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Deep Sea Outfall of Natural Gas Fired Combined Cycle Power Plant Cooling Water Application and Modeling

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Abstract

Combined Cycle Power Plants are in wide demand throughout the world, because they are characterized by short construction times, low investment costs, high operating efficiencies and low exhaust emissions. This type of power plants can reach fuel to electricity conversion efficiencies of 60%, at the same time it has minimal environmental impacts. The most important reason for this is the use of natural gas, which is a very clean fuel containing little or no sulfur, particulate matter and other unwanted ingredients. This study was investigated the effect of cooling water from natural gas combined power plant to Black Sea region of Turkey. The parameters, which affect the marine ecosystem, were determined and in addition temperature, suspended solid, COD values were measured. Modelling of these measured values was performed throughout discharge line with the CORMIX-2 software developed by EPA (Environmental Protection Agency) as environmentally purpose.

Key words

Deep sea outfall, model, natural gas, power plant

1. INTRODUCTION

Energy is what drives our lives. There is an ongoing global energy challenge caused by increasing energy demand, heavy dependence on oil and other fossil fuels which leads to air, water and land pollution. Large carbon emissions lead to global warming, climate instability and raises health concerns over pollution. Depletion of the fossil resources that are not uniformly distributed globally force the humanity to use the available precious energy resources as efficiently as possible [1].

Electricity power generation industry being the most important energy sector in many countries faces real problems; the continuous increase in fuel prices, exploding growth in energy demand, the recent strict environmental regulations and the severe competition after the liberalization of the energy market. As a result, power generation authorities seek performance improvements of the power plants. Operating more efficiently is important for the power plants to be able to compete in the deregulated energy market [2].

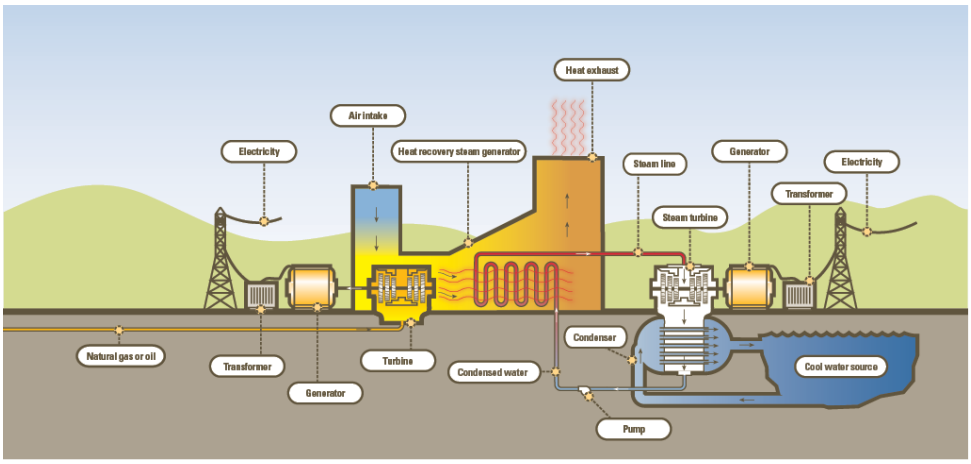

Figure 1. Combined Cycle Power Plants

Gas turbine performance has been enhanced considerably in recent years due to the rapid development of component design and material technologies. Many applied power generation systems based on the gas turbine have been proposed, and several systems have already been applied in real settings. The gas/steam combined cycle plant, for instance, has already emerged as a standard technology for base load power generation [3].

Combined Cycle Power Plants utilize both gas turbines and steam turbines to generate electricity. In a combined cycle power plant, the gas turbine is coupled to a generator to allow it to produce electricity even it runs solo without a steam turbine. As the exhaust stream of the gas turbine has high energy, the gas turbine exhaust is connected to a heat recovery steam generator (HRSG) where steam is produced from the waste heat in the exhaust gas. The generated steam is used to turn the steam turbine that produces more electricity in addition to the simple gas turbine cycle. The steam turbine is connected to a condenser where the excess heat is rejected to the environment. This equipment's are the main components of a combined cycle power plant. These are also the components which determine and dominate the performance of a power plant. Apart from these main components, there are many auxiliary systems such as cooling systems, lubrication systems, pumps etc. in a combined cycle power plant [4].

