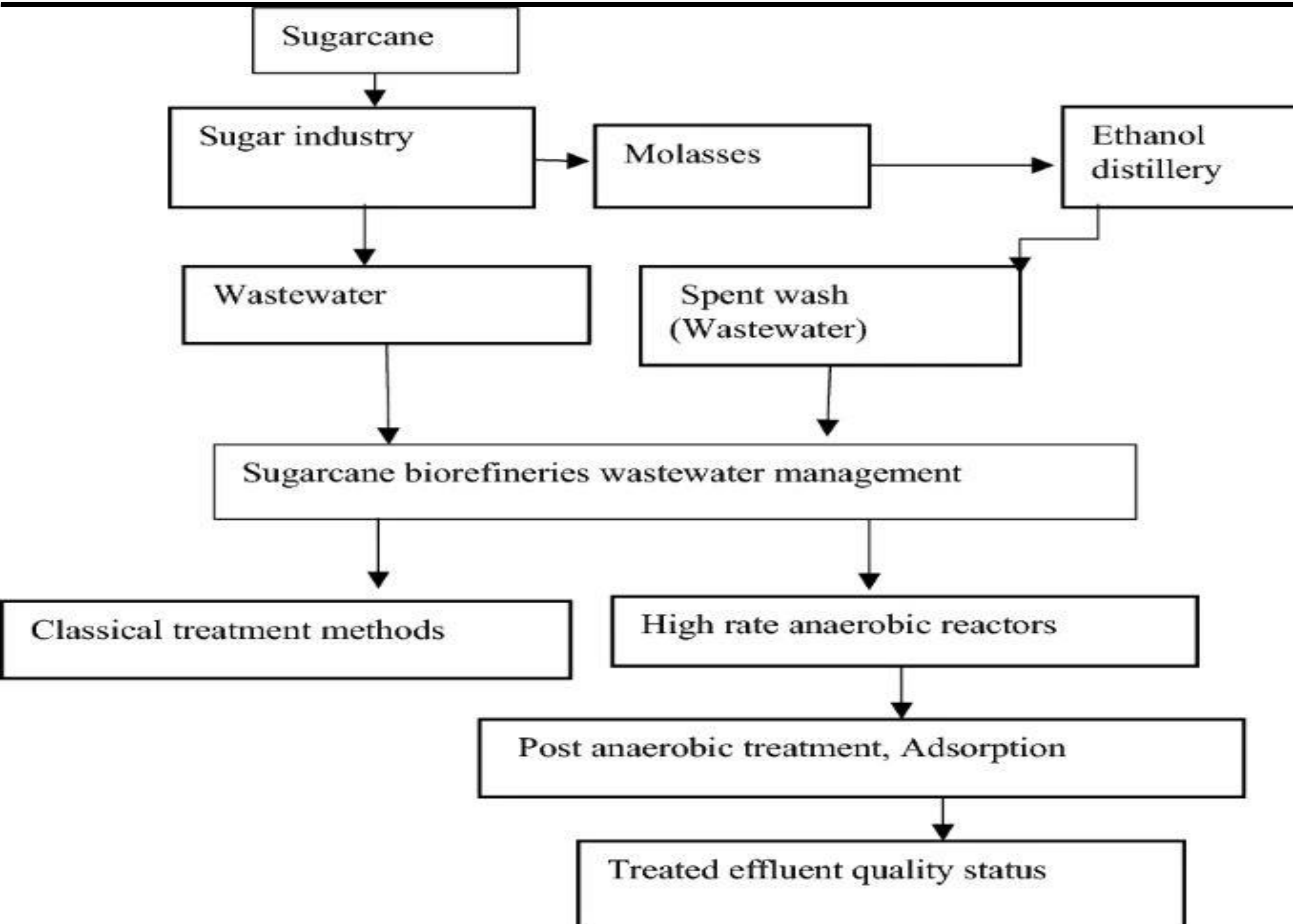
SUGAR MILL & DISTILLERY COMPLEX waste water treatment


Sugarcane
Sugar industry
Molasses
Ethanol distillery
Wastewater
Spent wash (Wastewater)
Sugarcane biorefineries wastewater management
Classical treatment methods
High rate anaerobic reactors
Post anaerobic treatment, Adsorption
Treated effluent quality status

SUGAR INDUSTRY

- ✓ The sugar industry subsumes the production, processing and marketing of sugars (mostly saccharose and fructose). Globally, most sugar is extracted from sugar cane and sugar beet.

- ✓ Sugar is an essential basis for soft drinks/sweetened beverages, convenience foods, fast food, candy/sweets, confectionery, baking products and the respective industries.

- ✓ Around 460 million tonnes of sugar is produced every year. The largest producers are Brazil (72%), India (15%) and the European Union (10%).

