



## Protecting Environment through Technology Innovation

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**Abstract:** Environmental issue associated with various types of power plants, is an international problem. The situation of the environment in developing countries, that it is being damaged and Pakistan is no exception. Energy is produced by different sources, and is creating a range of pollution problems. Consequently, environmental degradation is due to the production of harmful pollution constituents at the source of the energy. The purpose of this research is to determine solutions to such environmental problems and minimize pollution by using environmentally friendly equipment. This paper includes the practical example of 'Tiefstack Thermal Power station' in Germany, which is a modern power station with minimum population hazards to the environment. Considering today's projects of setting up power plants, methods of using sophisticated equipment are chosen to limit the use of landfill and solid waste in the combustion process. Waste minimization measures are produced by modern technology applications, such as improved and efficient furnaces that are economical in fuel use. Increasing the sulphur content in the atmosphere, causing Acid fog, Acid rain, and other factors creating the situation of global warming is examined. Several methods of controlling compounds of sulphur and particulate emissions are described. Various types of nuclear waste are discussed and different types of disposal methods are illustrated. In the end, measures, recommendation and conclusions are drawn, concisely.

**Keywords:** Environmental problems, Power Plants Pollution, Waste Disposal Methods, Nuclear Waste, Wind Turbines and Solar Power Plants

### 1. INTRODUCTION

Regarding the mainly thermal and coal fired power plants in Pakistan, it is imperative to all of us, in general and electrical engineers in particular, to be aware of their environmental effects. Environmental hazards which can be considered to be the result of those power plants which are polluting the air. With increasing pollution there is more danger to the growth of our current flora, thereby tolerant species can be used in the trials of plant resistance to different air pollutants. (Achakzai, *et al.*, 2017). As Electricity generation mostly based on fossil fuels, and electricity generation from fossil fuels is responsible for roughly 40% of all carbon dioxide emissions. Long-term strategies for mitigating global warming will soon necessitate alternative energies (Lim, *et al.*, 2017).

In this regard, ways and means must be tried to minimize these environmental problems. Unfortunately, some of the previously built power plants were set up on the basis of feasibility rather than considering environmental aspects in power generation. In many cases thermal power plants which have been set up in the past with little or no consideration of the environment.

As a result of proposed power units being set up in near future, it is high time to be environmentally aware as well as familiar with modern technology, for detection, monitoring and controlling of hazardous emissions.

### 2. FUNDAMENTAL OF ENVIRONMENTAL POLLUTION

Anything that adversely effects/or is hazardous to human, plant or animal life, is pollutant. Amongst others the most hazardous types of pollution is 'Air Pollution

#### 2.1 AIR POLLUTION

Common air pollutants are Dust, Smoke, Carbon monoxide, Sulfur Dioxide, Nitrogen oxide, Hydrocarbon, and various Toxic Gases. These pollutants are mostly commonly emitted by thermal power plants as well as some industries and automobiles.

According to WHO, 92% of the world's population lives in places where air quality exceeds WHO guideline limits WHO, "State of Global Air/ (2017).

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The central problem is human safety and the chief areas of concern are Air pollution, due to fossil fuels and nuclear radiation.

By referring (**Table1**) chemical sources of air pollution in order of contribution are motor vehicles, industry, fossils power plants, and space heating and refused disposal (Davis, 1991).

**Table.1 . Sources of Pollutants**

SOURCES	TONS/Yr	%age
Motor vehicles	86	60.6
Industry	23	16.8
Fossil power	20	14.1
Space heating	08	05.6
Refuse disposal	05	03.5

On the other hand the radioactive pollution from nuclear power is even less troublesome than the above sources when compared to the contribution of nature. This can be generalized by looking at (**Table-2**) which presents the summary of average radioactive exposure per person (Davis, 1991).

