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Pyrolysis Process

Pyrolysis is one of the technologies available to convert biomass to an intermediate liquid product that can be refined to drop-in hydrocarbon biofuels, oxygenated fuel additives and petrochemical replacements. Pyrolysis is the heating of an organic material, such as biomass, in the absence of oxygen. Biomass pyrolysis is usually conducted at or above 500 °C, providing enough heat to deconstruct the strong bio-polymers mentioned above. Because no oxygen is present combustion does not occur, rather the biomass thermally decomposes into combustible gases and bio-char. Most of these combustible gases can be condensed into a combustible liquid, called pyrolysis oil (bio-oil), though there are some permanent gases (CO-2, CO, H2, light hydrocarbons), some of which can be combusted to provide the heat for the process. Thus, pyrolysis of biomass produces three products: one liquid, bio-oil, one solid, bio-char and one gaseous, syngas. The proportion of these products depends on several factors including the composition of the feedstock and process parameters. However, all things being equal, the yield of bio-oil is optimized when the pyrolysis temperature is around 500 °C and the heating rate is high (1000 °C/s) fast pyrolysis conditions. Under these conditions, bio-oil yields of 60-70 wt% of can be achieved from a typical biomass feedstock, with 15-25 wt% yields of bio-char. The remaining 10-15 wt% is syngas. Processes that use slower heating rates are called slow pyrolysis and bio-char is usually the major product of such processes. The pyrolysis process can be self-sustained, as combustion of the syngas and a portion of bio-oil or bio-char can provide all the necessary energy to drive the reaction.

Types of Pyrolysis

There are generally three types of Pyrolysis:

- **Slow Pyrolysis**
- **Fast Pyrolysis**
- **Flash Pyrolysis**

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Slow Pyrolysis:

It is characterized by lengthy solids and gas residence times, low temperatures, and slow biomass heating rates. It is used to modify the solid material and minimize the oil produced. On the other hand, fast pyrolysis and ultra-fast (flash) pyrolysis maximize the gases and oil produced.

Temperature: Med-high (400-500 °C)

Fast Pyrolysis:

It is a rapid thermal decomposition of carbon-containing materials in the absence of oxygen in moderate to high heating rates. It is the most common method used in research and in practical use. The major product is bio-oil. Pyrolysis is an endothermic process. Char is accumulated in very large quantities and is to be removed frequently.

Temperature: Med-high (400-650 °C)

Flash Pyrolysis:

It is a very rapid thermal decomposition pyrolysis process, the heating rate is also very high. The main products are gases and bio-oil. Flash pyrolysis produces a very less quantity of gas and tar as compared to slow pyrolysis.

Temperature: high (700-1000 °C)

Advantages and Disadvantages of pyrolysis

Advantages

- Unlike traditional incineration plants, a pyrolysis plant could be located close to begin generation and does not produce any harmful dioxins.
- Pyrolysis plants are efficient at converting waste into useful products, for example synthetic oil for fuel.
- Reduce Greenhouse gas emission and reduce landfills.

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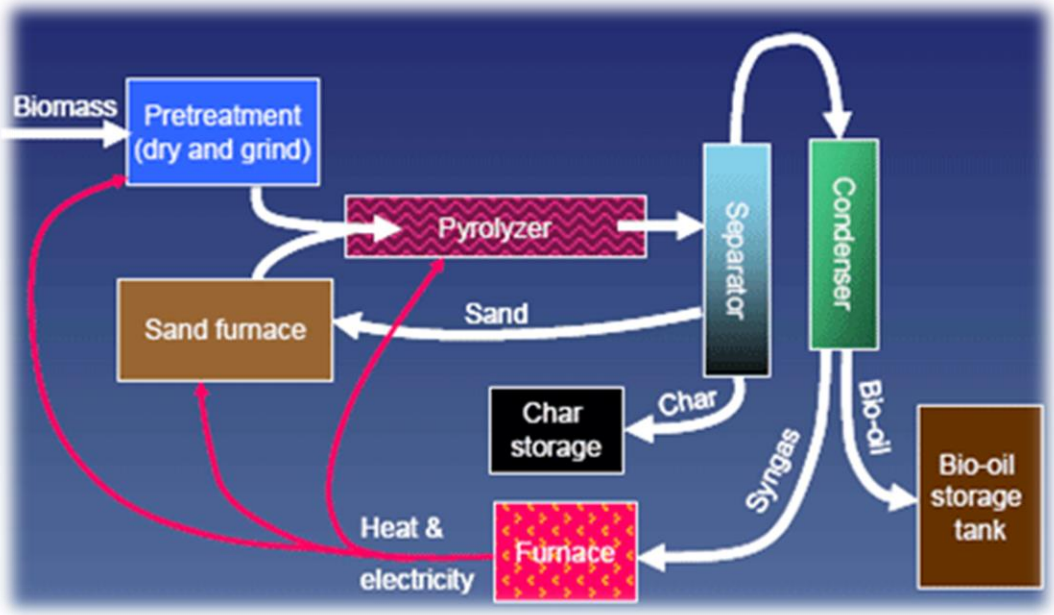
- Unlike incinerators, which burn waste at extreme temperatures, a pyrolysis plant relies on a lower temperature method that results in less noxious byproducts and reduced carbon emissions.
- The capability to control the reactor signifies that this technology can quickly transform various kinds of materials into bio-oil.
- Pyrolysis oil made out of the conversion of solid wastes indicates potential as a substitute energy source in power plants or any other industrial settings that use steam boilers or internal combustion engines.

