CHAPTER FIVE
THE ECONOMICS OF POLLUTION

5.1. Definition

Pollution is an activity which impairs the quality of one or more receiving environments. In biological terms pollution is said to occur when some metabolic change is observed in animal or other populations and which would not have occurred otherwise. In economics, however, pollution is only significant when the utility of one or more individuals is reduced by the pollutants in question.

Pollution may be defined as the presence/release of certain substances (harmful environmental contaminants) beyond the absorptive capacity of the earth.

Most of the substances that cause pollution are naturally present in the environment in low concentration, and are usually considered to be harmless. Thus a particular substance is considered as pollution only when its concentration is relatively high and cause adverse effects. Even relatively benign products of human activity are liable to be regarded as pollution, if they precipitate negative effects later on. The nitrogen oxides produced by industry are often referred to as pollution, for example, although the substances themselves are not harmful. In fact, it is solar energy (sunlight) that converts these compounds to smog.

Pollution can take two major forms: *local pollution and global pollution*. In the past, only local pollution was thought to be a problem. For example, coal burning produces smoke, which in sufficient concentrations can be a health hazard. One slogan, taught in schools, was "The solution to pollution is dilution." The theory was that sufficiently diluted pollution could cause no damage. In recent decades, awareness has been rising that some forms of pollution pose a global problem. For example, human activity (primarily nuclear testing) has significantly raised the levels of background radiation, which may lead to human health problems, all over the world. Awareness of both kinds of pollution, among other things, has led to the environmentalism movement, which seeks to limit the human impact on the environment.

Whether something is pollution depends almost entirely on context. Blooms of algae and the resultant eutrophication of lakes and coastal ocean is considered pollution when it is fueled by nutrients from industrial, agricultural, or residential runoff in either point source or non-point source form (see the article on eutrophication for more information). Heavy metals such as lead

and mercury have a role in geochemical cycles (i.e. they occur as within 'nature'). These metals may also be mined and, depending on their processing, may thus be released in large concentrations into an environment previously not playing host to them. Just as the influences of anthropogenic release of these metals to the environment may be considered as 'polluting', such pollution could also occur in some areas due to either autochtonous or historic 'natural' geochemical activity.

Carbon dioxide are sometimes referred to as pollution, on the basis that these emissions have led, or are leading, to raised levels of the gas in the atmosphere and, furthermore, to harmful changes in the Earth's climate. Such claims are strongly disputed, particularly by political conservatives in Western countries and most strongly in the United States. Due to this controversy, in many contexts carbon dioxide from such sources are labelled neutrally as "emissions."

5.2. Types of Pollution

Essentially, there are three types of pollution:

i. *Air pollution*

ii. *Water pollution*

iii. *Solid waste*

A. Air pollution:

It is the addition of harmful chemicals to the atmosphere. Alternatively, it can be defined as the contamination of the air by noxious gases and minute particles of solid and liquid matter (particulates) in concentration that endanger health.

Important pollutant gases include:

- Carbon monoxide
- Nitrogen oxides
- Hydrocarbons
- Tropospheric ozone, which is ozone in the lower part of the atmosphere. (In the upper part, it helps to reduce the amount of ultraviolet radiation from the sun that reaches the earth.
- Chlorofluorocarbons, which destroys the stratospheric ozone layer.
- Sulfur dioxide, which causes acid rain.

Air pollutants are classified either primary or secondary. A primary air pollutant is one that is emitted directly to the air from a given source. An example of a primary air pollutant would be carbon monoxide, because it is produced as a byproduct of combustion. A second air pollutant is formed in the atmosphere through chemical reactions involving primary air pollutants. An example of a secondary air pollutant would be the formation of ozone in photochemical smog.

Sources of air pollution

Sources of air pollution are commonly divided in to two groups: anthropogenic (generated by human activity) and natural. Anthropogenic sources of pollution are those due to human choices, and natural sources are those resulting from forces.

Anthropogenic sources are mostly related to burning different kinds of fuel. They include:

- Combustion fired power plants.
- Vehicle with internal combustion engines
- Devices powered by Two Stoke cycle engines.
- Stoves and incinerators, specially coal ones.
- Wood fires, which usually burn inefficiently.
- Farmers burning their crop waste.