**Table. 2. Average radioactive exposure per person**

SOURCES	EXPOSURE	
	DOSES	%
Natural background	100	67.60
Medical Irradiation	45	30.7
Fall out	0.9	0.60
Miscellaneous	0.7	0.50
Occupational	0.7	0.45
Nuclear Industry	0.2	0.15

In addition, another study by Shahid, (2018) predicted the air pollutants emission calculated by the GAINS Model upto 2030 (Shahid, 2018). The figures are tabulated below:

**Table.3, The air pollutants emission calculated by the GAINS model upto 2030**

(kt/Year)					
Year	SO <sub>2</sub>	NO <sub>x</sub>	PM <sub>2.5</sub>	PM 10	TSP
1990	409	326	417	511	7526
1995	582	412	510	610	8584
2000	928	590	564	705	1068
2005	954	640	581	733	1111
2010	1381	854	655	863	1403
2015	2360	1278	766	1064	1861
2020	3687	1794	924	1313	2344
2025	5281	2353	1126	1629	2924
2030	8255	2957	1477	2213	4040

Furthermore, He also stated that shift from oil to coal in order to meet energy requirements, can result in very high emissions of SO<sub>2</sub>, and in this regard Pakistan is the 2<sup>nd</sup> largest consumer of the CNG in the world, which ultimately contribute to increasing in NO<sub>x</sub> emissions. However, such particulate emissions have already exceeded the WHO limits in almost all urban areas of Pakistan.

From the above analysis, it can be observed that power plants are, therefore, the growing contributors to environment problems. Another researchers, stated in their study that thermal power plants are the greatest source of global CO<sub>2</sub> which is expected to increase manifold upto 2050, due to increase in energy consumption worldwide (Perwez, and Sohail, 2014). Therefore, with the increase in the number and sizes of power plant, the nature of these problems to plant and animal life will be severe.

Amongst all the power plant pollutants the following shown in (**Table.4**) are of most concern. (Davis, 1991).

**Table4The Power Plants Pollutants**

POLLUTANTS FROM FOSSIL POWER PLANTS	POLLUTANTS FROM NUCLEAR POWER PLANTS
Oxides of sulphur	Radioactivity release
Oxides of Nitrogen	Radioactivity wastes
Oxides of Carbon	Thermal pollution
Matter Particulates	
Thermal Pollution	

Oxides of Sulfur : Principally most of this pollutant is emitted by central power station power plant and by burners for spaces and industrial, heating.

Oxides of Nitrogen: (NO<sub>x</sub>) Both mobile and stationary sources are important emitters.

Oxides of Carbon: its largest source is the car engine. Unburned Hydrocarbons(HC): The automobile is the main source of gaseous hydrocarbon emission.

Particulates: Stationary power and heating plants are responsible for most of the particulate emission and the internal combustion engine is responsible for a significant fraction in many cities. Above described pollutants from fossil fuels power plants have made the situation crucial.

Such fossil fuels thermal power plants have greater environmental impacts such as air pollution and global warming, so that serious attention is a needed in the development of wind power plants. By installing wind turbines there will be reduction in harmful emission and a positive impact on the regional and global environment (Mengal, *et al.*, 2014).

## 2.2 GREEN HOUSE EFFECT:

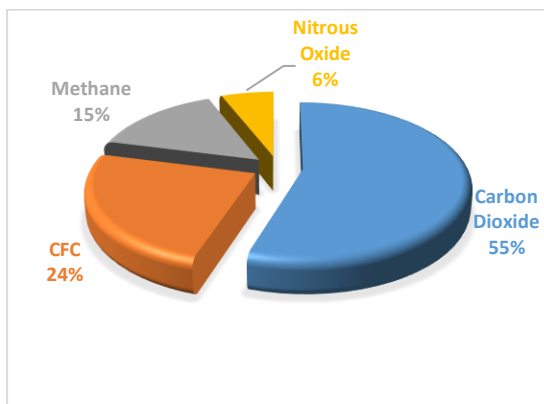
The trapping of heat in the earth's atmosphere causes global warming.

This problem is created by huge amount of carbon dioxide, released in to the air, as we burn coal, oil and gas, and thus increasing the green-house effect. Actually, light from the sun is absorbed by the earth's surface and then is radiated back toward space as infrared energy which is blocked by greenhouse gases. Due to the overheating of the earth, the greenhouse effect appears to be increasing. Its contributing agents are as follows.

(Table.5 and Fig. 1) shows the percentage of various pollutants contributing in greenhouse effect (Davis, 1991).

**Table.No.5. Percentages of Various Pollutants contributing in green house effect**

Carbon Dioxide	55%
CFC (CHLORO FLORO COMPOUND)	24%
Methane	15%
Nitrous Oxide	6%



**Fig.No.1**

## 2.3 OZONE DEPLETION

Ozone air pollution and climate change pose major threats to living organisms on earth.