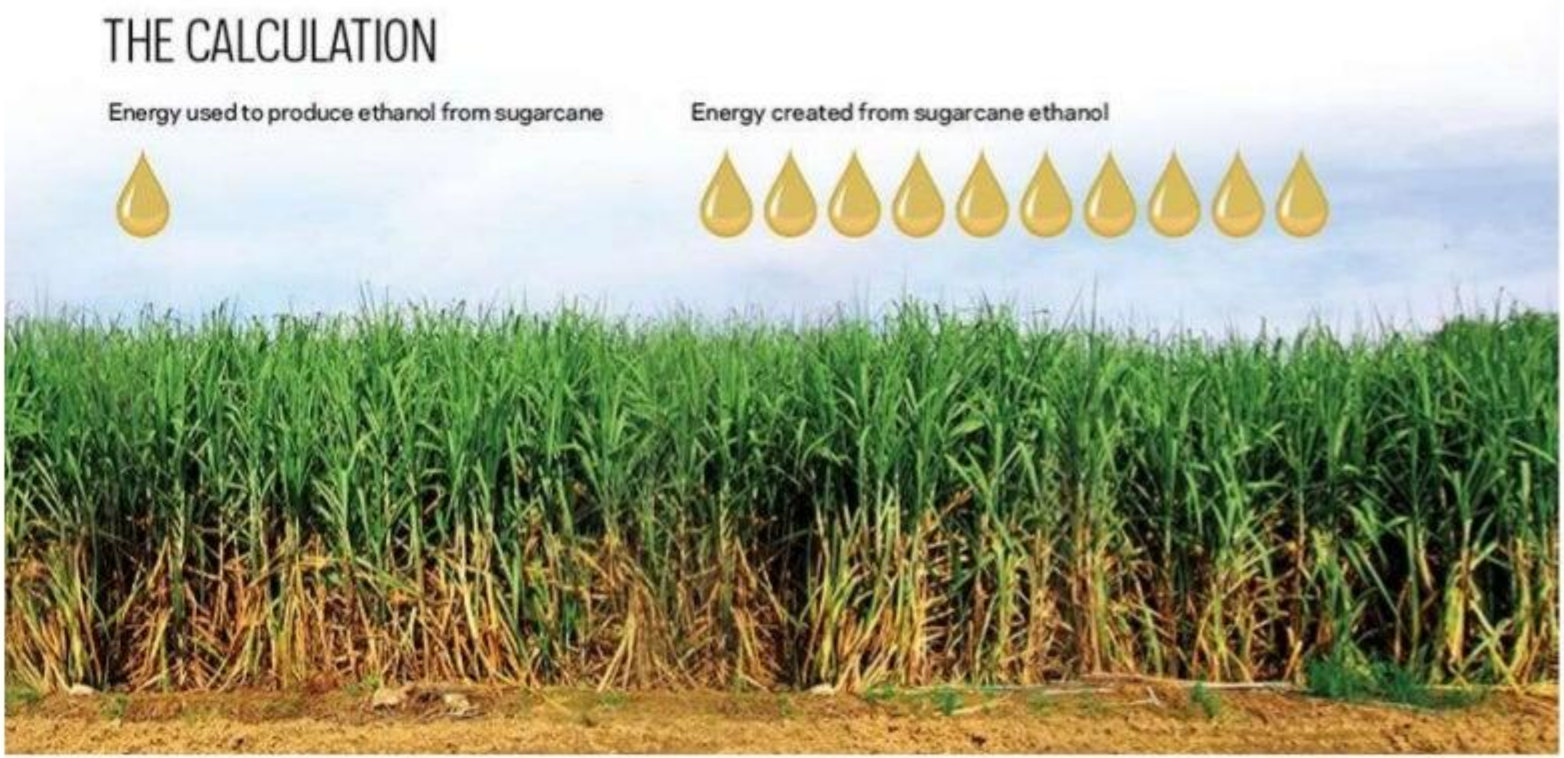
BEET SUGAR

- Beet sugar is derived from sugar beet.
- Sugar beet is a tap root, and it has a conical, white, fleshy root .
- The root of the beet comprises 75% water, 20% sugar, and 5% fiber.
- Sugar beets grow entirely in the temperature zone.
- Sugar beets account for 20% of sugar produced.
- Top 5 beet sugar producers in the world are France, the United States, Germany, Russia and Turkey.

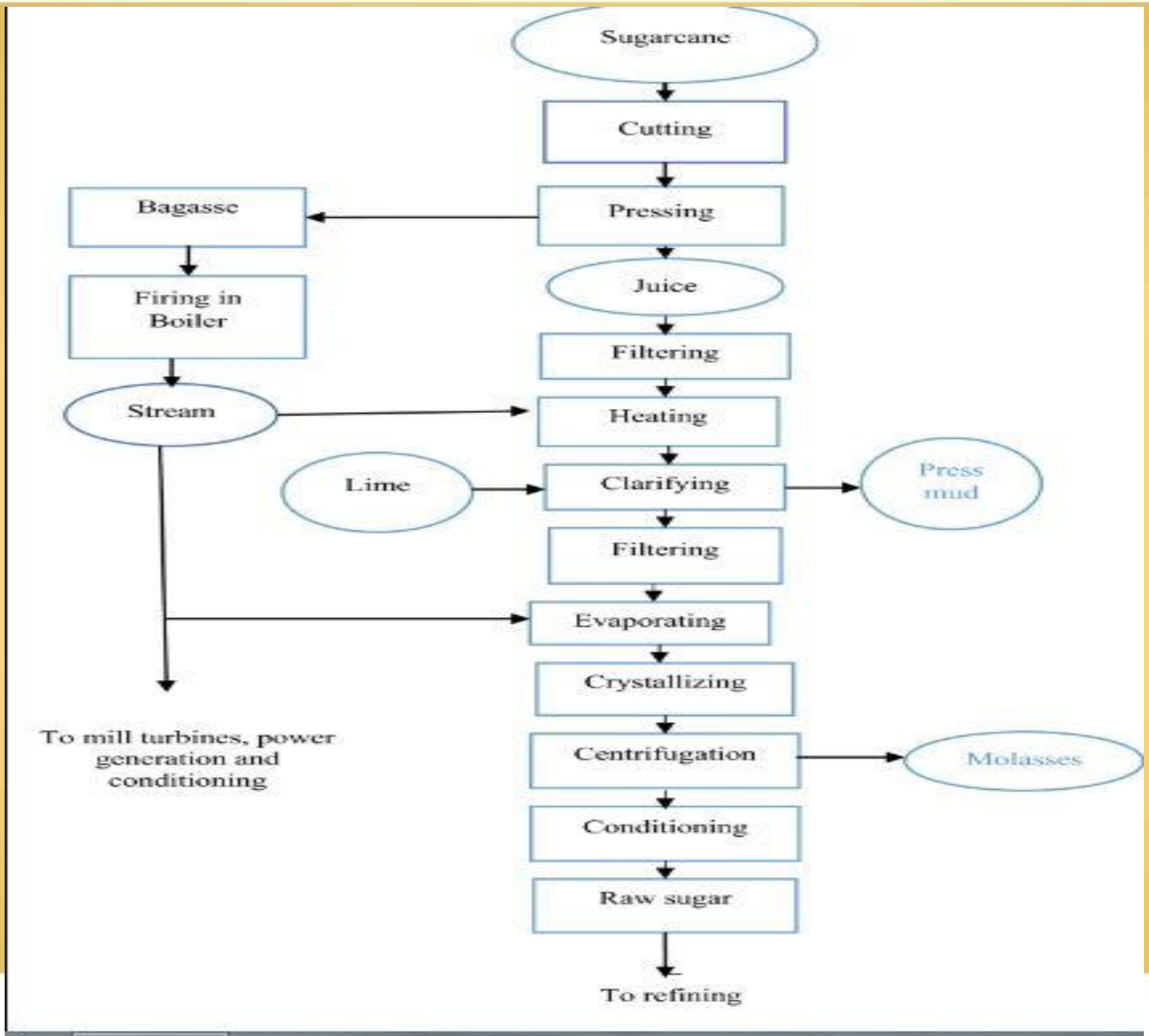
CANE SUGAR

- Cane sugar is derived from sugar cane.
- Sugar cane is a tropical tall true grass .
- A mature stalk classically comprises 11-16% fiber, 12-16% soluble sugars, 2-3% non-sugars, and 63-73% water.
- Sugarcane grows entirely in the tropical and subtropical zones.
- Cane accounts of 80% of sugar produced.
- Top 5 cane sugar producers in the world are Brazil, India, China, Thailand, Pakistan and Mexico.

In the past, sugar industry produced only sugar but nowadays sugar industries are involved in the production of sugar, electricity and ethanol. So sugar industry is now called as the cane industry.



HOW SUGAR IS MADE?



WHY DO WE TREAT WASTEWATER OF SUGAR INDUSTRY

?

- Wastewater from sugar industry, if discharged without treatment, poses pollution problem in both aquatic and terrestrial ecosystems .

