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Air Quality Impact Assessment Studies at Singoli Bhatwari Hydroelectric Power Plant

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Abstract

Air Quality Impact Assessment studies of Singoli Bhatwari Hydroelectric Power Plant are reported. The plant site is connected to the dam site via a road. Computations of concentrations of four pollutants namely Carbon monoxide (CO), Sulphur dioxide (SO_2), Oxides of Nitrogen (NOx) and Suspended Particulate Matter (SPM) have been made at various sites around the plant using CALINE-3 model. Sources considered responsible for air pollution are vehicular traffic on road and construction activities around the plant site. The model was validated with the observed Ambient Air Quality data collected at various sites within a radius of 10 km of the plant site. The results have shown that pollutant concentrations at various places around the plant are well within the ambient air quality standards of these pollutants.
Key words: Air Quality, Concentration, Vehicular Traffic, Model

Introduction

Present study has been made to learn air quality impact assessment of the proposed Singoli Bhatwari Hydroelectric power plant on the air quality of the surrounding areas. The study has been conducted through Air Quality Modeling.

Two sites (Kund and Begubagar) were chosen for air quality measurement. These sites were near the proposed dam and power house location.

Methodology

In this study concentration contribution from the polluting sources has been evaluated by applying mathematical dispersion model. Vehicles are the main source of air pollution at this site. Vehicles are responsible to release gases and also take part in spreading dust particles in air. They have been treated as line sources. Traffic density (Appendix-A, Table 4) was calculated under three categories; two wheelers, light and heavy vehicles. The total number of vehicles plying on the road is 174 for the concerned study period.

Major air pollutants are Carbon monoxide (CO), Sulphur dioxide (SO_2), Oxides of Nitrogen (NOx) and Suspended Particulate Matter (SPM). Input data for the appropriate application of the model include source strength, distance of various receptors from proposed project, meteorological data and turbulence parameters. Acquisition and pre-processing of these data is an important part of this modeling study, since performance of a model greatly depends on the quality of input data. Atmospheric stability measurements were classified according to Pasquill's stability classes of A, B, C, D, E and F, which range from extremely unstable to extremely stable (Turner, 1969).

In the present study, hourly averaged meteorological data (Appendix-A, Table 5) of Wind Speed, Wind Direction, Mixing Height, Temperature and Stability for the period 29/11/06 to 05/12/06 obtained from the study region has been used. The meteorological parameters are converted into appropriate units as required by the model.

CALINE -3 model has been used to compute the concentration of air pollutants at different vulnerable places as shown in **Fig. 1** of the study area. The dotted line shows the road (link) between the proposed Project and Dam site. The model was first validated by comparing the computed values with the observed values at a site where monitoring was also done.