Sources not directly related to burning fuel include:

- Industrial activity in general.
- Oil refining
- Waste deposition in landfills, which generate methane.
- Fumes from paint, varnish, and other solvents.
- Aerosol sprays and refrigeration, which once depended on Freon and other chlorofluorocarbons.
- Arsenic and chlorine found in drinking water and inhaled in bathroom showers.
- Dust and chlorine foumding drinking, especially of erodible land see dust bowl.
- Military actions, including the use and testing of nuclear bombs, poison gases, and germ warfare.
- Rocketry, which produces many tons exotic emissions quickly and which deposits some of them directly into the tenuous upper atmosphere.

Natural sources include;

- Volcanic activity, which produce sulfur, chlorine, and ash particulates.
- Dust from natural sources, usually large areas of land with little or no vegetation.
- Methane, emitted by the digestion of animals, usually cattle
- Smoke and carbon monoxide from wildfires.
- Radon gas from earth minerals.
- Pine trees, which emit volatile organic compounds (VOCs) and oxygen.

Effects on health

It is estimated that three million people may die of air pollution each year worldwide. 2.8 million of the 3 million mortalities may be due to indoor air pollution. 90% of the 3 million estimated deaths are in developing nations. 70, 000 die each year in the US. (Some estimates are as low as 50, 000 or as high as 100, 000). Deaths from air pollution are compared to deaths from second hand smoke and chemical weapons. In the US, more people die from air pollution than from car accidents. They die specifically from agitated asthma, bronchitis, emphysema, lung and heart diseases, and other respiratory allergies. The EPA estimates that a proposed set of changes in diesel fuel technology (Tier 2) could result in 12, 000 fewer premature mortalities, 15, 000 fewer heart attacks, 6,000 fewer emergency room visits by children with asthma, and 8,9000 fewer respiratory related hospital admissions each year in the US.

The worst short term civilian event from pollution in India was the 1984 Bhopal Disaster. Leaked industrial vapors killed more than 2,000 people outright and injured anywhere from 150,000 to 600,000 others some, 6,000 of whom would later die from their injuries. The worst single incident of air pollution to occur in the United States of America occurred in Donora. Pennsylvania in late October, 1948, when 20 people die and over 7,000 were injured. The United Kingdom suffered its worst air pollution event when the December 4th Great Smog of 1952 formed over London. In six days more than 4, 000 died, and 8,000 more died within the following months. An accidental leak of anthrax spores from a biological warfare laboratory in the former USSR in 1979 near Sverdlovsk is believed to have been the cause of hundreds of civilian deaths.

Intentional air pollution in combat is called chemical warfare. Poison gas as a chemical weapon was principally used during World War I, and resulted in an estimated 91,198 deaths and 1,205,655 injuries. Various treaties have sought to ban its further use. Non-lethal chemical weapons, such as tear gas and pepper spray, are widely used.

Regulation and Monitoring

The atmosphere is a complex, dynamic and fragile system. Concern is growing about the effects of air pollutant emissions in a global context, and the inter-linkages of these emissions with global warming, climate change and ozone depletion. In this respect different countries have established several standards that are expected to keep the sustainability of the environment. For instance, the United States of America has established an agency called United States Environmental Protection Agency (EPA). The USEPA was supposed to establish "acceptable" levels of exposure to contaminants. One of the ratings chemicals are given are carcinogenicity, or how likely they are to cause cancer. Levels range from, not carcinogenic, likely carcinogen, known carcinogen, and unknown. But some scientists have said that most of these levels are far too high and people should be exposed less to them. The U.S. has a maximum fine of US$25,000 for dumping toxic waste. However, many large manufacturers plead guilty, as they can easily afford this relatively small fine.

But one of the excellent moves towards maintaining the ecosystem was the international agreement made in Kyoto Japan to combat global warming by sharply reducing emissions of industrial gases. The agreement so reached upon was known as the Kyoto Protocol. The Kyoto Protocol is an amendment to the United Nations Framework Convention on Climate Change (UNFCCC), an international treaty on global warming. It also reaffirms sections of the UNFCCC. Countries which ratify this protocol commit to reduce their emissions of carbon dioxide and five other greenhouse gases, or engage in emissions trading if they maintain or increase emissions of these gases. A total of 141 countries have ratified the agreement. Notable exceptions include the United States and Australia.