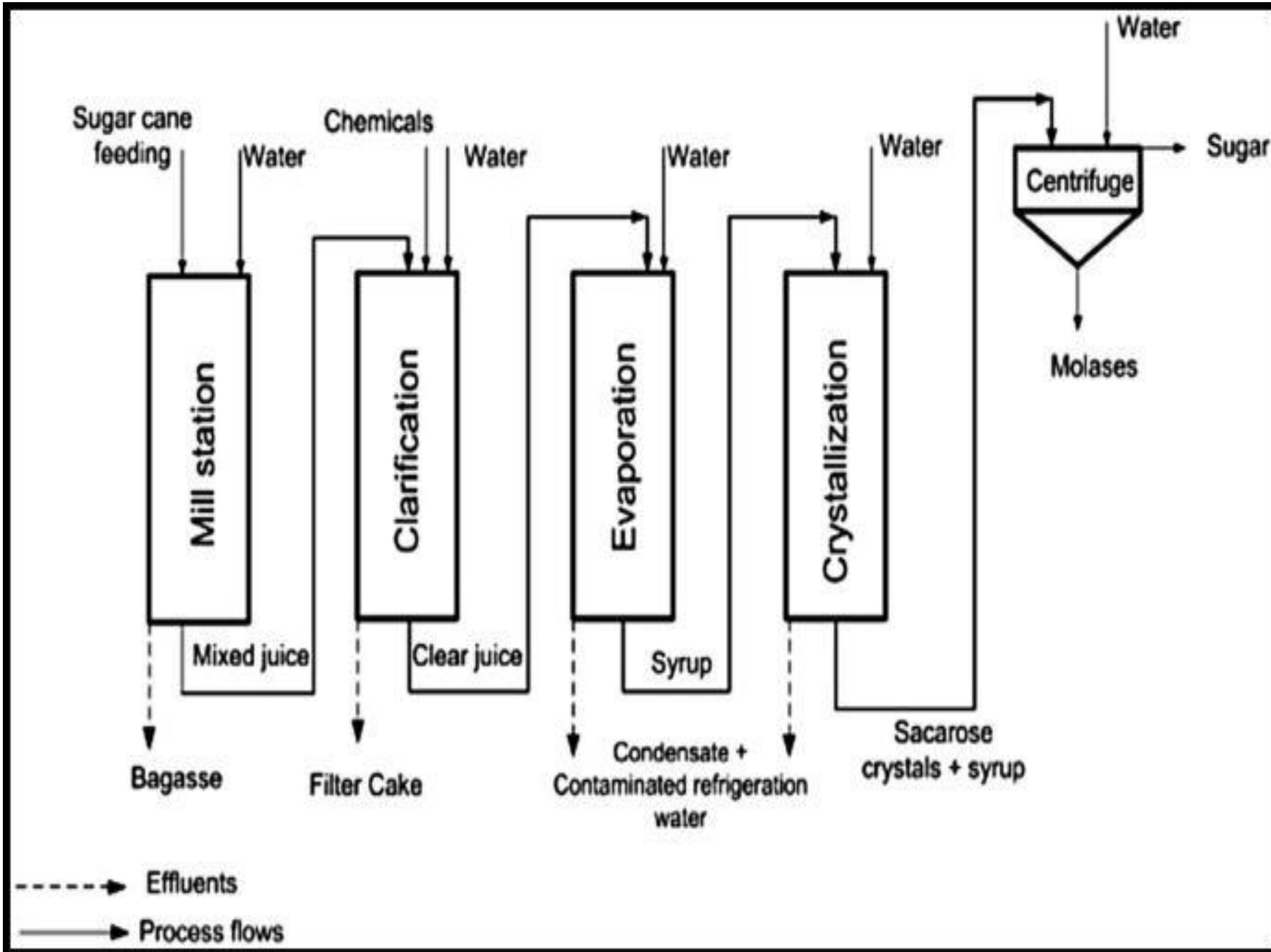
- Also, sugar industry wastewater when not treated completely produces unpleasant smell when released into the environment.


SOURCES OF WASTEWATER

- Sugar industry wastewaters are produced mainly by cleaning operations.
- Washing of milling house floor, various division of boiling house like evaporators, clarifiers, vacuum pans, centrifugation, etc. generates huge volume of wastewater.
- Periodical cleaning of heat exchangers and evaporators with NaOH and HCl to remove the scales on the tube surface contributes organic and inorganic pollutant loadings to wastewater.
- Leakages from pumps, pipelines, centrifuging house also contribute to wastewater produced.
- Except this, wastewater is also produced from boiler blowdown, spray pond overflow, and from condenser cooling water which is discharged as wastewater when it gets contaminated with cane juice.

Table 1. Typical Composition of Sugar Industry Wastewater

Sr. No	Parameter	Average Values	Effluent Standard for Discharge on Inland Surface Water	Effluent Standard for Discharge on land for Irrigation
1.	pH	10.69	5.5-9.0	5.5-9.0
2.	COD	5102(mg/L)	250	-
3.	BOD	1998(mg/L)	30	100
4.	TS	4530(mg/L)	-	-
5.	TDS	3758(mg/L)	-	-
6.	TSS	772(mg/L)	100	200
7.	Oil & Grease	14	10	10


Water
Sugar cane feeding
Water
Chemicals
Water
Water
Water
Sugar
Centrifuge
Mill station
Clarification
Evaporation
Crystallization
Molases
Mixed juice
Clear juice
Syrup
Bagasse
Filter Cake
Condensate + Contaminated refrigeration water
Sacarose crystals + syrup
Effluents
Process flows

- The sugar industry wastewater is characterized by its brown colour, low pH, high temperature, high BOD, high COD, odour problem, total solids, and high percentage of dissolved organic and inorganic matter.

- Wastewater from sugar industry generally contains carbohydrates, nutrients, oil and grease, chlorides, sulfates, and heavy metals.

TREATMENT METHODS

- Treatment of sugar industry wastewater requires a process that combines mechanical, chemical, and biological treatment measures.
  - Screening, grit removal, flow equalization, sedimentation, or dissolved air flotation are used to reduce suspended solids (SS) load from sugar industry wastewater.
  - Biological treatment methods are applied for the reduction of soluble organic matter and disinfections. Biological treatment includes aerobic and anaerobic process.
  - Except biological methods, physicochemical methods are also used for sugar industry wastewater treatment.

BIOLOGICAL METHODS

Since, sugar industry wastewater contains mostly sugars and volatile fatty acids, which are easily biodegradable; therefore all the biological ***(anaerobic and aerobic) treatment processes*** are suitable.

AEROBIC TREATMENT

- ✓ Aerobic biological treatment generally involves degradation of organic in the occurrence of oxygen. Conventional aerobic treatment includes activated sludge, trickling filters, aerated lagoons, or a combination of all.

Figure 1. Trickling Filter

- ✓ Earlier, lagoons were used for sugar industry wastewater treatment because of being an economic process. However, larger area requirements and emission of unpleasant and annoying odour during the treatment process are some of the disadvantages of lagoons. Aerated lagoons were also used in past and showed lesser residence time and area required compared to lagoons, to treat sugar industry wastewater, but oxygen consumption and HRT(hydraulic retention time) were found to be high, and still large area requirement is disadvantage.

Figure 2. Aerated Lagoons

ANAEROBIC TREATMENT

- Anaerobic treatment method for concentrated wastewater, in terms of pollutants (as the sugar industry wastewater), is widely used method in the industries. It has several advantages over aerobic processes, which include the lesser energy required; methane production due to the degradation of organic matters, which is a source of energy; and lesser sludge production, which indirectly reduces sludge disposal costs greatly.

