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Environmental Impact Assessment from the Emission of Combined Natural Gas Cycle Power Plant

Evaluación de Impacto Ambiental de la Emisión de Central Térmica de Ciclo Combinado de Gas Natural

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ABSTRACT

This research paper analysed the potential environmental impact of natural gas power generation in the surrounding area. The main purpose of this study is to determine the present environmental condition, to study the activities related to the project and to assess the possible environmental impacts due to these specific activities. Thermal power plants have a significant impact on the environment during construction and operation phase. The major environmental disciplines include surface and ground water hydrology, meteorology, air quality, water quality, noise, terrestrial and aquatic ecology.

The flue gas emitted from the chimney of power plant is the main source of air pollution. The emitted flue gas will determine how much impact it has on the environment. The power plant produce electricity using natural gas as fuel and natural gas does not contain any sulphur contents. The main pollutants are nitrous oxide ($NO_{2)}$, particulate matter (PM), CO from exhaust gas coming out from the turbine through stack and their qualities are well underneath National Ambient Air Quality Standards (NAAQS). Noise and Vibration in the examination region is assed to be minor because of plant activity and doesn't affect on neighbourhood faunal species. Weighty metal fixations in the ground water found underneath as far as possible and water is suitable for using domestic and irrigation purpose. The analysis revealed that surface water quality is suitable for aquatic flora and fauna. Study also indicates that power plant has no negative impact on climatic condition, air quality and aquatic eco system.

Keywords: power plant emission, natural gas, environmental impact, air quality, surface water quality.

RESUMEN

Este trabajo de investigación analizó el impacto ambiental potencial de la generación de energía con gas natural en el área circundante. El objetivo principal de este estudio es determinar la condición ambiental actual, estudiar las actividades relacionadas con el proyecto y evaluar los posibles impactos ambientales debido a estas actividades específicas. Las centrales térmicas tienen un impacto significativo en el medio ambiente durante la fase de construcción y operación. Las principales disciplinas ambientales incluyen hidrología de aguas superficiales y subterráneas, meteorología, calidad del aire, calidad del agua, ruido, ecología terrestre y acuática.

El gas de combustión emitido por la chimenea de la central eléctrica es la principal fuente de contaminación del aire. El gas de combustión emitido determinará cuánto impacto tiene en el medio ambiente. La planta de energía produce electricidad utilizando gas natural como combustible y el gas natural no contiene ningún contenido de azufre. Los principales contaminantes son el óxido nitroso (NO2), el material particulado (PM), el CO de los gases de escape que salen de la turbina a través de la chimenea y sus cualidades están muy por debajo de las Normas Nacionales de Calidad del Aire Ambiental (NAAQS). Se considera que el ruido y la vibración en la región de examen son menores debido a la actividad de las plantas y no afectan a las especies de fauna del vecindario. Las fijaciones de metal pesado en el agua subterránea se encuentran debajo en la medida de lo posible y el agua es adecuada para uso doméstico y de riego. El análisis reveló que la calidad del agua superficial es adecuada para la flora y fauna acuáticas. El estudio también indica que la planta de energía no tiene un impacto negativo en las condiciones climáticas, la calidad del aire y el ecosistema acuático.

Palabras clave: emisión de centrales eléctricas, gas natural, impacto ambiental, calidad del aire, calidad de las aguas superficiales.

INTRODUCTION

Natural gas (NG) is one of the key sources of energy for producing electricity which maintains a healthy and clean environment. In India, for electricity generation coal contributes 53.3%, whereas natural gas contributes 6.7% of total electricity generation (Agrawal, et.al, 2014). Besides, additional sources for electricity generation comprises lignite, diesel, nuclear, hydroelectricity and renewable energy sources such as biomass,

urban and industrial waste, wind and solar energy, as shown in the illustrations in table 1(CEA, 2020). Being a secure source of energy and domestically abundant, the use of NG gas also provide a large number of environmental benefits compare to other fossil fuels. Burning natural gas emits fewer inimical pollutants compare to other fossil fuels, and an incremented reliance on natural gas can potentially truncate the emission of many of these most inimical pollutants (USA: UCS,2012).Thermal effluents are responsible for rising water temperatures, whose harmful effects have been published in several publications (Bush, et. al, 1974 and Madden, et. al, 2013). In the literature, the physical, living, convivial and economic environmental situation of the Sundarbans and the circumventing areas denote that most of the effects of coal-fired electricity are negative (Chowdhury AH, 2017).Chaudhary AH, 2011 reported that habitat impairment and consequent damage to biodiversity often occur far from the point of exhaustion as a result of globalization and increased international trade.

