

**BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI CAMPUS**  
**DEPARTMENT OF CHEMICAL ENGINEERING**  
**I Semester – 2022 - 2023**  
**Course Title: Environmental Management Systems (CHE G513)**  
**Mid semester – Closed Book – 40 Marks + Open Book – 40 Marks**  
**Date- 27.12.2022      Time: 2:00 PM - 5:00 PM**

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- 1. Question paper is comprised of two parts – Closed Book and Open Book of 40 Marks and time is 90 Minutes for CB and OB, respectively.**
- 2. On returning CB Answer Script – Open book is to be answered in separate Answer Script.**
- 3. Make necessary assumptions where ever needed.**

**1. (3+3+3 = 9 Marks) – Laws and Regulations**

- a. What are the CPCB's core functions ? What are the essential business activities that the CPCB must undertake in support of the mission ?
- b. Presently more than 400,000 tonnes of E-waste is generated which may increase in coming years. MoEFCC has evolved the guidelines for E-Waste Management. Explain the guidelines for E-waste management.
- c. As NAMP is being operated through various monitoring agencies, a large number of personnel and equipments are involved in the sampling, chemical analyses, data reporting. Explain the NAMP program in the form of flow chart ?

**2. (3+4 = 7 Marks) – Sustainability**

Unsustainable patterns of consumption and production are root causes of the triple planetary crises of climate change, biodiversity loss and pollution.

- a) As the world develops strategies for sustainable recovery from the pandemic, governments and all citizens should seize the opportunity to work together to improve \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_
- b) Write the 4 SDG Goals w.r.t Chemical Engineering.

**3. (3+3 = 6 Marks) – TMDL Study**

- a) EPA and several commenters also suggested that the states consider whether there may be areas that differ significantly from the rest of the region in terms of fish tissue concentrations, local sources, or other factors, and if so, to consider separating the single regional TMDL into sub-regions or separate TMDLs. Explain the three assumptions made in the TMDL study ?
- b) When a pollutant load is discharged into a flowing stream or river, it is subject to fate and transport processes that modify stream concentrations. The principal factors determining stream concentrations are advection, dispersion and reaction. Explain these concepts and relate how these affect the TMDL for receiving water streams.