- Sugar industry waste waters are biodegradable except oil and grease which are not easily degraded by anaerobic processes, because oils produce long chain fatty acids during the hydrolysis step which causes retardation in methane production . Long-chain fatty acids were reported to be inhibitory to methanogenic bacteria.

Reactors, generally used for anaerobic treatment of sugar industry wastewater are,

- Anaerobic batch reactor
- Anaerobic Fixed-bed reactors (AFR)
- Up-flow Anaerobic Fixed Bed (UAFB) reactor
- Up-flow Anaerobic Sludge Blanket (UASB) reactor

Up-flow Anaerobic Sludge Blanket (UASB)

- This reactor is used for the anaerobic process.
- In this anaerobic treatment complex organic matter is get converted into methane gas through the stages like hydrolysis, acidogenesis, etc.
- UASB is widely applicable for treating various types of wastewater.
- UASB has advantages over aerobic treatment.
- UASB is used for treating wastewater in sugar industry, distillery, dairy industry, slaughter house and high strength municipal wastewater.

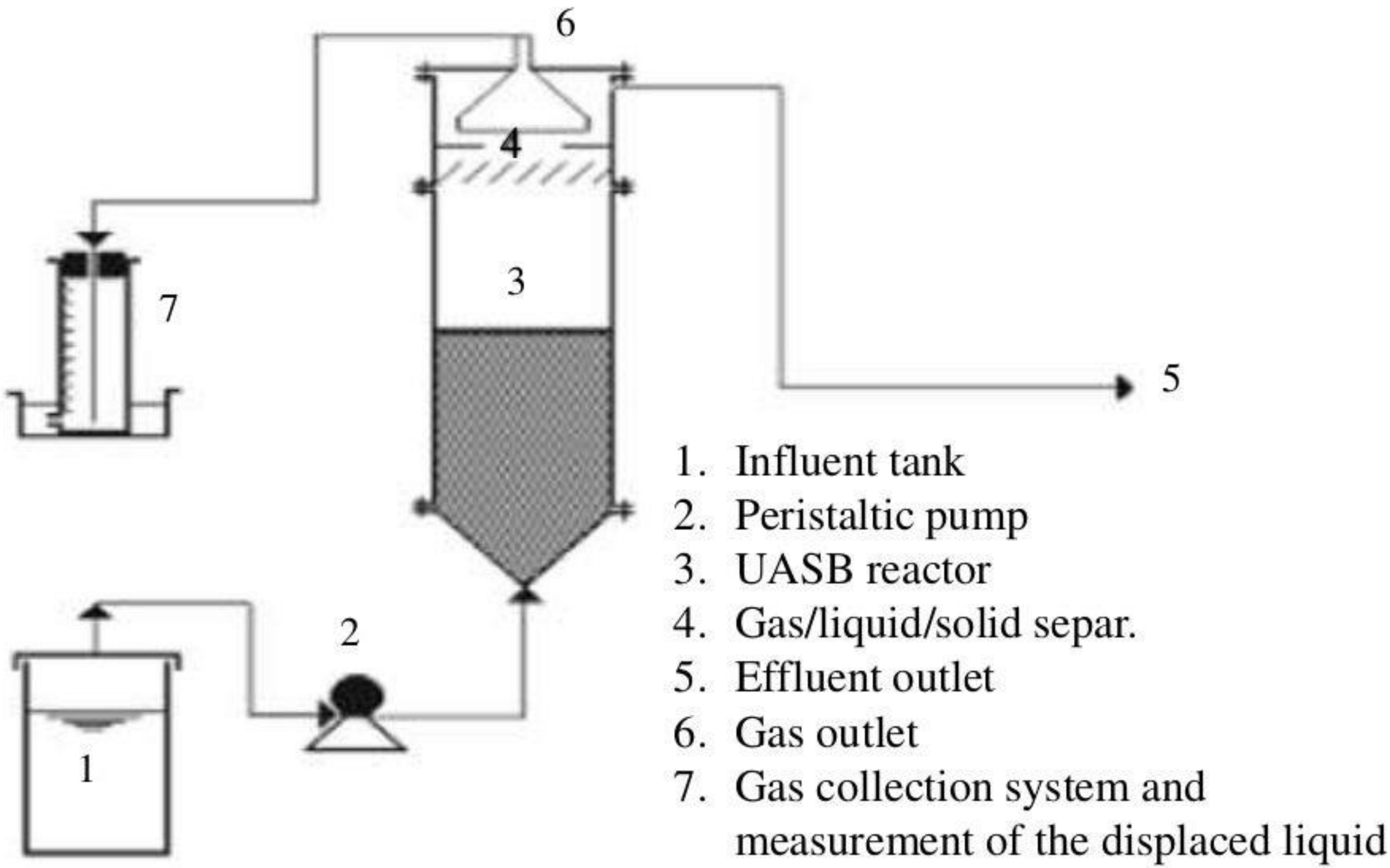
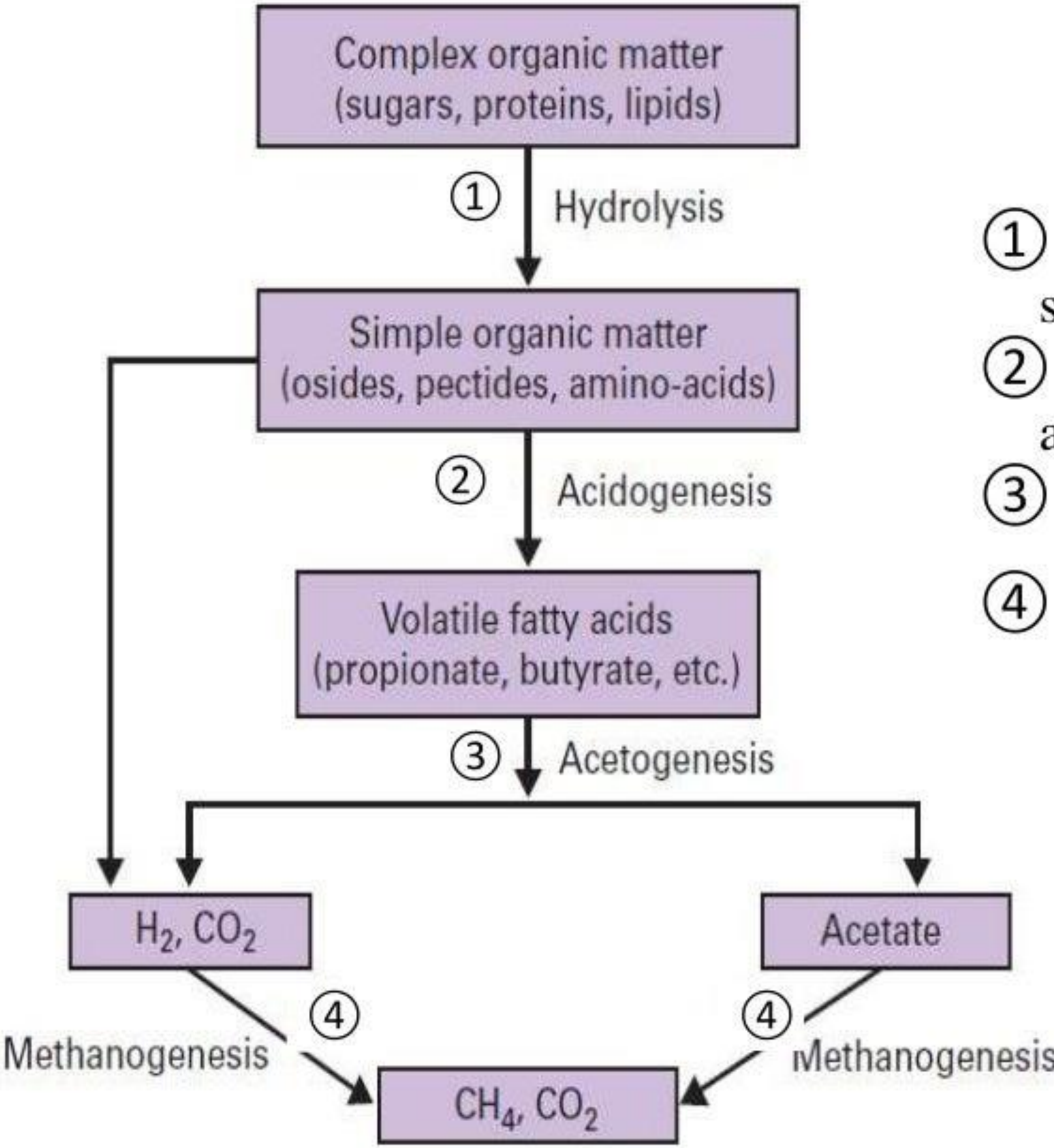