Thus, without ozone, every living thing on the earth's surface would be incinerated. In this regard

(Tai and Martin (2017) says that among various air pollutants, tropospheric ozone (O<sub>3</sub>) is particularly damaging to crop yields (Tai and Martin (2017)).

The presence of ozone in the upper atmosphere (20 to 40 km and up) provides a barrier to Ultra Violet (UV) radiation. In 1947 it was realized that potential air pollution aerosols and refrigerants react with ozone. It was estimated that 5% reduction in ozone could result in a 10% increase in the skin cancer. Thus CFC that are inert compounds in the lower atmosphere becomes a serious air problem at higher elevations.

A significant increasing trend and spatio-temporal variability of tropospheric NO<sub>2</sub> columns over Pakistan have been found. Major sources of NO<sub>2</sub> emissions are found to be natural (soil emissions and climatic) and anthropogenic (crop residue and fossil fuel burning, industrial burning processes, and motor vehicles) (Zia-ul-Haq, *et al.*, 2014).

## 2.4 ACID RAIN

Chemical reactions in the atmosphere convert SO<sub>2</sub>, NO and volatile organic compound (VOC's) to acidic compounds and associated oxidants in the presence of air and moisture. The concern about acid rain relates to the potential effects of acidity on aquatic life to crops and forests, and damage to the building material.

Major acid pollutants ACID FOG is quite similar to acid rain or acid snow i.e. sulphuric and nitric oxides from power plants and to some extent from motor vehicles. It is formed by the mixing of pollutants with the water vapours near the ground. These pollutants condense around very tiny particles of fog or smog and turn into acid fog. When the fog water is heated, nearly pure sulphuric acid results (Davis, 1991).

## 3. CONTROL OF PARTICULATE EMISSION AND SO<sub>2</sub>

Particulate matter is compound of smoke, dust and solids of different organics and contribute to undesirable climate conditions. Dust and ash emanating from industries are the largest contributors to particulate emission.

Control of particulate emission from large fossil fuel combustion plants is now a well-established art. For an efficient control of air pollution from the power plants, it is extremely important to measure, sense and detect pollutant. A power plant having an emission level less than 400 mg of SO<sub>2</sub>, 200mg of NO<sub>2</sub> and 50 mg of dust per cubic meter was considered to be the most environmental efficient power plant.

But with the modern technology and optimization in combustion process, these emission can be reduced to as less than 100 mg SO<sub>2</sub> and 20 mg of dust per cubic meters of chimney exhaust. A vivid example of this is the TIEFSTACK power station at Hamburg which is currently considered Europe's most modern coal fired power plants. With its output 50 million K. Watts of electricity plus 600 million kilowatts of district heating, it qualifies as a larger power station. Yet it operates with just one single turbine generator unit and this unit, due to its air cooled generator, takes up a hall measuring 100 meters in length, thus making it the worlds largest. A rectangular water boiler, which just produces the steam required for peak load operation is also a superlative metering inclusion in the Guinness Books of Records: it is 17.5 meter high with an empty weight of 175 tonnes. When in operation it produces up to 216 tonnes of steam per hour(Zia. ul-Haq, *et al.*, 2014).

## 2.5 3.1 DETECTING, MONITORING & CONTROL EQUIPEMNET

A number of measuring and detection equipment are one commercially available which can be utilized for effective control of pollution by careful selection. These include (Shamis,1992)

- i. Dust Density Monitor
- ii. Smoke Density Monitor
- iii. Soot monitor
- iv. Dust concentration Monitor
- v. Portable Dust concentration Measuring system
- vi. Carbon Monoxide Analyser
- vii. Sulfur Dioxide / Dust concentration Monitor
- viii. SO<sub>2</sub>/NO<sub>x</sub>/Dust/ opacity combined analyser
- ix. Velocity Monitor
- x. Dataloggers
- xi. Refuse Incinerators
- xii. Exhaust Gas analyser
- xiii. Flue Gasses desulphurization system

## 2.6 3.2 GENERAL METHODS OF SO<sub>2</sub> CONTROL

### I. BURNING OF LOW SULFUR FUEL

In case of small power plant units, residential, commercial and industrial heating is feasible only by limiting the sulfur content of the fuel. Sulfur removal is of prime importance at the present time.