The most satisfactory long term solutions to air pollution may well be the elimination of fossil fuels and the ultimate replacement of the internal combustion engine. To these ends efforts have begun in USA, Japan, and Europe to develop alternative energy sources, as well as different kinds of transportation engines, perhaps powered by electricity or steam. A system of pollution allowances based on trading emission rights has been established in USA in attempt to use the free market to reward pollution reductions, and the international sale of surplus emission rights is permitted under the Kyoto Protocol. Other proposed solutions include raising electricity and gasoline rates to better reflect environmental costs and to discourage waste and inefficiency, and mechanical controls on coal-fired utility plants.

B. Water pollution

Water pollution is the addition of harmful chemicals or wastes to natural water. Or it is the contamination of water resources by harmful wastes.

Contaminants;

- Bacteria, as from sewage or livestock operations;
- Fertilizers, in runoff from agricultural fields or forestry;
- Food processing waste;
- Tree and bush debris from logging operations

Inorganic pollutant include

- Metals
- Acid mine drainage
- Acid rain caused by industrial or volcanic discharges
- Acid pollutions of lakes by runoff from acid soils;
- Carbon dioxide discharges and runoff, volcanic or mineral;
- Chemical waste industrial by products;
- Silt in storm water runoff from cleared land.

Dangers of water pollution:

Virtually, all water pollutants are hazardous to humans as well as lesser species; sodium is implicated in cardiovascular disease, nitrates in blood disorders. Mercury and lead can cause nervous disorders. Some contaminants are carcinogens. DDT is toxic to humans and can alter chromosomes. PCBs cause liver and nerve damage, skin eruptions, vomiting, fever, diarrhea, and fetal abnormalities. Along many shores of USA, shellfish can no longer be taken because of contamination by DDT, sewage, or industrial wastes.

Sources of water pollution

Like that of air pollution, the causes of water pollution can be divided in to two groups: anthropogenic sources and natural sources.

Anthropogenic sources include:

- Discharge of poorly-treated or untreated sewage;

- Runoff from construction sites, farms, or paved and other impervious surfaces;
- Discharge of contaminated /or heated water used for industrial process
- Acid rain caused by industrial discharge of sulfur dioxide (by burning high sulfer fossil fuels)
- Excess nutrients added by runoff containing large amount of detergents or fertilizers

Natural sources include:

- Seasonal turnover of lakes and embayments;
- Siltation due to floods;
- Eutrophication of lakes due to seasonal changes;
- Acid rains caused by natural volcanic discharges;
- Acid pollution of rivers and lakes by runoff from naturally acid soils;
- Carbon dioxide discharges and runoff, volcanic or mineral.

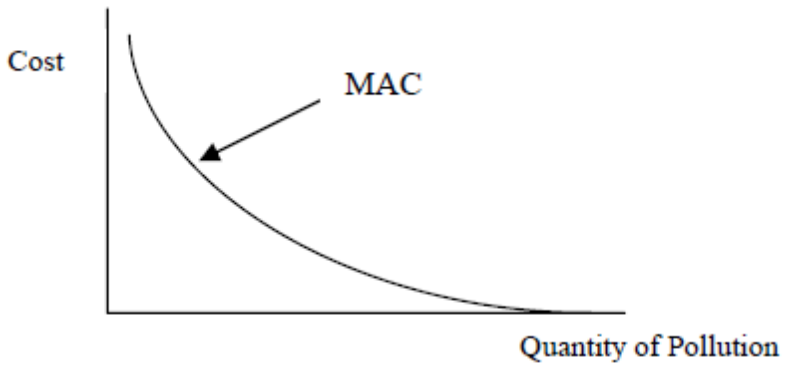
5.3. Optimal Level of Pollution Control

The efficient level pollution abatement (or the optimal level of pollution control) occurs where the marginal abatement cost (MAC) is equal to the marginal damage cost (MDC).

Definition: the marginal abatement cost (MAC) is the cost of abating or controlling an extra unit of pollution. It is also known as the marginal control cost.