Figure 3. Schematic Diagram of the Laboratory UASB reaction system

Mainly the following are the four key biological and chemical stages in UASB process:

- Hydrolysis
- Acidogenesis
- Acetogenesis
- Methanogenesis



① Complex organic molecules to soluble

② Small organic molecules to fatty acids

③ Conversion to acetic acid & CO_2

④ Final conversion to methane [CH_4]

Figure 4. Main Conversion Processes in Anaerobic Digestion

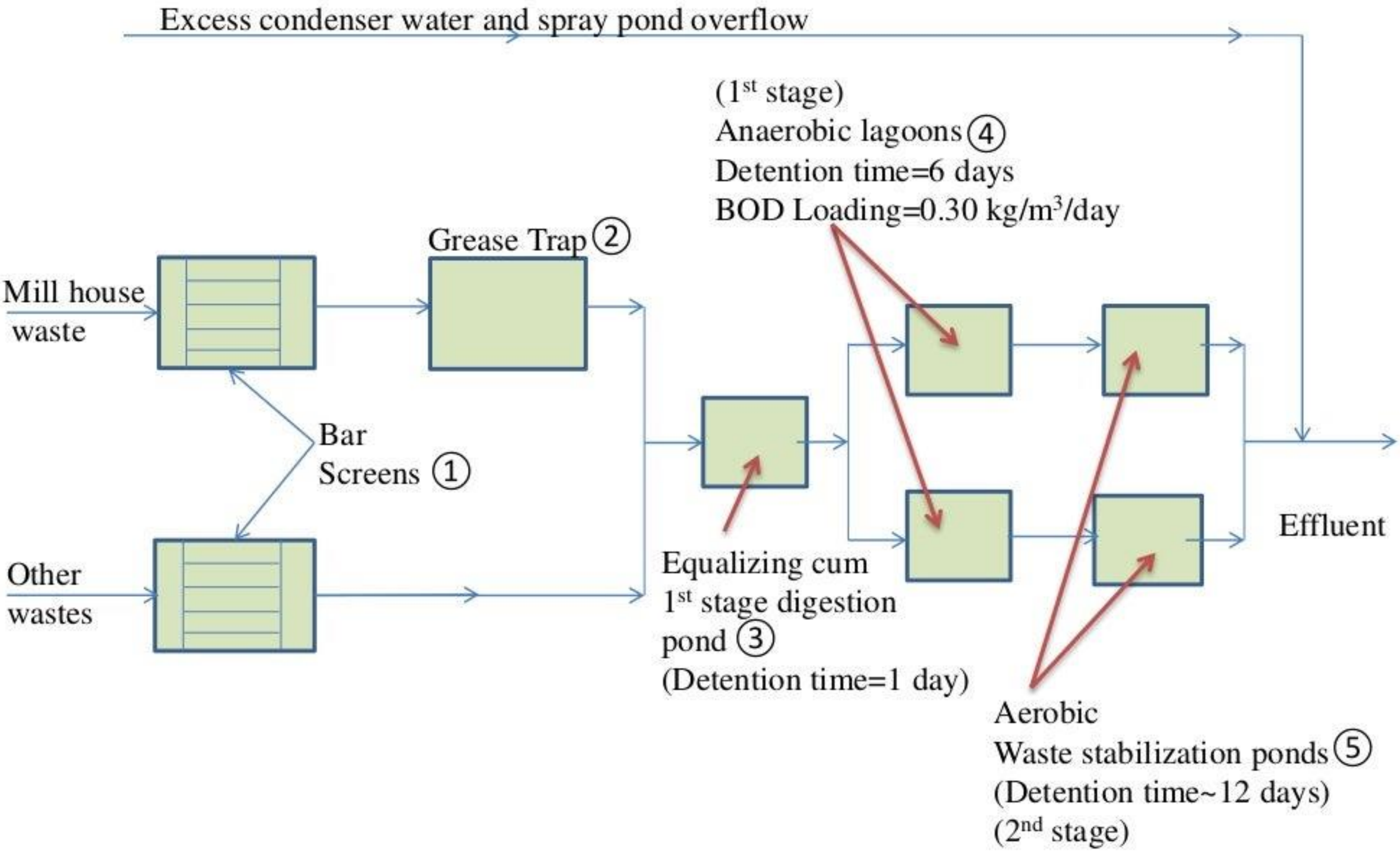


Figure 5. Treatment of cane sugar waste in a stabilization pond

PHYSICO-CHEMICAL METHODS

- Coagulation/flocculation with inorganic coagulants and adsorption are widely used for the removal of suspended, colloidal, and dissolved solids from wastewaters. Generally, coagulation/flocculation is used in the primary purification of industrial wastewater .

- In coagulation process, insoluble particles and/or dissolved organic materials collect to be larger, and are removed by sedimentation/filtration stages.

ELECTRO-CHEMICAL TREATMENT

Electro-chemical treatment process is an emerging wastewater treatment technology. Electro Chemical treatment method involves,

- ✓ Electro-Oxidation
- ✓ Electro-Coagulation
- ✓ Electro-Floatation

In Electro-Oxidation (EO) treatment**,** organic materials are oxidized to carbon dioxide and water or other oxides by electrochemically generated reactive oxygen and/or oxidizing agent.

Whereas, ***Electro-Coagulation process*** involves generation of anode material hydroxides and/or poly hydroxides which remove the organics by coagulation.