Disadvantages

- One disadvantage is that the process is far more expensive.
- Technology is still evolving and the market is not yet ready for bio fuels.
- Another thing to remember is this procedure demands a constant supply of fuel if the plant cannot get enough waste material to work with, it will not run at its full capacity.



Process of Pyrolysis

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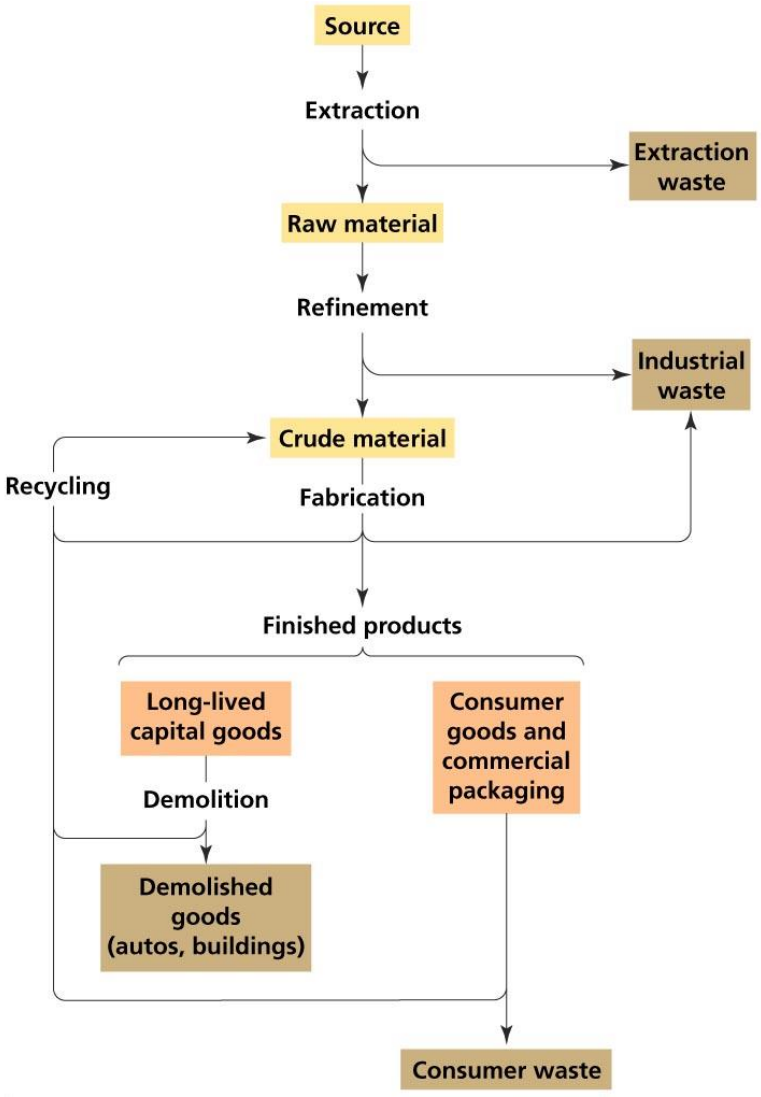
Industrial waste

- **97% of this is wastewater**
- **Industrial solid waste = roughly equivalent to amount of municipal solid waste**
- **Waste is generated at several points in the life cycle of products.**
- **At each stage there are opportunities for efficiency improvements, source reduction, and recycling.**



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Industrial waste is typically produced during the manufacturing of products, agricultural production or during the extraction of natural resources. That is basically any process that turns raw materials into products that are sold or distributed. This can include scrap metal, excess plastic, wood chips, fly ash from powerplants, construction debris.