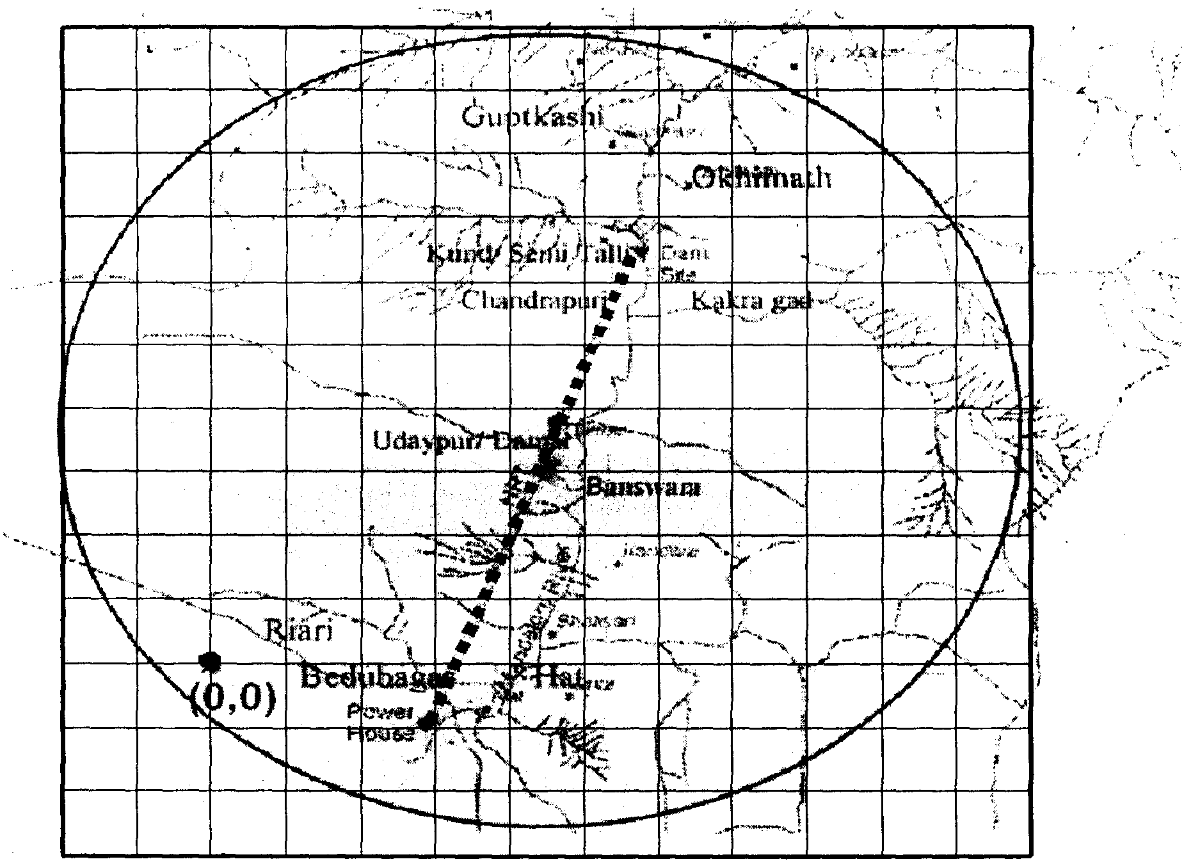

Fig.1: The Circular Grid Study Area

The emission rate of air pollutants on a reasonably straight highway from a continuous line source was determined according to the methods described by Goyal et al., (1999). Emission factors of vehicles have been taken from Table 1:

Table 1: Emission Factors for Vehicles

Emission Factors for Vehicles (g/km-veh)				
Category	CO	NOx	SOx	SPM
Two wheelers	2.4	0.4	0.05	0.05
Light vehicles	0.50	0.025	0.6	0.025
Heavy vehicles	1.4	2.5	2	0.06

The source strengths of air pollutants have been estimated as given in Table2:

Table 2: Source Strength (gm/km)

Category	**CO**	**NOx**	**SOx**	**SPM**
Two wheelers	420	70	8.75	8.75
Light vehicles	87.5	4.375	105	4.375
Heavy vehicles	245	437.5	350	10.5

CALINE 3: The Model

CALINE-3 is a third-generation line source air quality model developed by the California Department of Transportation. It is based on Gaussian diffusion equation and employs mixing zone concept to characterize pollutant dispersion over the roadway (Benson, 1980). The purpose of the model is to assess air quality impacts near transportation facilities in what is known as the micro scale region. Given source strength, meteorology, site geometry, and site characteristics, the model can reliably predict pollutant concentrations for receptors located within 150m of the roadway.CALINE-3 divides individual highway links into a series of elements from which incremental concentrations are computed and then summed to form a total concentration estimate for a particular receptor location. Each element is modeled as an ''equivalent'' finite line source (FLS) positioned normal to the wind direction and centered at the element midpoint. Element size increases with distance from the receptor to improve computational efficiency. Incremental downwind concentrations are computed using crosswind Gaussian formulation for a line source of finite length:

$$C(x, y) - \frac{q}{\pi \sigma_z u} \int_{y_1 - y}^{y_2 - y} \exp\left(-\frac{y^2}{2s_y^2} \right) dy, \qquad (1)$$

where q is the linear source strength, u is the wind speed, σ_y and σ_z are the horizontal and vertical Gaussian dispersion parameters, and y1 and y2 are the FLS endpoint y-coordinates.