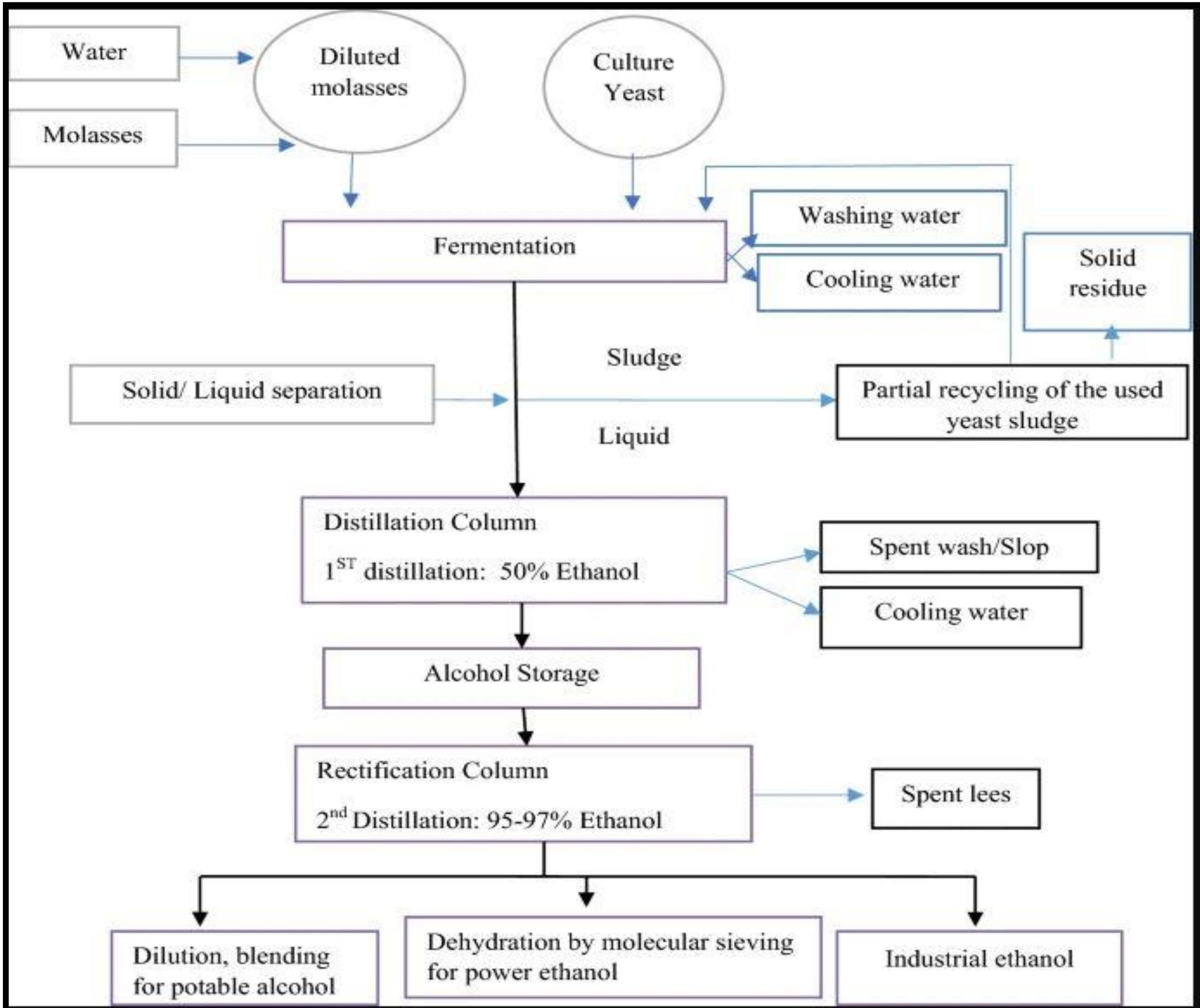
Electro-Flotation process removes pollutants with the help of buoyant gases bubbles generated during electrolysis, which take with them the pollutant materials to the surface of liquid body.

Distillery Industries Wastes

- The distilleries using molasses, a bye-product of sugar industry, for production of alcohol by fermentation and distillation process, generate highly organic and colored wastewater.
- Considered as one of the most polluting industries.
- Total waste volume is 6O to 100 litres per litre of alcohol produced.
- The waste streams comprises spent wash, which is the main source of the waste water, spent lees and yeast sludge.

Continued….

- Spent lees is usually mixed with the spent wash.
- In the production of alcohol from molasses, 3 to 10 kg of molasses are used for producing 1 litre of alcohol and for each litre of alcohol about 10 to 15 litres of spent wash is produced.
- The distillery spent wash is hot, highly coloured and acidic, apart from containing high percentage of dissolved inorganic and organic matter, the latter being particularly responsible for high biochemical oxygen demand (BOD) and the polluting nature of the waste.
- Spent wash, contains dissolved salts and has a persistent dark brown color.


Water
Molasses
Diluted molasses
Culture Yeast
Fermentation
Washing water
Cooling water
Solid residue
Sludge
Solid/ Liquid separation
Partial recycling of the used yeast sludge
Liquid
Distillation Column
1ST distillation: 50% Ethanol
Spent wash/Slop
Cooling water
Alcohol Storage
Rectification Column
2nd Distillation: 95-97% Ethanol
Spent lees
Dilution, blending for potable alcohol
Dehydration by molecular sieving for power ethanol
Industrial ethanol

Spent lees

The sediment of wine in barrels or the remnants of a liquid left in container, together with any sediment.

Table Spent lees characteristics

S. No.	Parameter	Range
1	Ph	3.6 - 4.5
2	COD	5,000 - 6,000
3	BOD	200 - 300
4	Total solids	
	Dissolved	5,000 - 6,000
	Suspended	500 - 1000
5	Chlorides	50 - 100

Note: All values from S. No. 2 to 5, are in mg/L
Source: Draft report prepared on, "Development of Methodology for Environmental Auditing" by Dr. B. Subba Rao of EPRF, Sangli, for CPCB

Yeast sludge

- Yeast sludge containing about 30 percent solids settles down in the fermentation vats and constitutes a major source of waste.
- The yeast sludge is disposed separately after drying.
- In addition, waste water may be generating from
  - Bottling,
  - Fermentation tank cooling and washing and
  - Utility section of the plant which is used as a diluent for the treated spent wash.

Sources of wastewater

In a distillery, sources of wastewater are

- Stillage,
- Fermenter and
- Condenser
- Cooling water and
- Fermenter wastewater.