Nowadays, large no of research have been carried out to estimate environmental impacts through Lifecycle Assessment (LCA) method for combined natural gas thermal power plant (Hellweg, e.t al, 2015).Natural gas is a clean and alternative source of energy, but natural gas combustion still produces a considerable amount of air emissions. The major pollutants in natural gas and electricity generation are nitrogen oxides or NO_2. In addition to causing respiratory problems, NO_2 reacts with other substances in the air to create particles and ozone. Particulate matter and ozone lead to a long list of adverse health effects such as Breathlessness, heart attacks, early death, and so on. It is therefore required to assess the effect on the environment of the natural gas power station on the atmosphere, water quality, aquatic ecology etc. (Ghosh, et.al,2020). Paulina et al. studied that Natural gas generated electricity will grow over the next few decades in the United States, reducing greenhouse gas emissions compared to coal(Jaramillo et al. 2007). Natural gas usage is predicted to rise by 20 per cent by 2030. Both U.S. natural gas production and pipeline imports from Canada and Mexico are predicted to reasonably constant (U.S. DOE, 2006).

Natural gas is responsible for about 132 million tonnes of CO_2 equivalent per year (U.S. EPA, 2005). India's share of natural gas in its main energy mix is projected to rise to 20 per cent in 2025 from 11 per cent in 2010. The national transmission pipeline system are projected to be completed by 2025, the distribution of natural gas is predicted to be as high as 20% by 2030 (Vision 2030). Over the last few years, natural gas demand in India has grown significantly. As a result of its greater availability, increasing transport and distribution infrastructure, the redeems realized through the use of natural gas instead of alternative fuels, the environment-friendly nature of natural gas as fuel and the saving in the supply of gas at reasonable prices to end consumers. Natural gas plays a growing role in generating electricity. In addition to providing cost-

effective fuel for electricity generation, greater use of natural gas enhances the emissions profile of the electricity generation industry.

MATERIALS AND METHODS

Study Area: The 726 MW NGCC (Natural Gas Combined Cycle) thermal generating station is discovered in the state of Tripura, North-East India. The plant is situated very close to the State PWD road. Geographically, the site is located at a latitude of 23°29'59.2" North and longitude of 91°26'13.7" East, approximately. The closest Airport is (Maharaja Bir Bikram Singh Airport at Agartala) at a distance of about 61.5 km. The study area consists of a wide geographical area with a radius of 10 km from the power plant. In a combined cycle power plant (CCPP), electricity is generated from the gas turbine generator and temperature of exhaust gases are sufficient for producing steam to produce further electricity through a steam turbine which makes electricity generation more efficient. Fig. 1 shows the actual spot of plant site. Natural gas is used as fuels in thermal power plant to produce electricity. Study Area was selected in Tripura region, i.e. natural gas combined cycle power plant with capacity of 726 MW. The water comes from the plant's water reservoir, which collects water from the Gomati River, 2 km north of the plant. The study was conducted mainly on the basis of data from documents published by government and non-government organizations, and involvement of academics, activists included in natural exercises (Ministry of environment and forests, 2010). but data collection has presented numerous challenges. The majority of the results are based on available research. Hence, misinformation may result in a marginal error. Information is also gathered from published reports, government websites and recognized institutions and appropriate government departments were consulted to obtain information and maps of the impact zone of the project area (Ministry of Environment, Forests and climate change Government of India (MOEFCC,GOI) and Tripura State Pollution Control Board(TSPCB)).