### II. DISPERSION BY TALL CHIMNEY

For the long time it was thought that chimney height is detrimental to the extent of the air pollution and greater heights such as 200 meters for a typical 2000 MW plant are sufficient to disperse chimney

exhaust safely. But recent studies have found that chimneys heights does not ensure safer environment. As an example, industrial exhaust of Western Europe has caused acid rain in Scandinavia (White,1978).

## III. SULFUR REMOVAL FROM FUEL OR STACK GASES

Numerous methods of removing sulfur from power plant fuel are being developed. They include GASIFICATION OF HIGH SULFUR FUEL (with sulfur removal before combustion and STACK GAS CLEANING which is made by liquid scrubbing or dry catalytic processes) All these processes have yet to be developed to the point of proven feasibility, in the large scale operation, and in general they are expensive.

## IV. REMOVAL OF SULFUR DURING COMBUSTION PROCESS

Several proposed methods for coal gasification are based on the use of fluidized beds. An important application under development is fluidized –bed combustion for the efficient burning of coal. Potential advantages if this method is as expressed below:

- i. The ability to burn a wide variety of coals, including those with high sulfur and / or mineral (ash) content.
- ii. A reduction in emission of the atmosphere pollutants, nitrogen oxides and sulphur oxides.
- iii. High combustion efficiency is achieve
- iv. Solid mixing is extremely rapid and therefore swift heat transfer rates can be obtained to surface immersed in the bed. This can lead to a saving of 75% in the tube requirements.
- v. The lower cost of coal crushing as compared with the widely used pulverized coal firing.
- vi. The system can readily be designed for operation at raised combustion pressure small size of plants and reduced possibilities of corrosion or erosion of gas turbine blades.

## 4. SOME DIFFICULTIES IN OPTIMIZATION OF POLLUTION CONTROL

It may be realized that certain requirements with regards to environment protection and efficiency of the plant contradict with one another e.g. the production of Nitric oxides in the coal dust fired system can be reduced considerably if the flame temperature is kept low. However, this results in the combustion process being incomplete and thus giving a higher and higher output of poisonous. Carbon monoxide and more solid coke particles in the form of Flyash and slag.

Furthermore Flue gases that have not completely burned, cause considerable corrosion to the walls on the combustion chamber. Therefore a favourable compromise for the flue gas temperature may be sought. Load variation may also hinder these temperatures in the coal burner therefore the flue gases have to be preheated, something which in turn has undesirable effects on the heat balance in the feed water thus necessitating additional circulation of the water. So one thing leads to another, and the regulating technology gets more and more complicated. However appropriate regulation system said with computer technology optimization of the firing process can be achieved. Unfortunately, despite this large quantities of harmful chemicals can still be produced such as Nitric oxides. Dust and sulphur-Dioxides along with hydrogen fluoride and Hydrochloric Acid. These can be minimized by using modern technology. The dust particles in the flue gases can be pupated electro statistically. The nitric oxide can be denitrificated when reacted with honey combs of Titanic Oxide Sulphur, Dioxide Hydrogen Fluoride, Hydrochloric acid quantities of dust can be washed in gas washing unit. The waste effluents can be treated both chemically and physically. Heavy metals are precipitated ammonia and solid are removed. Acid PH- level raised to neutral level before the water is allowed to flow away. Many by- products such as gypsum, slag and flyash can be utilized profitability. It is suggested that particulate emissions from new electrical plant must not exceed 0.18 kg/ 10000000k cal input (0.116/1000000B.T.U input) or about 0.1% of the coal removed in combustion. For a coal of 10% ash contents, would mean 99% removal of the ash in the coal is necessary. For the control of sulphur dioxide (SO<sub>2</sub>) the following are the general methods which will help at different circumstances.

## 5. NUCLEAR RADIATION HAZARDS

The generation of electricity in nuclear power station involves the mining and processing of uranium to fuel the nuclear reactor, the operation of the reactor themselves and the transport, treatment and disposal of the radioactive material due to which, tragic effects on human life as well as on the environment have resulted. The nuclear power plant effect on the environment, stem mainly from following stages.