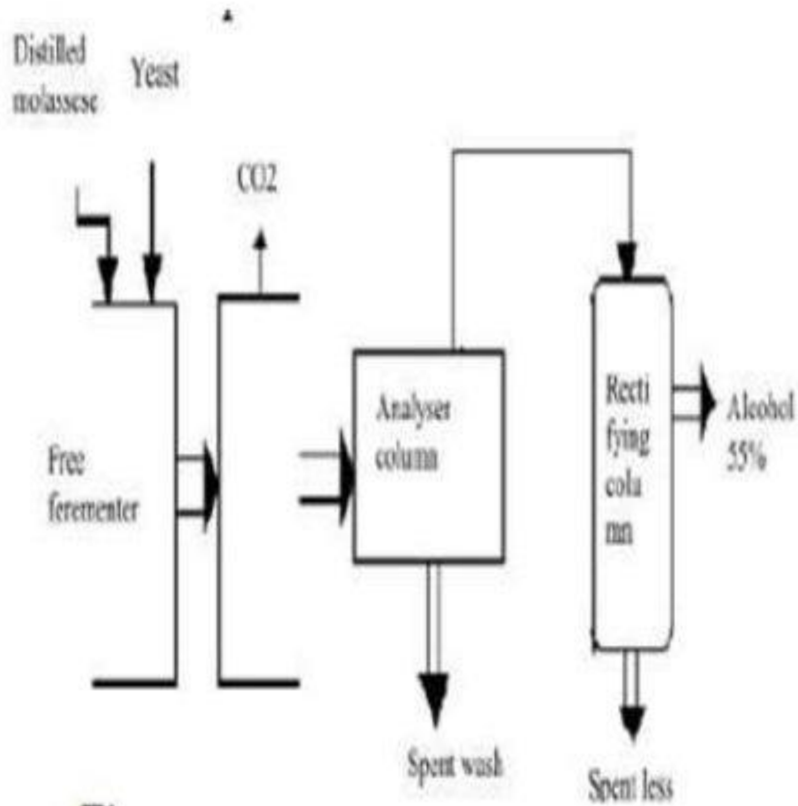


Fig. Schematic production of distillery wastewater (Chang *et al.*, 2003)

Treatment and management of wastewater

- The technology currently used by distilleries for treatment of waste water are *biomethanation* followed by *two stage biological treatment* and disposal in water courses or for utilization on land for *irrigation*, *composting with or without biomethantion* and *concentration and incineration*.
- These technologies treat the waste water up to a certain level.
- These are unable to remove total dissolved solids as well as colour to safe and acceptable limits for disposal into surface water or on land.

Characteristics of Distillery Wastewater

Indian Standard guide for treatment of distillery effluents

(All values except *p*H and BOD are expressed as percent.)

SL No.	CHARACTERISTIC	FROM LITERATURE[1]	DATA FROM 15 FACTORIES SURVEYED BY NEERI[2]
(1)	(2)	(3)	(4)
i)	*p*H value	4·5 to 5·0	3·0 to 5·4
ii)	Total solids	8 to 9	0·15 to 10·4
iii)	Volatile solids	5·3 to 6·0	0·11 to 7·5
iv)	Ash	2·7 to 3·0	0·02 to 2·2
v)	Calcium (as CaO)	0·26 to 0·4	—
vi)	Potash (as K_2O) (*see* Note)	0·6 to 1·5	0·03 to 0·72 (7 factories)
vii)	Sodium salts (as Na_2O)	0·15 to 0·2	—
viii)	Iron, etc (as hydroxides)	0·01 to 0·03	—
ix)	Acid insolubles	0·1 to 0·15	—
x)	BOD (5 days at 20°C), mg/l	30 000 to 70 000	10 000 to 73 000
xi)	Phosphorus (as P)	—	0·1 to 1·0
xii)	Nitrogen (as N)	—	0·01 to 1·5

NOTE — In general potash content ranges between 7 to 15 percent of the total solids.

Management of distillery wastewater bv ***CPCB*.**

S. No.	Parameter	Batch process	Continuous process	Biostill process
1	Volume, L/L Alcohol	14 - 15	10 - 12	7 - 9
2	Colour	dark brown	dark brown	dark brown
3	pH	3.7 - 4.5	4.0 - 4.3	4.0 - 4.2
4	COD	80,000 - 1,00,000	1,10,000 -1,30,000	1,40,000 - 1,60,000
5	BOD	45,000 - 50,000	55,000 - 65,000	60,000 - 70,000
6	Solids			
	Total	90,000 - 1,20,000	1,30,000 - 1,60,000	1,60,000 - 2,10,000
	Total volatile	60,000 - 70,000	60,000 - 75,000	80,000 - 90,000
	Inorganic dissolved	30,000 - 40,000	35,000 - 45,000	60,000 - 90,000
7	Chlorides	5,000 - 6,000	6,000 - 7,500	10,000 - 12,000
8	Sulphates	4,000 - 8,000	4,500 - 8,500	8,000 - 10,000
9	Total nitrogen	1,000 - 1,200	1,000 - 1,400	2,000 - 2,500
10	Potassium	8,000 - 12,000	10,000 - 14,000	20,000 - 22,000
11	Phosphorus	200 - 300	300 - 500	1,600 - 2000
12	Sodium	400 - 600	1,400 - 1,500	1,200 - 1,500
13	Calcium	2,000 - 3,500	4,500 - 6,000	5,000 - 6,500

Note: All values from S. No. 4 to 13, are in mg/L

Source: Draft report prepared on, "Development of Methodology for Environmental Auditing" by Dr.B. Subba Rao of EPRF, Sangli, for CPCB

Methods of treatment

- **Biological treatment**: Distillery wastes are amenable to biological treatment, both anaerobic and aerobic. Since distillery wastes are of high biochemical oxygen demand, normally anaerobic treatment precedes any aerobic biological treatment.

  a) ***Anaerobic Processes*** **-** The anaerobic treatment of distillery wastes can be either anaerobic digestion or anaerobic lagooning.

  i. ***Anaerobic digestion:*** An excellent method of reducing about 90 percent of the biochemical oxygen demand of distillery waste, and a burnable gas containing high percentage of methane is also recovered as a by-product from this process.

  ii. ***Anaerobic lagooning*** **-** Anaerobic lagooning is cheap and effective method of treatment of distillery wastes. Subbarao reported 95 percent biochemical oxygen demand reduction in an anaerobic lagoon treating distillery wastes. (Subbarao (B A). Technical report on sugar distillery industry waste disposal. 1971. Walchand College of Engineering, Sangli.)

Biological treatment continued….

b) Aerobic Processes: The conventional aerobic biological processes, namely, trickling filters and activated sludge units have been adopted for treatment of distillery wastes. Extended aeration can also be adopted for treating these wastes.

i. *Trickling filters* - Trickling filters, single-stage or two-stage, are adopted for treating either diluted distillery waste or pretreated distillery waste. Deep trickling filters made of plastics media are found to be useful in treating concentrated organic wastes including distillery wastes

ii. *Activated sludge process* -The performance of activated sludge and extended aeration plants for treating diluted or pretreated distillery waste has been reported.

Disposal to Water Course

- The spent wash may be treated by anaerobic process followed by one of the aerobic processes, such as extended aeration, activated sludge process, trickling filtration or aerated lagooning and diluted with condenser waters to keep the BOD of the final effluent below 100 mg/l before disposing of into a water course (see Fig.).
- It may be necessary to dilute the influent to the aerobic processes. This can be done by using part of the condenser water.
- If suspended solids in the spent wash are high then it is useful to separate them, dry and incinerate them or dispose of on land. The settled spent wash can then to be taken for biological treatment.

