CHAPTER I
INTRODUCTION

Energy has long been viewed as an essential ingredient in meeting man's basic needs and in stimulating and supporting economic growth and the standard of living, so much so that often a nation identifies its wellbeing with its gargantuan and growing need for energy. Statistical data on energy consumption of the world in recent years [1] shows that world consumption has increased by about 50% in less than ten years. It has been estimated that the per capita use of energy has more or less doubled during the past 30 years, and current trends indicate that consumption will grow at a faster rate in the future. This increase is a natural result of growing socio-economic activities and the rising standard of living. The increasing global demand for energy has hitherto been met to an increasing extent by the use of fossil fuels and hydro power. Nuclear energy has been developed and used commercially for about two decades to meet a fraction of the electrical energy needs. The total installed nuclear generating capacity in the world in 1976 was 79.9 GWe from 187 power reactors operating in 19 countries [2]. The estimates demonstrate the wide range of possibilities, which is wider after 1985, because of possible changes in rates of growth of economic activity and a variety of other considerations that may affect the rate of commissioning of nuclear power stations. Using the IAEA estimates, nuclear energy will contribute about 11—13% of the total electricity generating capacity in the world in 1985 and about 17—20% in the year 2000. At the local and in some cases regional level, the environmental aspects of energy production and use have become of paramount importance and have served as warnings of what could be in store on a wider scale if serious consideration is not given to the environmental implications of man's demands for energy. From recent examinations of the impact of energy on the environment, it has become apparent that individual nations are not isolated in this respect and that the actions of one country may well result in environmental damage in a neighbouring State. Against this background, an awakened public awareness of the issues has demanded that an attempt be made to examine rationally the environmental aspects of the energy-related society. Although nuclear power stations do not emit fly-ash or noxious gases into the atmosphere as fossil-fuel-operated plants do, the radioactivity released from the products of nuclear fission has been the main focus of public concern about the expansion in the use of nuclear power despite the stringent control measures and precautions taken There have been many attempts to set up acceptable levels for radioactivity in the environment or in man, and although the ICRP recommendations are generally accepted in evaluating occupational hazards, their extension to large populations and the environment as a whole has been subjected to extensive criticism.

Coal has always been the backbone, as it is a main source of the power generation requirement for the entire developmental activities [2], however, it has harmful health consequences also [3, 4]. In India, the production capacity of coal raised about 300 percent and increases to 930 Mtce in 2040, making India next to China amongst the worldwide producers [5]. To meet the future power demand, total installed capacity is expected to enhance three times (from 159 GW in 2014 to 450 GW in 2030), and it is estimated that the total coal utilization will increase 2-3 times from 660 million tons/year to 1800 million tons/year; and subsequent CO2 emissions from1, 590 million tons/year to 4,320 million tons/year [6]

The total premature mortality due to the emissions from coal-fired TPPs is expected to grow 2-3 times reaching186,500 to 229,500 annually in 2030 [6]. Asthma cases are also associated with coal-fired TPP emissions will grow to 42.7 million by 2030 [7]. The coal based power plant areas with yearly SO_2 emissions greater than 50Gg year–1 produce statistically considerable OMI signals, and has a higher correlation value ($R = 0.93$) is found between SO_2 emissions and OMI-observed SO_2 burdens. Contrary to the decreasing trend of national meanSO_2 concentrations reported by the Indian Government, both the total OMI-observed SO_2 and annual averageSO_2 concentrations in coal-fired power plant regions increased by >60% for the period of 2005 to 2012, entail the air quality monitoring network needs to be optimized to reflect the true SO_2 situation in India [8]

A report shows that in 2011-2012, 80,000 to 1,15,000 premature deaths and more than 20 million asthma cases from exposure to air pollution emitted from Indian coal plants, resulted [6]. The pollution from the coal industry includes the consideration of issues such as land use, waste management, and water, air, noise, thermal, visual pollution caused by the coal mining, processing and the use of its products [1, 9]. In association to emissions pollution, the burning of coal produces a good total of coal ash, which may have various heavy metals. World Health Organization (WHO) reports in 2008 that, the coal particulates pollution is estimated to shorten approximately 1,000,000 lives annually worldwide [9]. Despite of various utilization modes of fly ash, a significant amount (at least 70%) is still being disposed in lagoons and landfill and its consequences – Air pollution– Water pollution [10]. Ash ponds may also contains some harmful heavy metals like As, B and Hg, have a fashion to leach out over a period of time and due to this the surrounding ground water gets polluted and becomes unsuitable for public uses [11, 12]. Large areas of land are also required for coal based thermal power plant as fly ash dumping sites, and consequently, there might be changes in soil quality and it becomes more alkaline due to the alkaline nature of fly ash [11].