The nuclear fuel cycle

- i. Low –level close radiations from nuclear plant effluents.
- ii. Low and high – level close radiations from wastes.

The general effects of pollution on environment are classified in shown skeleton (**Fig.2**) (Davis, 1991).

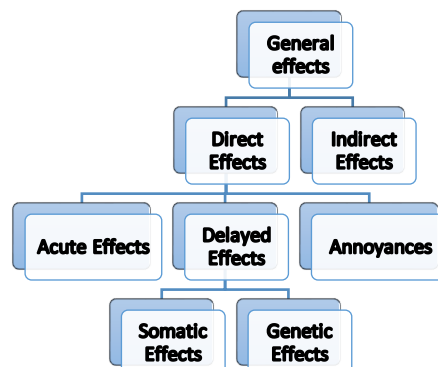


Fig. 2. Effects of Pollution

## 2.7 5.1 DIRECT EFFECTS

### (a) ACUTE EFFECTS

Immediate results of short – term exposure to high level damaging agents leading to temporary or permanent incapacity or death.

### (b) DELAYED EFFECTS

Effects on the exposed person. Manifestation of damage may not be evident for many years or even decades. These effects may include cancer, disorder of the respiratory track and damage to the nervous system.

#### i. SOMATIC AND GENETIC EFFECTS:

Somatic effects include damage to genetic makeup. While genetic effects includes damages to future generations, by damaging the chromosomes of the reproductive cells.

### (c) ANNOYANCES

These includes noises loss of amenities and reduction in the quality of living.

## 2.8 5.2 INDIRECT EFFECTS

Damages to the means of food production such as farmland, domestic animals, crops and productive water damage to property and damage to wild life. It is expected that in the near future, most of the energy required for electricity production will come from nuclear fuels. This means that the total nuclear power level could increase by a factor of 30 to 50 by the end of the century. Since radiation sources will be widely distributed, the possible population exposure to radioactive emission is a serious concern.

## 2.9 5.3 NUCLEAR FUEL WASTE DISPOSAL

The safe disposal of nuclear wastes is an important problem created by large scale use of nuclear energy.

Radioactive wastes with very long half-lives require processing chemically to a stable form and storage in some isolated environment, protected from any natural phenomenon for thousands of years. This is probably the most important and limiting problem.

The wastes associated with nuclear power are:

- i. Gaseous effluents
- ii. Uranium mines
- iii. Spent fuels
- iv. Low level wastes
- v. High level wastes

## 2.10 5.4 METHODS FOR FUEL DISPOSAL

For the first method, the waste is buried deep in the earth in a very stable geological site and sealed off forever.

Suitable fibre glass and a filtration system is necessary where large amount of airborne activity is involved. A tall stack is used to discharge the filtered effluents. Its height must agree with local metrological conditions so that radioactivity is sufficiently diluted before it reaches to ground level.

The last method is such that radio nuclides lose their radioactivity in it through decay and is broadly used in the treatment of all general low level wastes. Its aim is to ease the risks of unnecessary release of waste to the environment.

The above mentioned methods should be thoroughly planned and conducted in a manner ensuring natural regulations and international recommendations on radiation exposure.

## 2.11 5.5 THE PRODUCTIVE UTILIZATION OF WASTE

The waste effluents coming out from the power station are later treated chemically and physically heavy metals are precipitated, ammonia and solids removed and the slightly acid pH- values is raised to neutral level, before the water flows into the bay. The particles removed from the flue gases are no longer emitted into the atmosphere but instead great quantities of solids wastes are collected. Depending on the operating load 23000 to 33000 tons of flyash, 12000 to 30000 tons of gypsum, 2000 to 4000 tone of slag (coarse ash) and 1000 to 2500 tone of sludge and filter cakes per annum. These gigantic rubbish creep is utilized profitably in the production of cement and concrete whereas gypsum is utilized in construction industry. The slag is suitable for

use in underground engineering, contains no dioxide and is highly weather resistant. At the moment, it is the sludge and filter cakes from the waste effluents purification system which are presenting problems. It is a great experience and insight being gained can only lead us to a cleaner and safe environment.