For the application of the model each element is divided into three sub-elements: central sub-element and two peripheral sub-elements. The geometry of the sub-element is a function of element size and roadway wind angle. Linear source strengths are computed assuming uniform emissions throughout the element. Emissions for the peripheral sub-elements are modeled as decreasing linearly to zero at the ends of the FLS. The receptor distance is measured perpendicularly from the highway centerline. The first element is formed at this point as a square with sides equal to the width of the highway.

CALINE-3 considers region directly over the highway as a zone of uniform emissions and turbulence. This is designated as the mixing zone, and is defined as the region over the traveled path (traffic lanes—not including shoulders) plus 3m on either side. The additional width accounts for the initial horizontal dispersion imparted to pollutants by the vehicle wake effect. Within the mixing zone, the mechanical turbulence created by moving vehicles and the thermal turbulence created by hot vehicle exhaust are treated as significant dispersive mechanisms (Dabberdt et al., 1995; Eskridgeand Rao, 1983). Evidence indicates that this is a valid assumption for all, except for the most unstable atmospheric conditions (Benson, 1979). Since traffic emissions are released near the ground level and model accuracy is most important for neutral and stable atmospheric conditions, it is reasonable to model initial vertical dispersion (SGZ1) as a function of turbulence within the mixing zone.

CALINE-3 permits specification of up to 20 links and 20 receptors within an X - Y plane (not to be confused with the local x - y coordinate system associated with each element). A link is defined as a straight segment of roadway having a constant width, height, traffic volume, and vehicle emission factor. Its endpoint coordinates specify the location of the link. The location of a receptor is specified in terms of X; Y; Z coordinates. Thus, CALINE-3 can be used to model multiple sources and receptors, curved alignments, or roadway segments with varying emission factors. The wind angle (BRG) is given in terms of an azimuth bearing (0360E).The program automatically sums the contributions from each link to each receptor. After this has been completed for all receptors, an ambient or background value (AMB) assigned by the user is added. Surface roughness is assumed to be reasonably uniform throughout the study area.

Results and Discussion

The predicted values of the concentrations at 10 sites in the area (Figure 1) for the four pollutants namely Carbon monoxide (CO), Sulphur dioxide (SO_2), Oxides of Nitrogen (NOx) and Suspended Particulate Matter (SPM) due to vehicular traffic on the road between hydroelectric power plant and dam site are given in Table 3. Air quality impact of air pollutants at the 10 receptors is shown in Figs.2, 3, 4 & 5. A look at these data shows that Banswara, Kund and Udaypur are the worst affected areas as they are located close to the road that connects the Dam and the Plant.

Table 3 : Model Computed Pollutant Concentrations at 10 Receptor Sites

SITE	CO($\mu g/m^3$)	NO_X($\mu g/m^3$)	SPM($\mu g/m^3$)	SO_2($\mu g/m^3$)
1.SEMI TALLI	2.0	5.0	110.0	5.0
2.KUND	2.4	5.3	110.1	5.2
3.BANSWARA	2.6	5.1	110.2	5.2
4.CHANDRAPURI	2.0	5.0	110.0	5.0
5.UDAYPUR	2.2	5.1	110.1	5.1
6.KAKRA GADD	2.0	5.0	110.0	5.0
7.RIARI	2.0	5.0	110.0	5.0
8.HAT	2.0	5.0	110.0	5.0
9.SITAPUR	2.0	5.0	110.0	5.0
10.SONPRAYAG	2.0	5.0	110.0	5.0