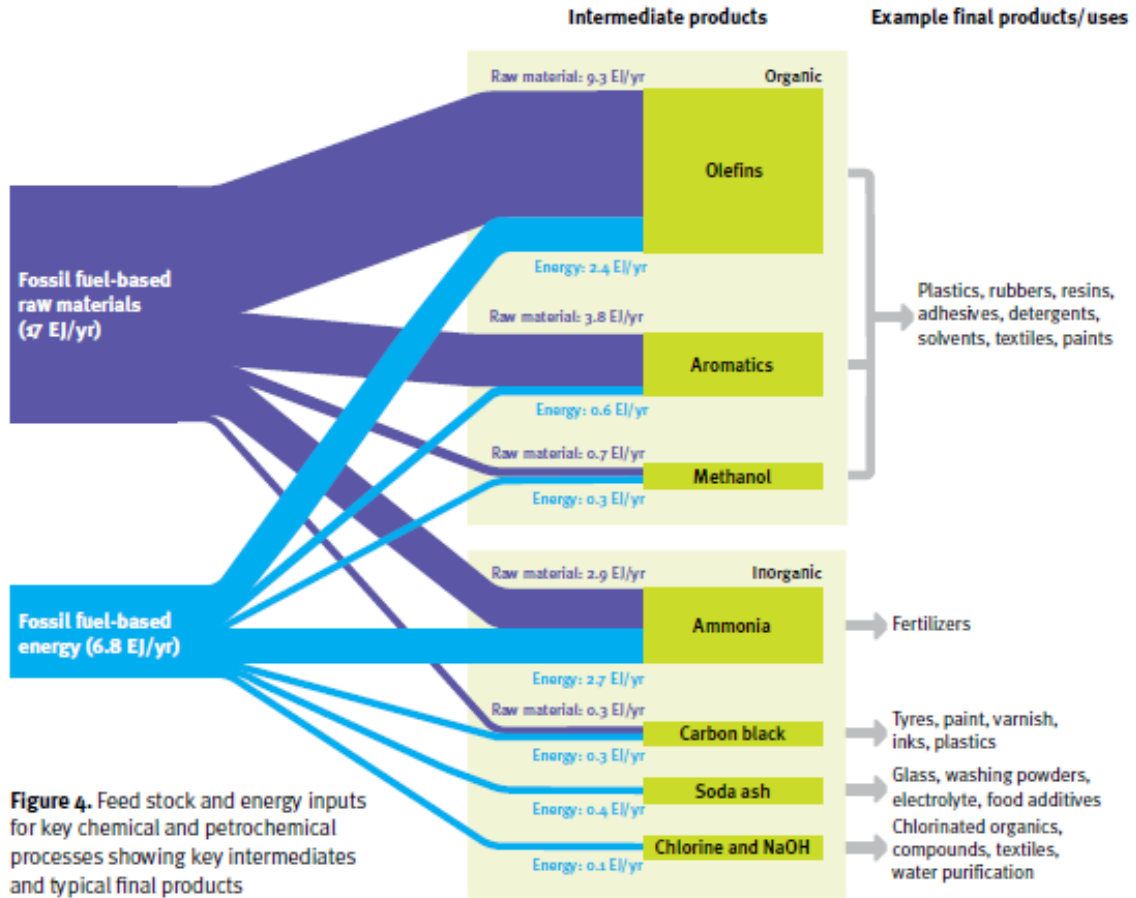
**4. (2+3 = 5 Marks) – EPIs**

Environmental performance indicators (EPIs) provide a reference point to track progress in a specific environmental area (Metcalf et al., 1996) and thus helps managers by creating measurable, quantitative goals.

- a) Mention two general categories of EPIs . – EPIs and ECIs
- b) What are the major challenges faced by manufacturing companies during the development and implementation of environmental key performance indicators?

**5. (8 Marks) – Policy Making CO2 Emissions – Climate Change**

a) When fossil fuels are used as raw materials, the carbon in the fuels is embodied in the final products and is only released at the end of the product’s life. Around 833 Mt CO<sub>2</sub>e is stored in plastics and fibres every year<sup>14</sup>. In addition, on an energy basis, fossil fuel raw materials account for more than half of the fossil fuel usage in the chemicals sector. The figure shows the energy and raw material inputs for the production of key intermediates and chemicals. Analyze the energy input and output for the process and Suggest the Mitigation technology options .



**6. (5 Marks) - BACT Study**

The use of whole tires and shredded tires as a fuel source is an alternative means of fuel that has become increasingly more popular in recent years in the cement, paper and electricity production industries. The intrinsic properties of the material offer higher heat content than coal and less nitrogen and sulfur, which can result in reduced NO<sub>x</sub> and SO<sub>2</sub> emissions. The average heat required to produce a ton of cement clinker is 5 mmBtu and emissions include: NO<sub>x</sub> – 262 tpy, CO – 20 tpy, PM – 39 tpy, SO<sub>2</sub> – 26 tpy, VOC – 20 tpy. Because the use of scrap tires as fuel is a relatively unique method of power generation, few control technologies exist which were designed specifically for use on tire-fueled kilns. However, wide ranges of particulate controls have been used for similar applications, which offer practical solutions for tire-fueled situations as well. Rank and explain the methods for PM control w.r.t BACT study.

**OPEN BOOK – 40 Marks**

1. The ecoinvent database discusses LCI and LCIA results. LCIA methods normally assign a factor to each elementary flow in the inventory table. Explain atleast 3 challenges with problem arising from linking LCIA methods to the elementary flows of a database on global perspective. **[7 M]**
2. The environmental mechanisms used for this impact category have a somewhat different structure, from the fate, effect and damage steps applied elsewhere. The mechanisms such as radiative forcing evaluate the GWP. The CO<sub>2</sub> equivalency factor is calculated as: Explain the GWP based estimation and GWP for LCI based analysis. **[5 M]**

$$GWP_{x,T} = \frac{\int_0^T a_x \times [x(t)] dt}{\int_0^T a_r \times [r(t)] dt}$$