The plant utilizes natural gas to produce electricity and the composition of natural gas shown in table 2. The plant design parameters are given in table 3. This study's main purpose is to find the potential impact of the natural gas power plant on the ecological and biological state of the study area. The aquatic environmental investigation was completed along Gomati River, 2 km upstream from the plant water consumption area and 8 km downstream of water admission facility.

RESULTS AND DISCUSSION

The major environmental disciplines include surface and ground water hydrology, meteorology, air quality, noise, terrestrial and aquatic ecology etc. were studied and presented in table 4-10.Table 7-9 were sourced from Ministry of Environment, Forests and climate change, Government of India. (MOEFCC, GOI) (2017) and publicly available. Table 4-6 and table 10 were sourced from Tripura State Pollution Control Board (TSPCB), 2005. Soils in the research area generally neutral with an average pH 7.07, which is shown in table 4. Average concentration of sodium, potassium, calcium and magnesium are 0.16%, 0.11%, 0.17% and 0.091 % respectively. Electrical conductivity is low with an average level of 50.2 µS/cm. chemically, the carbonate content of the soils is found to be very low and mostly below detection level.

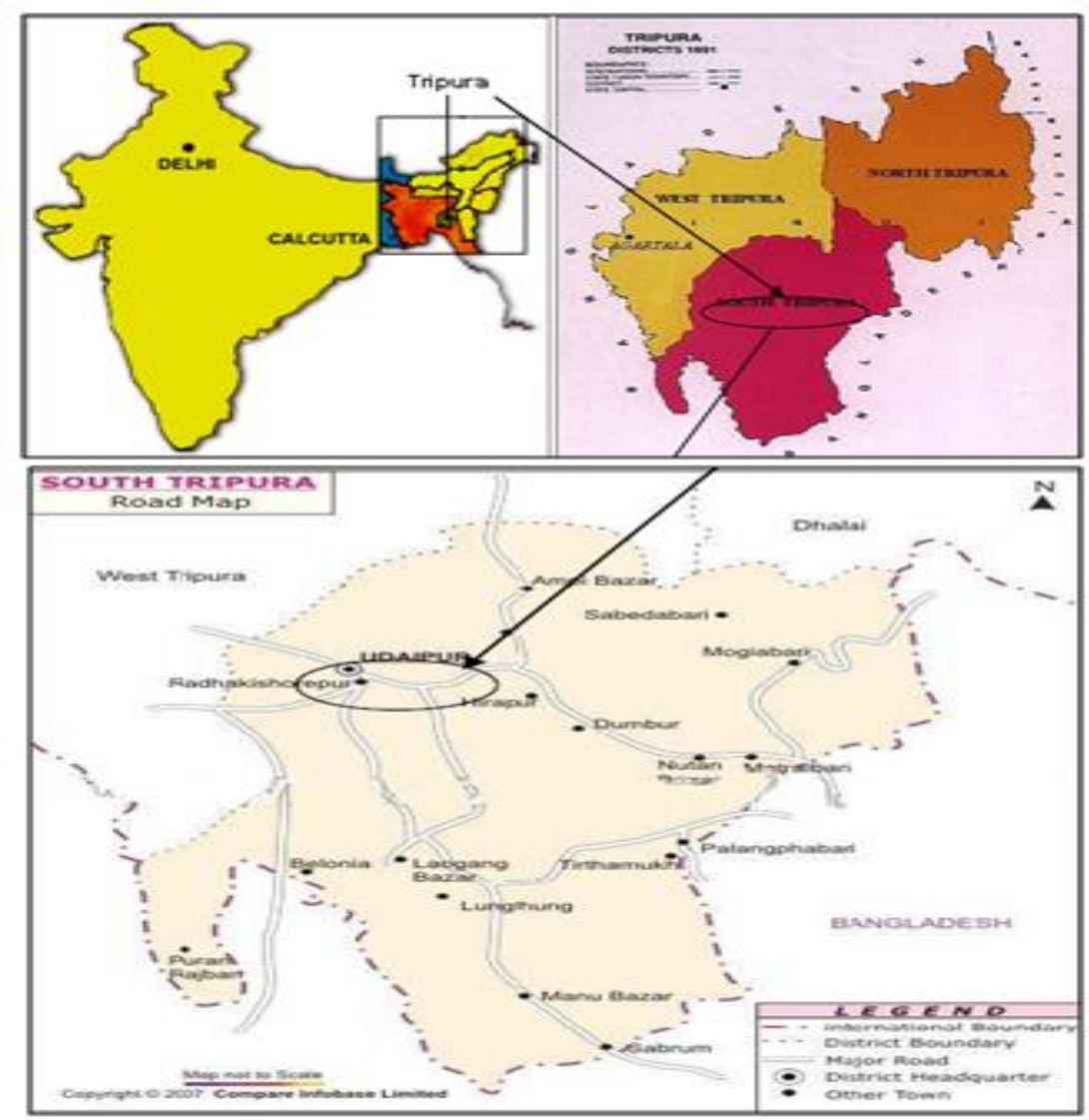

Figure 1: Study Area
(Source: https://otpcindia.in/images/PDD_26Dec2012.pdf)

Table 1: Total Installed Capacity in MW (As on 30.11.2020)

Fuel		MW	% of total
Total Thermal	Coal	1,99,595	53.3%
	Lignite	6,260	1.7%
	Gas	24,957	6.7%
	Diesel	510	0.1%
Hydro(Renewable)		45,699	12.2%
Nuclear		6,780	1.8%
Renewable Energy Source		90,399	24.2%
Total		374,199	100%

Table 2: Composition of natural gas

Composition	Percentage (%)
Methane	96.6937
Ethane	1.9780
Propane	0.3909
IsoButane	0.1115
Butane	0.0554
IsoPentane	0.0270
Pentane	0.0193
Hexane+	0.1115
Nitrogen	0.4027
Carbon Dioxide	0.3668
Hydrogen Sulphide	0

Table 3: Design specification of NGCC thermal power plant

Design specification	Data
Type of power plant	NGCC
Plant capacity	726 MW
Main Fuel	Natural Gas
Plant Load Factor	80 %
Life time	25-30 years
Net Calorific Value (kcal/kg)	8,800
Heat rate (kcal/kWh)	2450
Plant efficiency (net)	35.1%