## 6. NOISE POLLUTION

Noise pollution is one of the important types of pollutions because it hits the ear of a human being and can cause a serious effects on the human brain. The non-stop noise of the automobiles in large cosmopolitan cities like Karachi causes mental frustration. Air transport has made this problem even worse. The airports which are situated in the midst of cities are producing continuous noise which does not make sense. A serious contribution to solve this problem is given by the Germans, and at the world most busy airport i.e FRANKFURT AM MAIN they have installed a SOUND ABATEMENT WALL outside the airport.

## 7. DEFORESTATION

Trees are greatest producers of Oxygen and are called the lungs of the city, absorb carbon dioxide in a process called photosynthesis to make their own tissues. As a result they remove large amounts of greenhouse gas from the air. Destroying a large number of trees increases the likelihood of Global warming.

## 8. CONCLUSIONS

This discussion in this paper came to the conclusion that considerations are vital ones to run any country effectively. With an increasing population, environmental health may be maintained by the choice of suitable properties of the fuel in use, those that will not damage the environment of the living organisms. According to the needs of Pakistan and our direct reliance on thermal power station, the efficiency of these stations need to be improved. Since solar power stations and wind turbines are most suitable for all purposes of cleaner atmosphere and environment, they should be ones that must be installed for use in future in order to provide the maximum advantage and the optimum efficiency, in view of our climatic conditions. No input of impure components, no output of matter dangerous to our well-being.

## 9. RECOMMENDATIONS

Following recommendations are made:

- i. All measures to achieve a set of international standards should be mutually agreed by all the nations in a spirit of cooperation and strict implementation through international agencies and non-governmental organizations (NGOs). United Nations can also play a very important role in this regard.

- ii. A Subsidy should be given to install the solar panels and wind turbines and taxes should be reduced in order to promote green energy.
- iii. Deforestation must be stopped and plantations should be established in each province.
- iv. The proposed power projects are being set up by foreign investors and it can be understood that they will be more interested in their own higher profits than the prosperity of our country. The need at this time, is to be well aware of modern pollution control equipment, and advanced technology, in order to achieve higher environmental efficiency.
- v. Outside airports, a Sound Abatement Wall should be installed to minimize the effect of Noise pollution.
- vi. More importantly, the plans and policy for the environment must be implemented instead of just preparing papers.

### **REFERENCES:**

Achakzai, K., S. Khalid, M. Adrees, A. Bibi, S. Ali, R. Nawaz and M. Rizwan, (2017) "Air pollution tolerance index of plants around brick kilns in Rawalpindi, Pakistan," *Journal of Environmental* 252-258.

Davis, M., (1991) *Introduction to Environmental Engineering*, Singapore. Lim, G. H., W. J. Jung, H. T.

Kim S.Y. and T. Lee, (2017) "The Cognitive and a Nuclear Power Plant In Korea," *Nuclear Engineering and Technology*, 609-620.

Mengal, A., M. A. Uqaili, K. Harijan and A. G. Memon, (2014) "Competitiveness of Wind Power with

the Conventional Thermal Power Plants Using Oil and Natural Gas as Fuel in Pakistan," in *2013 International Conference on Alternative Energy in Developing Countries and Emerging*.

Perwez, U. and A. Sohail, (2014) "GHG emissions and monetary analysis of electric power sector of Pakistan: Alternative scenarios and its implications," in *Energy Procedia*,

Shahid, I. (2018) "Research Gate," 2 October 2018. [Online]. Available: [https://www.researchgate.net/publication/267150608\\_Air\\_pollutants\\_emissions\\_in\\_Pakistan](https://www.researchgate.net/publication/267150608_Air_pollutants_emissions_in_Pakistan)

Shamis, S. S. (1992) "Pollution Management," *Engineering Horizons*, November.

Tai A. P. and M. V. Martin, (2017) "Impacts of ozone air pollution and temperature extremes on crop yields: Spatial variability, adaptation and implications for future food," *Atmospheric*, vol. 169, 11-21.

WHO, "State of Global Air/ (2017) A special report on global exposure to air pollution and its disease burden," WHO.

White, G. (1978) "Environmental Effects of Arid Land Irrigation," UNESCO,

Zia. ul-Haq, S. Tariq, M. Ali, K. Mahmood, S. A. Batool and A. D. Rana, (2014) "A study of tropospheric NO<sub>2</sub> variability over Pakistan using OMI data," *Atmospheric Pollution Research*, 709-720.