2. MATERIALS AND METHODS

2.1 Study Area

The Black Sea, with its world's largest anoxic basin, is situated between the folded Alpine belts of the Caucasus and Crimea Mountains to the north and northeast, and the North Anatolian Mountains to the south, with an area of 432,000 km^2 and a volume of 534,000 km^3. The Strait of Bosporus connects the Black Sea to the Sea of Marmara to the south and southwest, which in turn, is connected to the Aegean Sea and the Mediterranean Sea through the Strait of Dardanelles. [5].

Figure 2. Locations of Black Sea

The Black Sea's catchment area which covers entirely or partially 22 countries in Europe and Asia Minor is more than 2 million km^2. Six of these countries are littoral (Bulgaria, Georgia, Romania, the Russian Federation, Turkey and Ukraine), while the other sixteen (Albania, Austria, Belarus, Bosnia-Herzegovovina, Crotia, the Czech Republic, Germany, Hungary, Italy, Macedonia, Moldova, Poland, Slovakia, Slovenia, Switzerland and Yugoslavia) do not have shorelines with the Black Sea.

The length of the Black Sea shoreline is 4,340 km approximately. The Bulgarian coastline is 300 km long; the Georgian coastline 310 km; the Romanian coastline 225 km; the Russian coastline 475 km; the Turkish coastline 1,400 km and the Ukrainian coastline 1,628 km. The Black Sea shoreline is not ragged. There are several big or small peninsulas and bays through the shoreline, but no large islands are present. The largest peninsula is Crimea, located in the north. The largest bays are, Odessa Gulf, Yagorliksky Bay, Tendrovsky Bay, Karkinitsky Bay and Kalamitsky Bay in the north; Novorossiysk Bay in the east; Sinop Bay and Samsun Bay in the south; and bays of Igneada, Burgaz and Varna in the west. The biggest island is Zmeiny (1.5 km^2), located in front of the Danube delta [6].

2.2 Sampling and Analytical Methods

Water samples were taken in the summer and autumn 2016. Temperature (^{0}C), dissolved oxygen (DO), pH and electrical conductivity (EC) were measured on site using a field multi-probe (HQ40d Portable). Chemical oxygen demand (COD) and suspended solid were measured according to Standard Methods for the Examination of Water and Wastewater (APHA 1995). Water quality parameters were assessed accordingly Turkish Water Pollution Regulation (Table 1).

Table 1. Monitoring results of water quality parameters and the limit values (Turkish Water Pollution Control Regulation)

Parameters	Limit Value	Summer	Autumn
pH	6-9	7.92	8.72
Temperature	35 ˚C	19.3	24.8
Suspended Solid (mg/L)	350	2800	646
COD (mg/L)	400	990	79
Dissolved Oxygen (mg/L)	-	9.78	8.93
Electrical Conductivity (µS/cm)	-	26.6	29

2.3 Model Description

CORMIX is a USEPA-approved simulation and decision support system for environmental impact assessment of mixing zones resulting from point source discharges. The methodology contains systems to model submerged single-port (CORMIX1) and multiport diffusers (CORMIX2) as well as surface discharge sources (CORMIX3). Effluents considered may be conservative, non-conservative, heated, or they may contain suspended sediments. The advanced information system tools described herein provide documented water quality modeling, regulatory decision support, mixing zone visualization, and tools for outfall specification and design optimization [7].

3. **RESULTS AND DISCUSSION**

The surface water quality parameters were given in Table 1. The pH of the water samples was within the range of 6.5–9. Also temperature values less than 35 ˚C degrees. The highest values of chemical oxygen demand (COD) were observed in the summer with 990 mg/L (Fig 3). Suspended solid is much higher than limit values both summer and autumn (Fig 4).