Types of Industrial Waste

Industrial waste can be hazardous or non-hazardous. Both, however, can cause a substantial environmental impact if not properly managed. Below are some common kinds of waste that can be hazardous to human life and the environment.

Solid Waste

solid waste can be generated by manufacturing processes such as:

- **Electric power generation**
- **The use of agricultural chemicals and inorganic chemicals**
- **Iron and steel manufacturing**
- **Water treatment**
- **Plastics and resins manufacturing**

Toxic Waste or hazardous waste

Industrial waste can also be **toxic or hazardous waste**. If not managed properly, this type of industrial waste can cause harm to humans, animals and the environment by contaminating waterways, such as rivers and lakes.

- This type of industrial waste is generally a byproduct of other materials generated at factories, hospitals and manufacturing facilities.

Hazardous waste
Waste that poses a potential danger to human health.
Four criteria:

- **Ignitability: substances catch fire**
- **Corrosivity: substances corrode metals**

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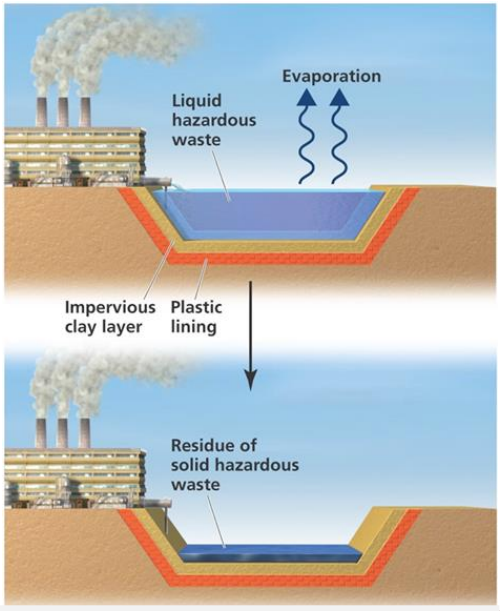
- **Reactivity: substances are chemically unstable and react with other chemicals in dangerous ways**
- **Toxicity: substances are known to be harmful to human health**

There are many types of hazardous waste; Two are worst because they persist for a long time without breaking down:

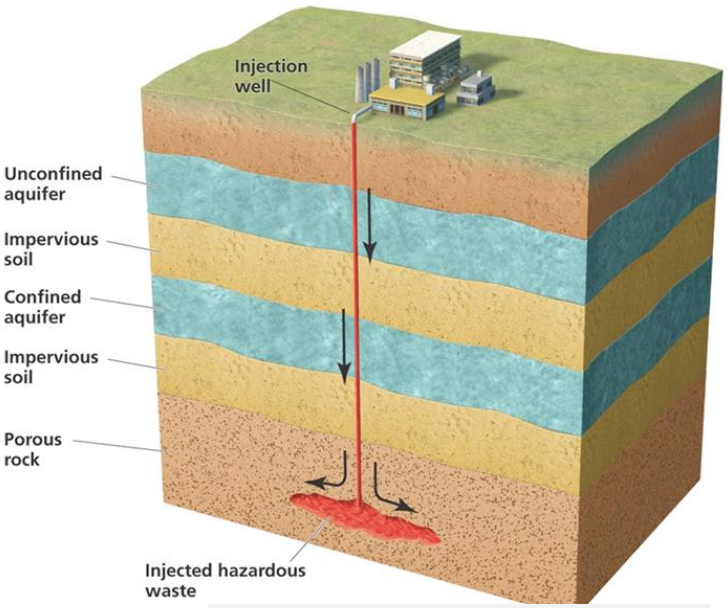
- **Heavy metals:** (mercury, lead, chromium, arsenic, cadmium, tin, copper from industry, mining, consumer products)
- **Organic compounds:** (synthetic pesticides, petroleum products, rubber, solvents, preservatives…)

Hazardous waste: Disposal methods

- ❑ **Landfills:** Special landfills with stricter regulations are used for hazardous waste.
- ❑ **Surface impoundments:** Ponds lined with plastic and clay. Liquid hazardous waste evaporates, leaving residue.
- ❑ **Deep-well injection:** Hazardous waste is pumped deep underground into porous and stable rock formations, away from aquifers.