3. The economy and the environment are inextricably linked. Whether one is looking at daily life or natural resources and other environmental issues, because resources are scarce, choices have to be made about how to use them. The basic fact is that resources used to meet one choice or alternative cannot be used to meet another. Explain the factors such as Trade – Offs, Marginal Cost and benefits w.r.t concept of Environmental Economics. **[10 M]**
4. The atmospheric SO<sub>2</sub> is a long range transboundary air pollutant responsible for respiratory problems and acid rain. The uncontrolled release of SO<sub>2</sub> from coal-fuelled power plants would raise the amount of anthropogenic SO<sub>2</sub> emission by about 150%, therefore, several attempts have been made on the regulation of the SO<sub>2</sub> emissions, i.e. the Helsinki Protocol (Protocol on the Reduction Sulphur Emissions or their Transboundary Fluxes by at least 30 per cent). Two techniques for removal of flue gases (in particular SO<sub>x</sub>) removal is given. Also input-output system is given below. **[13 M]**
  - a) Explain these two methods briefly.
  - b) Compare these emissions based on LCI analysis.

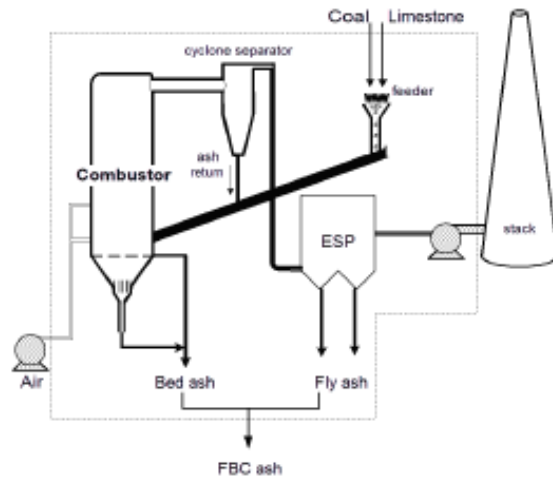


Fig. 1. Schematic diagram of the atmospheric circulating fluidised bed combustion

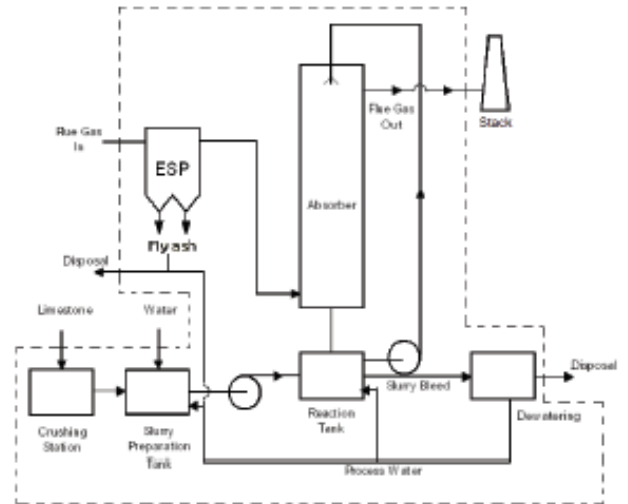


Fig. 2. Schematic diagram of the wet limestone scrubbing.

Tab. 4. Environmental impacts of the studied systems referring to 1 kg sulphur contained in the flue gas [ $10^{-3}$ EI point/kgS].

	ACFBC			FGD with Wet Lime Scrubbing			FGD with CuO		
<b>Input</b>									
Limestone	3			0.75			-		
Electricity	164			260			69		
Water demand	-			0.001			-		
CuO	-			-			27		
Al <sub>2</sub> O <sub>3</sub>	-			-			36		
Ammonia	-			-			1		
Natural gas	-			-			37		
<b>Output</b>									
<i>Emission to air</i>									
SO <sub>2</sub>	135			25			13		
NO <sub>x</sub>	114			102			25		
PM	6			1			2		
CO <sub>2</sub>	5			6			3		
<i>By-products</i>	0%	100%	stat.	0%	100%	stat.	0%	100%	stat.
	util.	util.	data	util.	util.	data	util.	util.	data
<i>Utilized</i>									
FBC ash	0	-55	-25	-	-	-	-	-	-
Fly ash	-	-	-	0	-49	-24	-	-	-
FGD gypsum	-	-	-	0	-35	-30	-	-	-
Boiler slag	-	-	-	-	-	-	0	-2	-2
SO <sub>2</sub>	-	-	-	-	-	-	0	-21	-21
Landfill	40	0	22	31	0	11	3	0	0
<b>TOTAL</b>	<b>467</b>	<b>372</b>	<b>424</b>	<b>425</b>	<b>311</b>	<b>351</b>	<b>216</b>	<b>189</b>	<b>189</b>