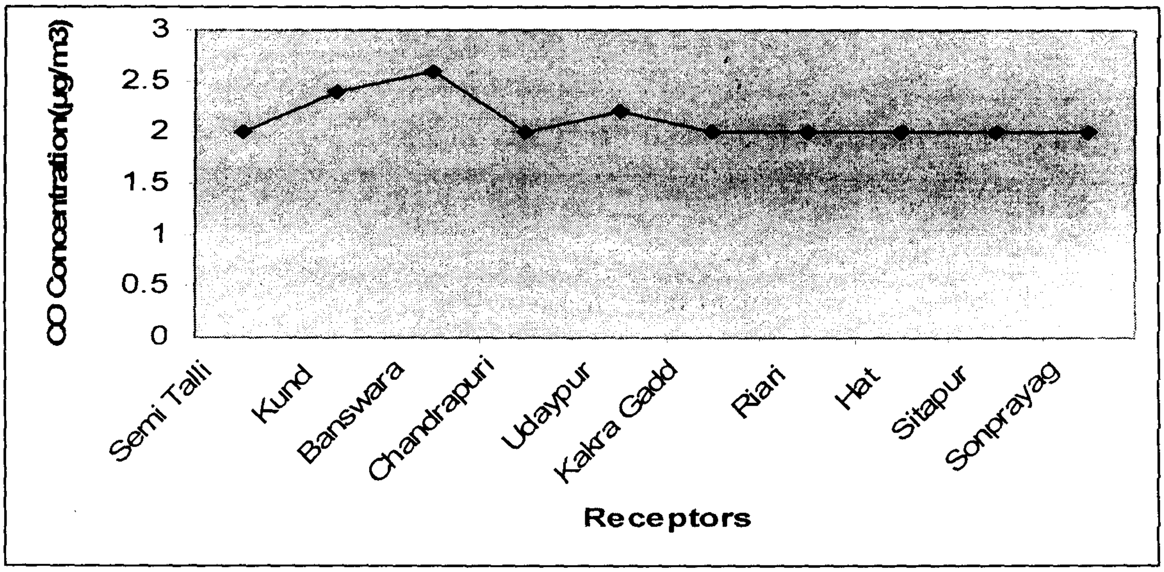

Fig. 2: Impact of CO Concentrations at Different Receptors

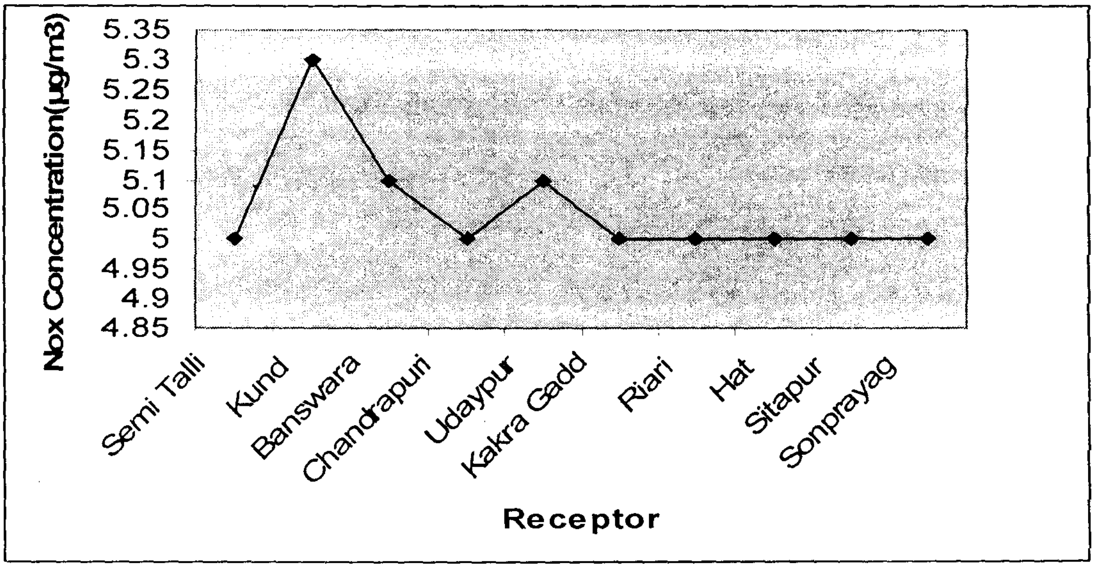

Fig. 3: Impact of NOx Concentrations at Different Receptors

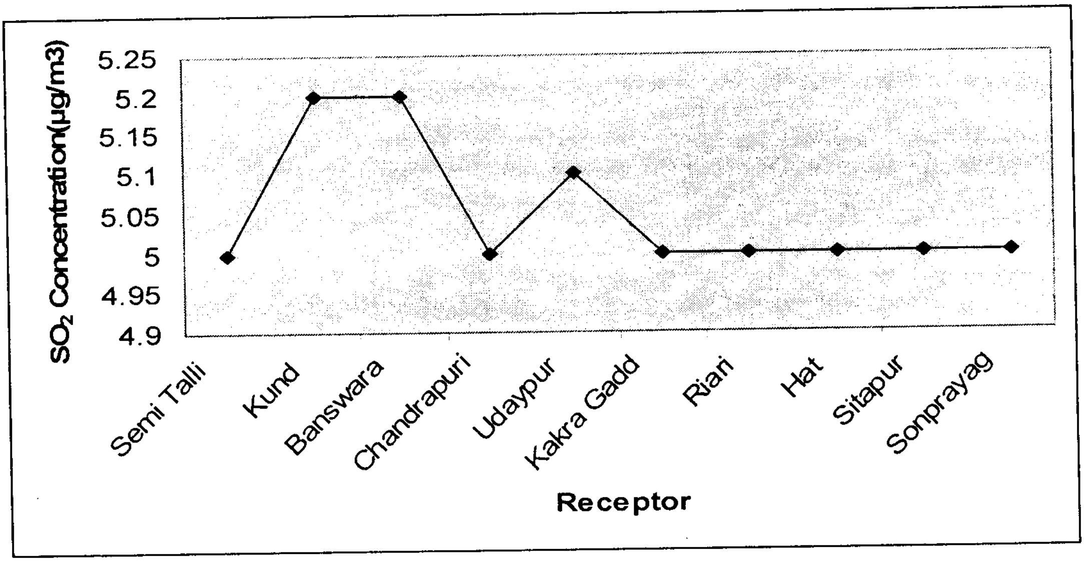

Fig. 4: Impact of SO_2 Concentrations at Different Receptors

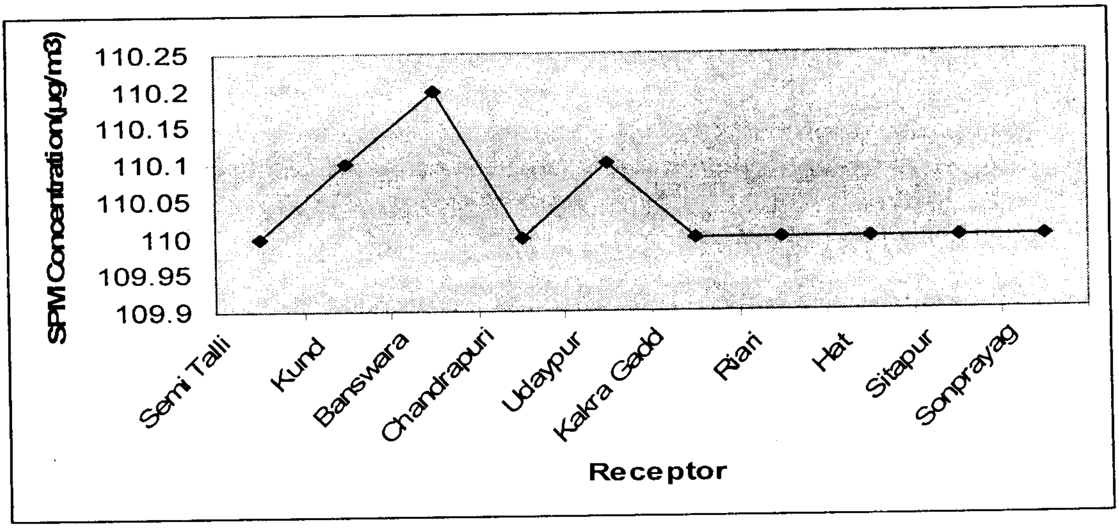

Fig. 5: Impact of SPM Concentrations at Different Receptors

It is to be noted that in case of SPM, while calculating source strength, the influence of ongoing construction activities has also been taken into account apart from emissions due to vehicular traffic, although the average has been taken only for the period during which traffic was plying on the road.