The climate conditions in the study area (10-year mean) are illustrated in table 6 (Indian Meteorological Department, Ministry of India., 2020). The climate near the project area is characterized by a warm and humid tropical climate with four distinct seasons such as summer/premonsoon (March-May), monsoon (June-September), post

monsoon (October-November) and winter (December-February). The climate warms up generally from the middle of March and the height of summer is reached during April-May, when average maximum temperature is in excess of 35°C. The average minimum temperature during this period is around 18.8°C. Monthly mean daily average temperature shown in table 5. Thunder storms during late afternoon are common during March, April and early May. Monsoon generally breaks in the middle of June when daily maximum temperature drops to some extent and lasts till the end of September. Monsoon generally retreats by October and winter sets in from end of November. Winter is severe in January when minimum temperature recorded is around 8°C. The average wind speed over the study period at study area was about 4.37 km/hr. It may be seen that rainfall peaks in the month of June. As much as 93.5% of the rainfall is received in seven months between April and October, while 51% of the rainfall is received in the three months of June, July and August. Relative humidity is maximum in July and minimum in March and generally varies between 70% and 85%. At site, the wind speed ranged between 3.87 km/hr to 4.87 km/hr.

Monitoring of ambient air quality took place in the study area and shown in table 7. The parameters studied were Particulate Matter (PM10 and PM2.5), Nitrogen Oxides (NOx), Carbon Monoxide (CO), Ozone, Hydrocarbon (Methane and Non-methane). Surveillance outcomes were matched to the National Ambient Air Quality Standards (NAAQS)[7].The average PM10 concentration in the study area found 66.08 μg/m^3, which is within the limit of 100 μg/m^3 as per NAAQS. The Lowest average PM2.5 concentration was recorded 14 μg/m^3 and highest was 51 μg/m3. The average Sulphur Dioxide (SO2), Nitrogen Di-oxide (NO2), Carbon Monoxide (CO), Ozone (O3) , Hydrocarbon varied from 4.21 to 8.3 μg/m^3,12.51 to30.52 μg/m^3,0.21 to 0.79 μg/m3,<10 to 31.20 μg/m3,0.85 to 2.65 ppm respectively.