ENVIRONMENTAL IMPACTS OF THE NUCLEAR FUEL CYCLE

Today, the dominant reactor type uses enriched uranium-oxide fuel, and is moderated and cooled by water. The water may generate steam directly in the reactor (BWR) or may transfer its heat to an external steam generator (PWR). Besides these light-water reactors (LWR), other types based mostly on the use of graphite of D2O as moderator have been developed. Experimental or prototype systems include the plutonium recycle reactor, where Plutonium makes up part or all of the fuel, and the fast breeder reactor (e g LMFBR), where the fuel is a mixture of plutonium oxide and natural or depleted uranium oxide The latter type of reactor is designed to produce more fissile material, usable as reactor fuel, than it consumes The 'nuclear fuel cycle' refers to the entire programme from the mining and milling of uranium, through the manufacture of fuel elements for the reactor, transport and reprocessing of irradiated fuel, to the management of wastes produced in all steps of the cycle The environmental impacts associated with all these steps are reviewed in this paper. Uranium mining and milling The uranium production in 1975 was about 26 000 tonnes and will, it is estimated, reach 40 000 tonnes in 1980 [4, 6—8] Current projections show that demand for low-cost uranium fuel will surpass uranium production capacity by 1985. The cumulative uranium requirements are estimated to be about 0 8—1 million tonnes in 1990 and 2-3 million tonnes by the year 2000 [6, 8] There is at present no consensus as to whether low-cost uranium to this amount actually physically exists in the uppermost part of the earth's crust from which it could be economically produced. In any case accelerated efforts for the exploration and exploitation of new resources to meet the projected increasing demands of the nuclear industry seem inevitable [6, 9].1 Uranium ores are mined by underground, surface or solution mining depending on the geological setting of the ore. For a 1000-MWe nuclear plant (LWR), about 50 000- 80 000 tonnes of uranium ore (0 2% U content) are required. Over the lifetime of a plant, about 30 years, the figure will be about 1 5 million tonnes This corresponds to the need for mining about 1000 acre-feet of uranium ore as compared to about 50 000 acre-feet of coal for a coal-fired plant of the same capacity [10][2]

The environmental impacts associated with uranium mining can be classified into impact on land and water (through spoil and waste water arising from mine drainage and/or from water used in drilling) and occupational health hazards Radon produced by the radioactive decay of 226Ra found in the ores has been considered a major factor in increasing the cancer incidence amoung uranium miners [11—14] Exposure is normally controlled by either natural or artificial ventilation and is kept within the permissible limits of radon concentration Control of dust generated in the mining processes is also necessary to prevent exposure to hazardous levels of silica as well as radiation It should be noted that the environmental impacts and occupational hazards associated with coal mining (to operate a 1000 MWe plant), tend to be more significant than those associated with uranium mining (to operate a plant with the same capacity). Accidental mining fatalities per coal plant exceed those from nuclear plant by a factor of three [15]. The number of 'environmental deaths' among coal miners (from pneumoconiosis) is much higher than in the case of miners in the uranium industry In the milling process, about 70% of the total radioactivity contained in the ore fed to the mills remains undissolved in the solid mill tailings [16]. The environmental effects of tailings piles include: wind erosion to unrestricted areas, river pollution from piles located near river banks, or from water level rising during flood conditions to the base of the piles causing leaching of radium from the material and percolation of water through piles into groundwater [17]. Studies [17-22] have shown that the tailings piles must be stabilized against wind and water erosion for very long periods (dictated by the radioactive half-life of 1620 years for 226Ra). Because of the radon emanations from the radium in the mill tailings, this material should not be used either in structural materials or in backfill material in connection with buildings intended for human occupation, and equally such buildings should not be constructed in the proximity of mill tailings piles Fuel fabrication The main potential hazard in the fuel fabrication process arises from the toxicity of hydrogen fluoride and fluorine used in the production of uranium hexafluonde. Safe methods of handling these chemicals are, however, well-established in the fluorochemical industry. The UF6 produced is a highly corrosive gas as passed through enrichment plants, but a solid at room temperature, and can be safely packaged in steel cylinders. It is at the point of discharge from the conversion operation as UF6 that material in the fuel cycle passes into the Non-Prohferation Treaty safeguards system set up by the IAEA. Under these safeguards, nuclear material in all subsequent operations of the cycle must be physically accounted for with great precision. As the level of uranium enrichment increases, so too does the risk of accidental agglomeration of sufficient quantities of 23SU to set off a chain reaction. Although criticahty accidents are very unlikely to occur, great care is needed to ensure that such events never occur. The depleted uranium residue from enrichment plants is normally stockpiled for