5. The pulp & paper industry has historically been considered a major consumer of natural resources (wood) and energy (fossil fuels, electricity), including water and a pollutant discharges to the environment. An overview of the kraft process is given below. The sulphate or kraft process is the most applied production method of chemical pulping, accounting for around 80% of world pulp production. The kraft process is used to obtain cellulosic pulps, containing around 10% of the original lignin. The pulp obtained from the kraft process quite often follows the bleaching sequence, thus obtaining bleached kraft pulp. Using the criteria of fresh water consumption and the volume of water discharged, the pulp & paper industry is considered one of the most polluting amongst all industrial sectors. The most common chemicals used for bleaching include the chlorine dioxide, oxygen, ozone and peroxide. **Show the mass & energy flows of environmental relevance in the process.** [5 Marks]

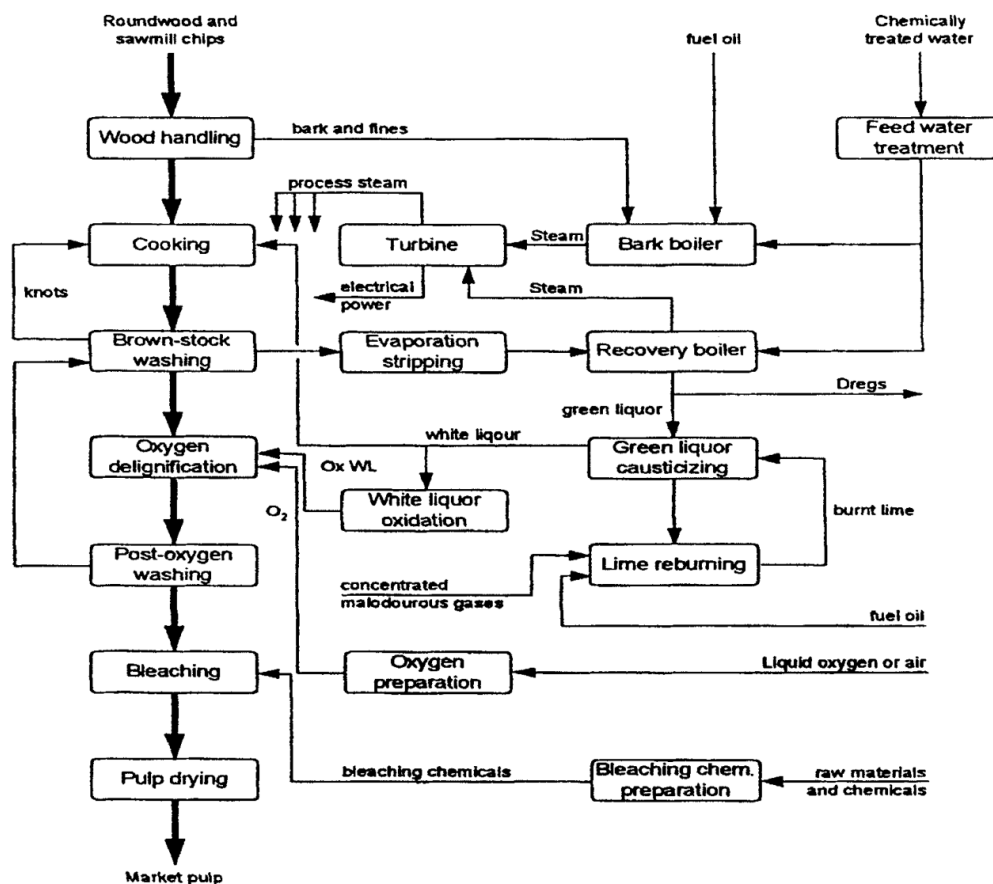


Figure 5. Overview of the processes in a kraft pulp mill. Source: SEPA, 1997.