The quality of surface and ground water analysis shown in table 8 and table 9.Surface water quality of Gomati river is observed from three different location such as upstream and downstream of Gomati river and jamjuri switch gate nala where river meets with the river. pH, Dissolved oxygen (DO), Electrical Conductivity (EC), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total dissolved solids (TDS), Total Hardness (TH), Total suspended Solid (TSS), Chloride, Sulphate varied from 7.43 to 7.49,6 to 6.4 mg/l, 1.8 to2.9 mg/l, 8to 20 mg/l, 117 10 134 μS/cm,75 to 85 mg/l,44 to 57 mg/l, 23 to 94 mg/l, 9.8 to 11.8 mg/l,0.8 to 7.38 respectively. The value of free ammonia contents of all three samples less than 0.1 mg/l indicates sewage pollution is absent in the surface water. Concentrations of heavy metal and toxic substances like lead, chromium, arsenic and cadmium present in the surface water of all three samples found below detection limits. Ground water pH varied from 5.61-8.13, which is within the normal acceptable range of 6.5 to 8.5. TDS, Alkalinity, Calcium, Magnesium, Chloride, Hardness varied from 28-150, 7.4-39, 6.2-15.6, 0.98-30, 13.7-59, 19.6-88 respectively. The

ambient noise scenario within the study area was monitored covering applicable land use zones in the area as commercial, residential and silence areas in accordance with the ambient noise standards MOEFCC, GOI and shown in table 10. The equivalent sound level during the day (Leq day) ranged from 43.0 to 50 dB(A), while the equivalent sound level at night ranged from 39 to 45 dB(A). The equivalent sound level during the day (day Leq) in the plant area was 66.0 dB(A) and the equivalent sound level at night was 53.1 dB(A).

On the basis of present study, it has been observed that Soil quality in the study area appear medium to low fertility type of soils with medium to low organic content and trace (nutrient) elements. Heavy metals like copper, chromium and zinc are present in low ranges, while the other heavy metals are mostly undetected. The analysis suggests that the soils are deficient in zinc as well as in micronutrients. The major pollutant from the operation of combined natural gas based thermal power plant is NOx. High levels of NOx into the atmosphere have detrimental effect and enhance the greenhouse effect and vegetation can damage foliage, reduce growth or reduce crop performance. The direct effect of nitrogen in the air is caused by acidification, toxic effects, and eutrophication. The level of NO2 in the ambient air quality standard may not have any significant impact on wildlife. Surface and ground water quality analysis do not reveal any paramount concerned in the parameter values which suggests that there is no major pollutants discharged to the Gomati River from power plant effluents. The results of surface water analysis also reveals that water of Gomati River in the study area can be used for washing, bathing, fish catching and irrigation purpose.

Operating the plant creates noise and vibration. Increasing the level of noise and vibration inside and around the proposed project site can be disruptive to local animal species. But study revealed that there is no significant impact of the plant operating noise. The effect on biological environment may have impact on flora and fauna. The effect on vegetation is mainly due to arrive procurement and the emissions of combustion gases which may lead to loss of living space of numerous species. Temperature of squander water is generally higher than normal water and discharging it into the river can harm the living organism of water. Any changes in air quality largely impact on terrestrial ecology and changes in water quality of river impact on aquatic ecology. The power plant use water from Gomati river and as a result of water withdrawal, the water at the bottom of the river can also significantly affect the ecosystem. There may be impacts from the discharge of water from the plant on river water quality which may lead to impact on aquatic ecosystem. The Gomati River provides important habitat to fish and other aquatic animals. The slightest change in surface water is reflected in the species composition and consequently, in the oceanic environment.