Validation of the Model

The results shown in Figs 2, 3, 4, & 5 reflect that the model predicted values are well within the permissible limits (Appendix-B, Table6). A comparison between predicted and observed concentrations shown in Fig.6 reveals that there are minor variations of predicted values with observed data in case of NOx and SOx, the variations in case of SPM are rather visible (Appendix-B, Table7). The variation in SPM may be due the fact that monitoring is done for a longer duration of time (approx 1000 min) whereas model predictions are based on hourly (60 min.) based meteorological and emission data. Since hourly observed data are not available at the plant site, while doing comparisons, simple arithmetical average values were calculated for the model predicted values and observed data. The comparison of the observed and model computed values thus reflects that choice of the model, pre processing of emission inventory and meteorological data is justifiable, a factor which is important for the present studies to obtain concentration of the pollutants at all the grid points in the study area.

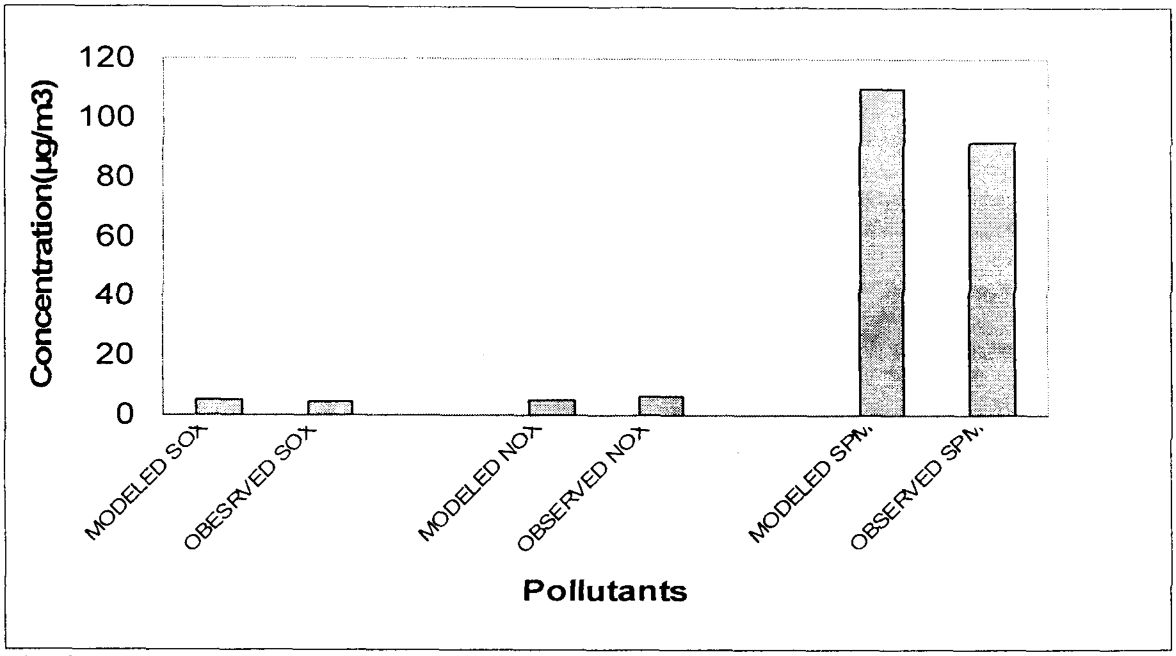

Fig. 6: Model Performance Comparison of Observed and Predicted Concentrations

Conclusions

Air quality assessment of Singoli Bhatwari Hydroelectric Power plant on its surrounding areas has been made using CALINE-3 model. Evaluation of the model performance using the monitored values shows that model is working satisfactorily, which proves that choice of model is appropriate to the requirement of the situation. The preprocessing of emission and meteorological parameters are also being conducted satisfactorily. The computed results show that concentrations of pollutants are well within the prescribed limits and that vehicular traffic on road and construction activities do not have any adverse impact on the air quality of the proposed plant surroundings.

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