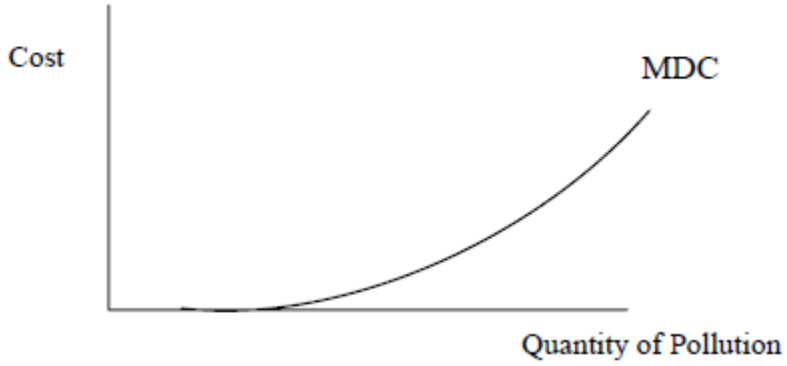
Note that there is a negative relationship between MAC and the quantity of pollution. The higher the MAC, the lower the quantity of pollution; and vice versa.

Graphically,



Definition: The marginal damage cost (MDC) is the health or environmental damage caused by an extra unit of pollution it is also known as the marginal pollution cost.

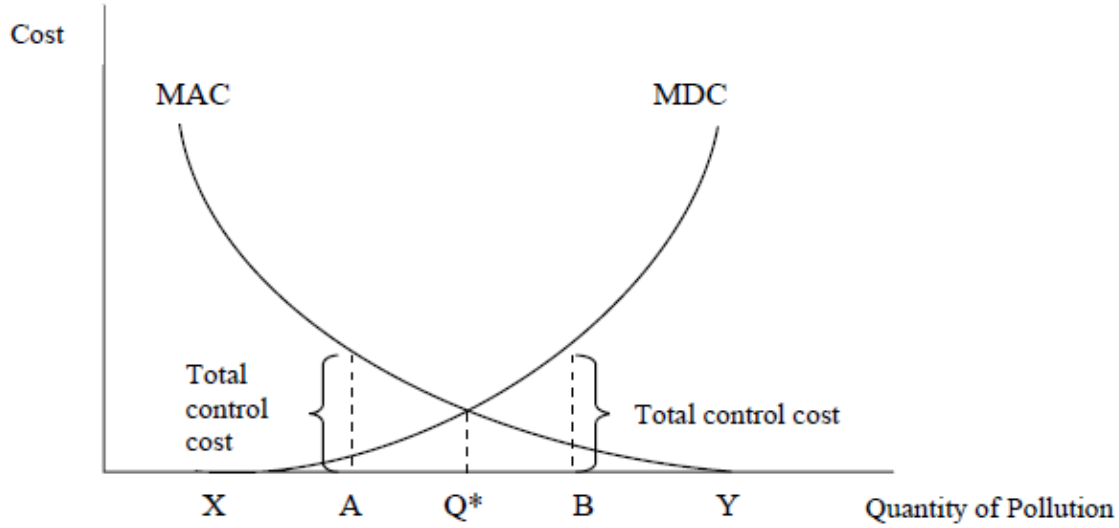
Again note that there is a positive relationship between MDC and the quantity of pollution. The higher the quantity of pollution, the higher the MDC, and vice versa. Graphically, the MDC doesn't start at zero but at positive amount of pollution because of the ability of the environment to assimilate certain amount of pollution without any damage.



Graphically, efficient pollution abetment occurs at the intersection of the MAC and the MDC curves, such as at point Q* in the graph below. At points below Q* such as point A, it is the case that amount spent on controlling pollution (MAC) is greater than the damage due to pollution (MDC). Therefore , the incentive is to reduce the amount spent on controlling pollution, MAC, thereby raise the quantity of pollution and move towards Q*.

On the other hands, at points above Q*, such as point B, it is the case that the damage caused by pollution (MDC) is greater than the amount spent on controlling pollution (MAC). Therefore, the incentive is to reduce the damage, MDC, by reducing the quantity of pollution, and move towards Q*. Equilibrium will, therefore, occur at Q*, where MAC = MDC, because that is where the market forces of MAC and MDC will be balanced such that there is no incentive to change.

Recall that Equilibrium is a situation where market forces are balanced such that there is no incentive to change. Hence, as long as MDC and MAC are equal, there is no incentive to change.



The *Ecologist* operates at X because they have zero tolerance for damage due to pollution.

The C*apitalist*, on the other hand, operate at Y because it is cheaper to pollute than to have pollution abatement. Therefore profit maximization dictates that private incentive is where zero amount is spent. This has a profound implication for policy; unless we control them, capitalists do not care about the adverse effect.

The *economic optimum* occurs where MAC =MDC (or at Q*). At this point, the damage is not zero, nor the amount be paid for contorting is zero