Surface impoundments



Deep-well injection

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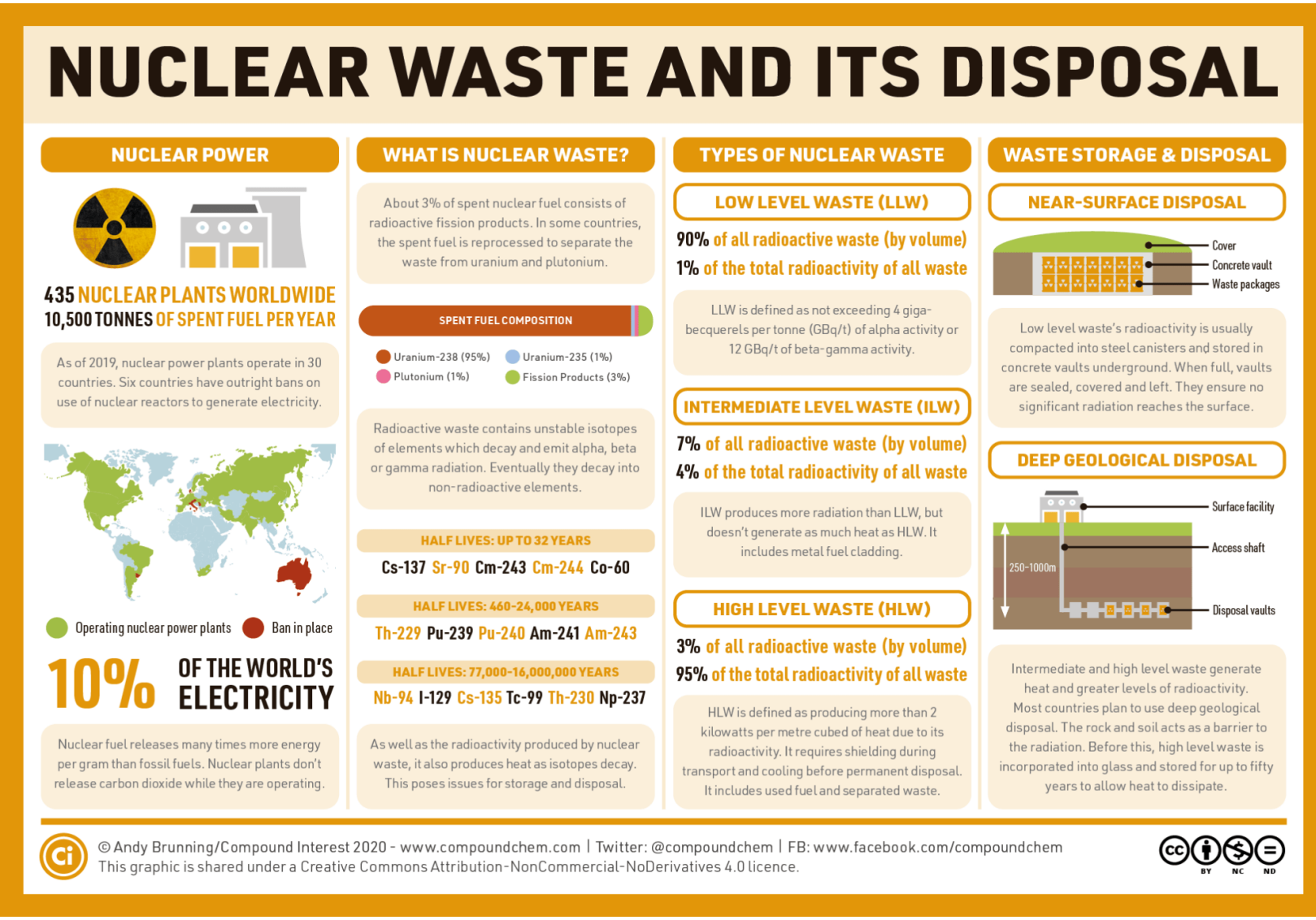
Radioactive waste

- ❑ **A special type of hazardous waste**
- ❑ **Especially dangerous**
- ❑ **Much produced by military and hospitals; some by research institutions**
- ❑ **It's extremely hard to find a place to dump it that is not opposed by local people**

Radioactive waste is a type of hazardous waste that contains radioactive material. Radioactive waste is a result of many activities, including nuclear medicine, nuclear research, nuclear power generation, nuclear decommissioning, rare-earth mining, and nuclear weapons reprocessing.



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Chemical Waste

Chemical waste is a significant issue in industrial settings due to the large quantity and the vast variety of chemicals used in manufacturing processes. Industries such as chemical manufacturing, oil and gas production, and mining generate large amounts of chemical waste as by-products of their operations. These wastes can include heavy metals, acids, bases, and toxic organic compounds.

Examples of chemical waste include:

- **Used solvents and cleaning agents**
- **Expired or unused chemicals from laboratories**
- **Leftover paint and varnish**
- **Pesticides and herbicides**
- **Batteries**
- **Industrial process waste, such as oil and heavy metal sludge**
- **Waste water containing heavy metals or other pollutants**