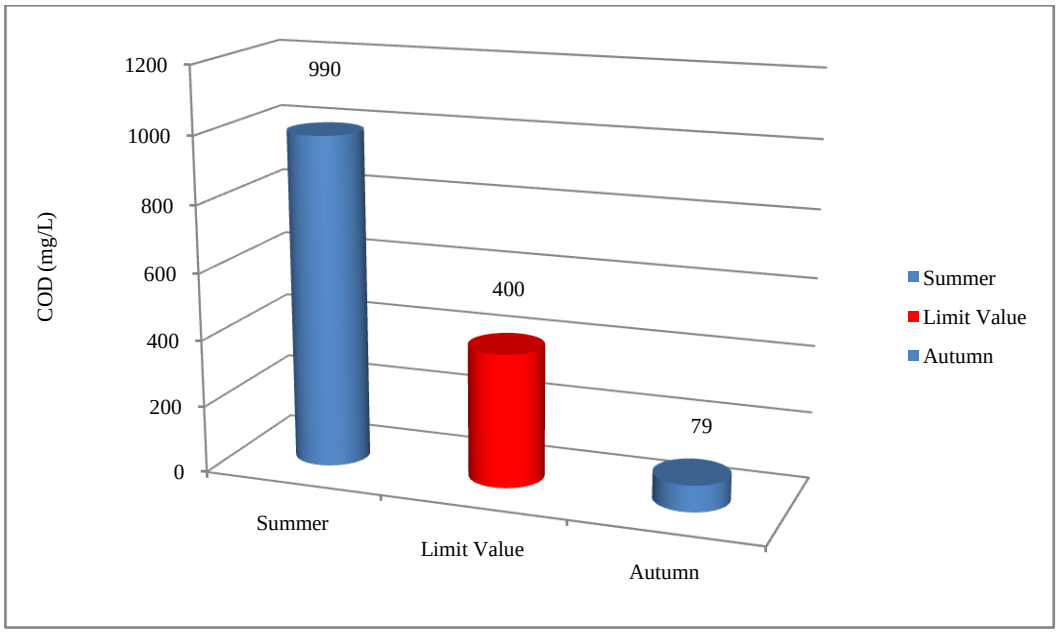

Figure 3. The comparison with the limit values for chemical oxygen demand of monitoring results

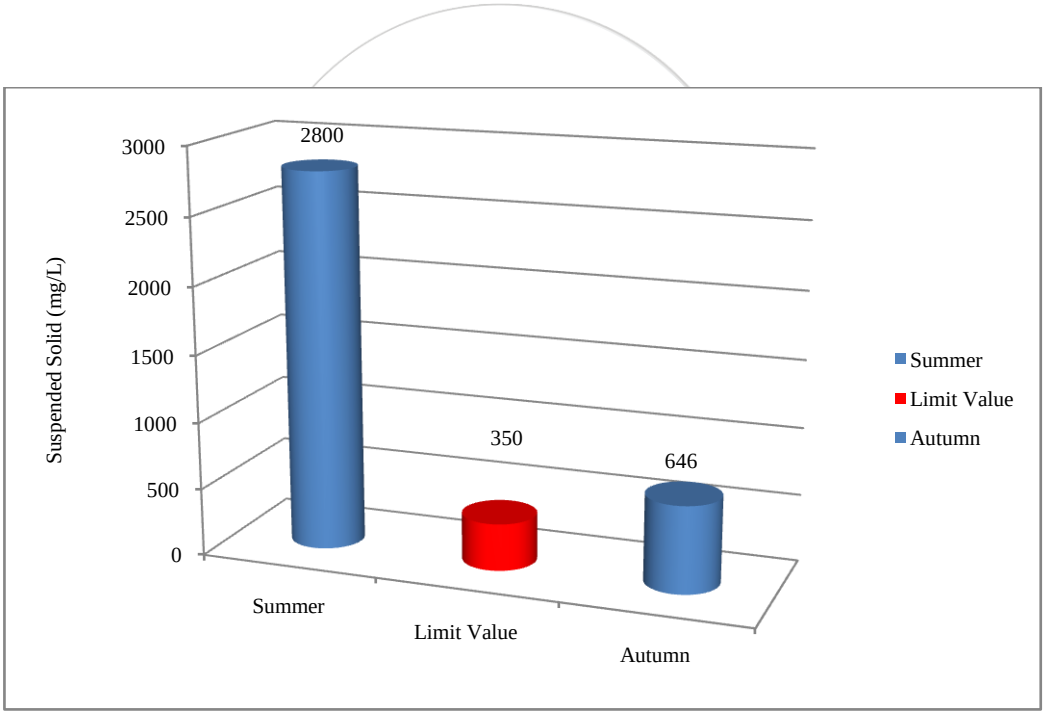

Figure 4. The comparison with the limit values for suspended solids of monitoring results

The electrical conductivity of the water samples was 26.6 and 29 (µS/cm), respectively. There were no boundary values of the electrical conductivity and dissolved oxygen according to Turkish Water Pollution Regulation. In addition, temperature values have to be one centigrade degree between ambient temperature and hot water discharge in accordance with Turkish Water Pollution Regulation. In order to determine the temperature difference was used Cormix2 model. Before mixing with the hot water into the sea, 9 °C degrees temperature difference was observed between ambient temperature and hot water discharge.