Table 4 : Physico-Chemical Characteristics of Soils in the Study Area

Sl. No	Parameters	Average value
1	pH (at 35 ^{0}C)	7.07
2	EC (umhos/cm)	50.2
3	Sodium (%)	0.16%,
4	Potassium (%)	0.11%,
5	Calcium (%)	0.17%
6	Magnesium (%)	0.091%
7	Chloride (%)	0.010%
8	Sulphate (%)	0.0073%
9	Nitrogen (%)	0.024%
10	phosphorus	0.0029%
11	Copper (%)	0.0026
12	Zinc (%)	0.0019

Table 5: Monthly mean of daily average temperature

Month	Temperature (^{0}C)	Month	Temperature (^{0}C)
January	18.7	July	28
February	21.9	August	28.9
March	27.2	September	28.2
April	27.9	October	27.1
May	28.7	November	23.7
June	28.9	December	20.2

Table 6: Climatic conditions of the study areas (10 years average)

Parameters	value
Temp. Avg. Max. (^{o}C)	35
Temp. Mean (^{o}C)	18.8
Relative Humidity Mean (%)	70-85
Rainfall Mean (mm)	471
Wind Speed Avg.(Km/hr)	3.87-4.8

Table 7: Air quality of study areas

Parameters	Min	Max	Avg	NAAQS
PM10(µg/m3)	31	98	66.08	100
PM2.5(µg/m3)	14	44	31.33	60
SO2(µg/m3)	4.21	8.4	5.78	80
NO2(µg/m3)	13.60	30.52	24.13	80
CO(µg/m3)	0.25	0.72	0.45	2
O3(µg/m3)	<10	31.20	-	100
Hydrocarbon(ppm)	0.76	1.81	1.26	-
Mercury(ng/m3)	-	<0.05	-	-

Table 8: Surface Water Quality Analysis

Parameter	Unit	Gomati River Up Stream	Gomati River Down Stream	Jamjuri Switch Gate Nala
pH		7.79	7.54	7.43
DO	mg/l	6.2	6	6.4
BOD	mg/l	2.9	1.8	1.8
COD	mg/l	20	12	8
EC	µS/cm	117	134	117
TDS	mg/l	75	85	75.2
TH	mg/l	56	52	44
TSS	mg/l	94	82	23
Free Ammonia	mg/l	<0.01	<0.01	<0.01
Chromium	mg/l	<0.01	<0.01	<0.01
Lead	mg/l	<0.005	<0.005	<0.005
Cadmium	mg/l	<0.01	<0.01	<0.01
Chloride (as Cl)	mg/l	9.8	11.8	11.8
Sulphate (as SO4)	mg/l	0.8	7.38	6.7
Arsenic	mg/l	<0.01	<0.01	<0.01
Total coliform	MPN/ 100 ml	920	350	540

Table 9: Physico-chemical conditions of groundwater of the study areas

Parameter	Range	Acceptable limit (IS:10500, 2012)
pH	5.61-8.13	6.5 - 8.5
TDS(mg/l)	28-150	500
Turbidity (NTU)	<1-30	1
Alkalinity (mg/l)	7.4-39	200
Calcium (mg/l)	6.2-15.6	75
Iron	<0.05-0.43	0.3
Magnesium (mg/l)	0.98-30	30
Chloride (mg/l)	13.7-59	250
Hardness (mg/l)	19.6-88	200
Total Coliform (MPN/100 ml)	<1.8	-

Table 10: Ambient Noise

Area	Noise level(Leq)in dB(A)	
	Day Time	Night Time
Commercial	44-50	40-45
Residential	43-47	39-45
Silence	48-49	42-43

CONCLUSION

The thermal power station has a very serious effect on the surrounding environment by generating large amount of NO_2 and particulate matter. The power plant use natural gas as a fuel and natural gas does not contain sulphur content and fuel is filtered in multistage. So flue gas coming out through the stack contains less particulate matter. The plant does not have a major impact on plant and animal community. Effluent waste generated from the power plant is filtered through RO plant and ETP (Effluent Treatment Plant) before discharging into the Gomati river. Therefore, impact on river water quality due to power plant activity has no major impact on aquatic habitat including fishes. So environmentally, the study area has not any negative impact .However, regular and long-term observation of air and water quality is necessary and intensive monitoring should be carry out to identify the long term impact of the study area on biodiversity and ecological condition.

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