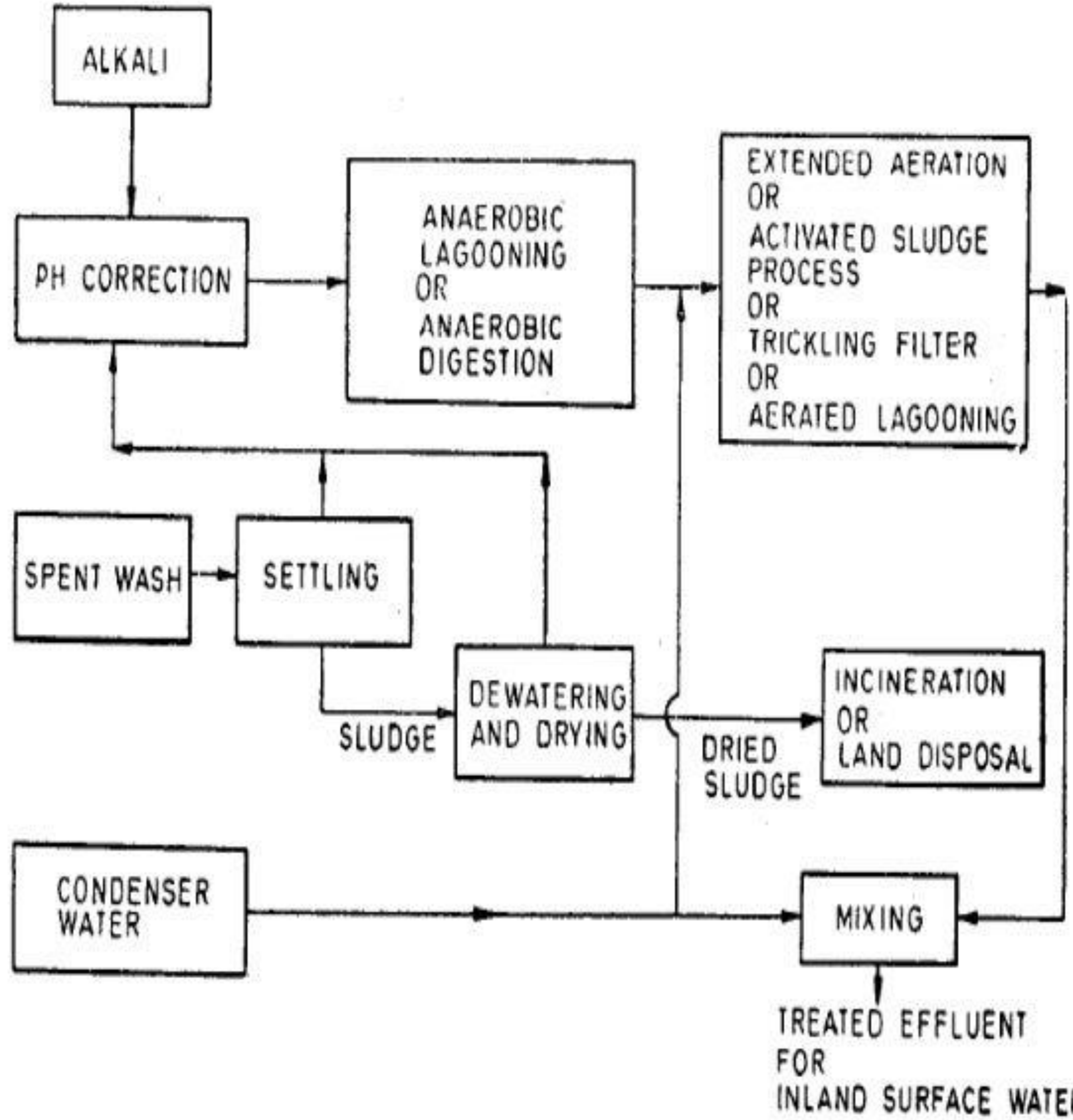


FIG. FLOW SHEET FOR THE TREATMENT OF SPENT WASH FOR DISPOSAL INTO INLAND SURFACE WATER

Land disposal

The spent wash may be treated by an anaerobic process such *as* anaerobic digestion or anaerobic lagooning followed by an aerobic process such as activated sludge process, trickling filtration, or aerated lagooning and the treated effuent diluted to have a biochemical oxygen demand of less than 500 mg/l and used for irrigation or disposed of on land.

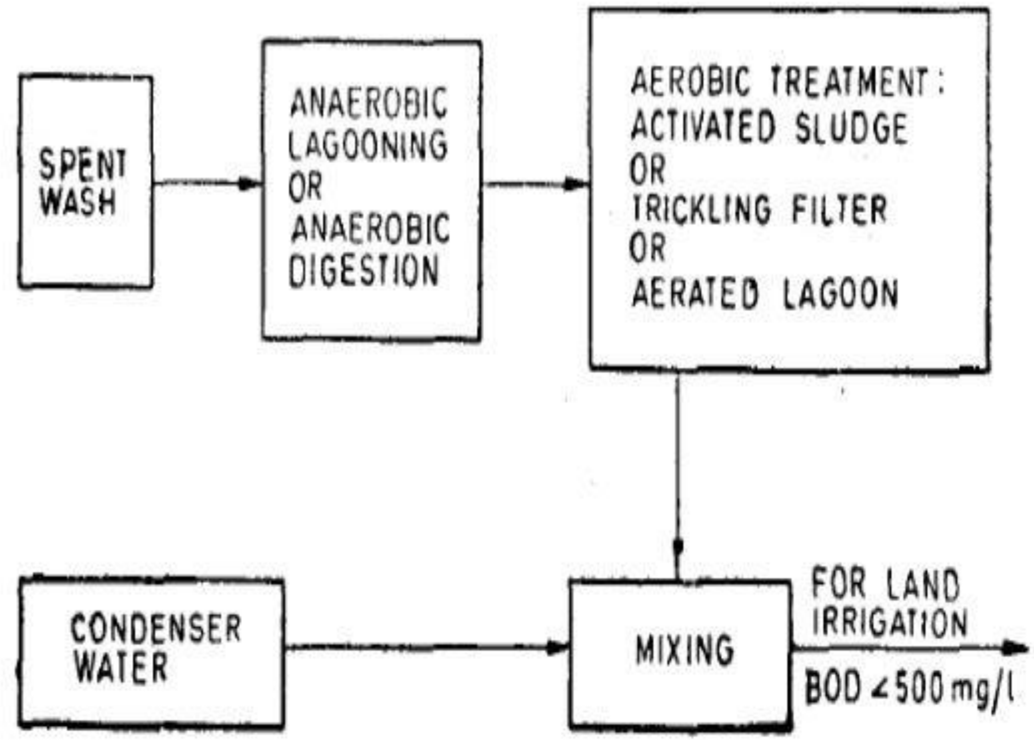


Fig. Flow Sheet for the Treatment of Spent Wash for Disposal on Land

Other methods

- Physical methods: includes Sedimentation, Screening, Aeration, Filtration (Membrane Technologies), and Flotation.
- Chemical methods: includes Chlorination, Coagulation, Adsorption, and Ion Exchange.

Thank you….!