The green line in the Figure 5 shows that one degree of difference between ambient temperature and hot water discharge. It indicates that 1 °C temperature difference value is seen that at 10 m. Isometric view of hot water discharge was revealed using Cormix2 (Fig 6). Figure 6 were presented as the change in color code discharged wastewater temperature.

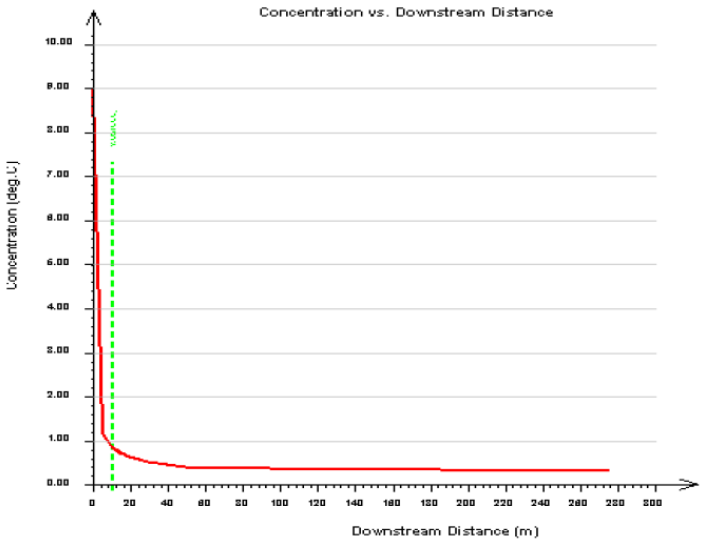

Figure 5. The difference graph between the ambient temperature and hot water discharge

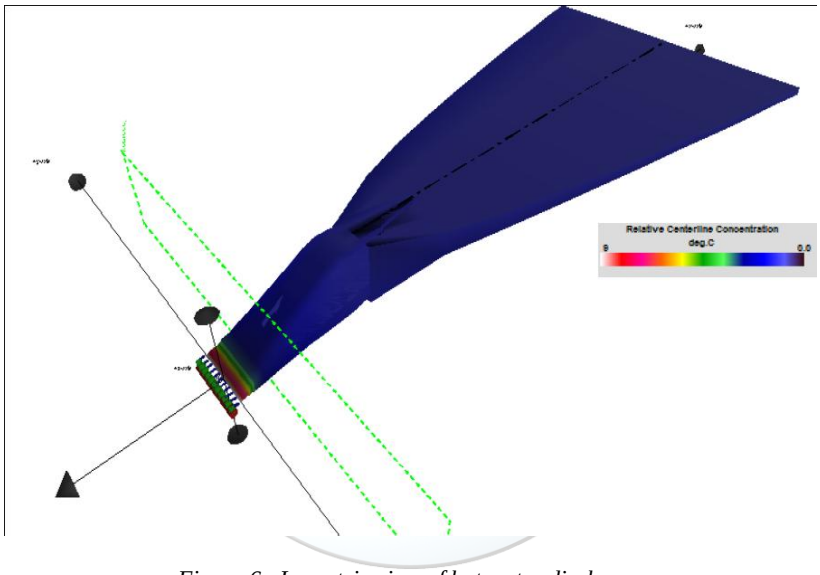

Figure 6. Isometric view of hot water discharge

4. CONCLUSION

In this study concentration of parameters such as pH, temperature, dissolved oxygen, suspended solid, chemical oxygen demand and electrical conductivity were measured in combined cycle power plant using natural gas in the Black Sea coast of Turkey. The CORMIX system is unique among mixing zone prediction methodologies in that it systematically accounts for boundary interaction, predicts density current behavior after boundary interaction, and provides rule-verified mixing zone analysis and advice for outfall design optimization [8]-[9].

A result of increasing erosion due to high precipitation rates are increasing the amount of solid substances carried into the rivers in the Black Sea. Suspended solid of the high value, the amount of solids transported by rivers is considered that due to the increase. The measurement results compared with the model results showed that 0.7 ˚C difference is acceptable. According to the model results, after mixing 10 meters into the sea of waste water has been obtained difference 1˚C. This difference is within acceptable limits as a regard of Turkish Water Pollution Regulation.

ACKNOWLEDGMENT

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