1.2: Green Chemistry Concepts

Agricultural Support

The growing of crops in different farming regions to feed the masses owes its potential greatly to harnessing the power of chemicals such as herbicides, pesticides, fungicides, etc. Although in general we tend to think of the benefits of pesticides, there are a number of issues associated with their use that go well beyond their ability to promote the cultivation and availability of food. For example, DDT (Figure 1.2.1) is a chemical that has seen much use in the US. Over the period of 1950 to 1980, it was used in agriculture at the rate of more than 40,000 tons each year worldwide and it has been estimated that a total of 1.8 million tons have been produced around the world since the 1940s. In the United States, it was manufactured by numerous companies including Monsanto, Ciba, Montrose Chemical Company, and Pennwalt. More than 600,000 tons (1.35 billion pounds) were applied in the US before it was banned in 1972.

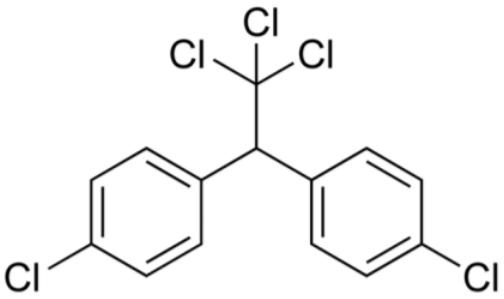

Figure 1.2.1: Shown above is a chemical representation of DDT or DicholoroDiphenylTrichloroethane, a colorless, crystalline, tasteless and nearly odorless organochlorine compound that displays insecticidal properties with huge environmental impacts. DDT has been formulated in multiple forms that include solutions in xylene or petroleum distillates, emulsifiable concentrates, water-wettable powders, including solutions in vaporizers and lotions. https://www.wikiwand.com/en/Dichlorodiphenyltrichloroethane

Nature's Best

The idea that nature produces chemicals that are "green" is a fallacy or a myth. The concept of green deserves some clarification at this point. What is green and what isn't is actually a matter of nature, quantity, human safety, long term effects, and acute toxicity. Green is generally a term associated with a sustainable (renewable) product or non-toxic process whose employment in society has no acute toxicity and a general favorable life cycle analysis. There are a number of documented chemicals in nature that are extremely toxic even at small doses thus invalidating the idea that nature is "green". For example, aflatoxin B1, shown below in Figure 1.2.2, is a toxin produced by *Apsergillus flavus* and *A. parasiticus* that is one of the most potent carcinogens known. It is a common contaminant of a variety of foods including peanuts, cottonseed meal, corn, and other grains as well as animal feeds. According to the Food and Agriculture Organization, the worldwide maximum levels of aflatoxin B1 is in the range of 1–20 µg/kg in food, and 5–50 µg/kg in dietary cattle feed.

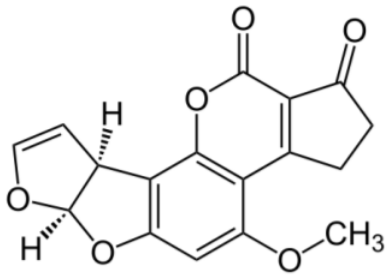

Figure 1.2.2: Shown above is a chemical representation of Aflatoxin B1, one of the most notorious carcinogens available. And it is "natural"! The IUPAC name is: 6aR,9aS)-2, 3, 6a, 9a-Tetrahydro4-methoxy-1H, 11H cyclopenta[c]furo[3',2':4,5]furo[2,3- h] [1]benzopyran-1,11-dione. https://www.wikiwand.com/en/Aflatoxin_B1

Shown in Figure 1.2.3 below is a derivative of lysergic acid. Lysergic acid, also known as D-lysergic acid and (+)-lysergic acid, is a precursor to a diverse array of ergoline alkaloids produced by the ergot fungus and found in the seeds of *Turbina corymbosa* (ololiuhqui), *Argyreia nervosa* (Hawaiian Baby Woodrose), and *Ipomoea tricolor* (morning glories, tlitliltzin). Amides of lysergic

acid, lysergamides (see Fig. 3), are widely used as pharmaceuticals and as psychedelic drugs (LSD). Lysergic acid received its name from the lysis of various ergot alkaloids.

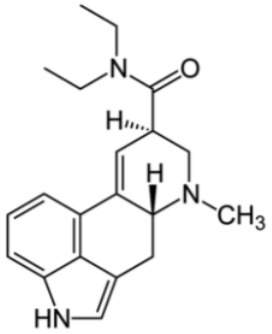

Figure 1.2.2: Shown above is the diethylamide version of lysergic acid.
https://www.wikiwand.com/en/Lysergic_acid

Again, as already stipulated, nature's best does not necessarily imply that her products are "green". Green, by virtue of the product distribution found in nature (e.g. cocaine), can certainly pose serious if not lethal implications for human consumption. We all know that sodium chloride is ubiquitous within nature. It is a common salt that manifests a cubic crystal lattice structure that readily dissolves in water where it is mostly found. Humans consume it in great quantities as a flavorant, seasoning, and preservative. Nevertheless, its mass consumption especially in the US has led to > 65 million people afflicted with high blood pressure while numerous others have all other maladies associated from its overconsumption.

Accidents & Waste Minimization

Waste because of the nature of living processes is a natural consequence. Within the schema of living cell frameworks, the ability to generate waste is considered a clear indication of a "living" system. Waste is a necessary by-product of any work function even if it is heat, light, or some other form of energy by virtue of the intrinsic inefficiencies associated with the utilization of "fuel" or raw materials. For example, even a newborn that is fed on breast milk, a ideal natural food source for babies, does not simply produce a non-material, i.e., heat/energy dissipation, waste product. The problems associated with waste including inherent inefficiencies with using resources are how it builds up and affects the quality of the environment. In general, we cannot prevent waste because everything is subject to entropy.

The crux of the problem associated with waste boils down to safety. As alluded to in the Prezi example above, rust can cause material fatigue or loss of integrity that can compromise functionality. Additionally, chemical processes that produce waste need to adhere to the three general "R"s of Green Chemistry.

the Three "R"s of Green Chemistry

- Reduce
- Reuse
- Recycle