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Ambient Air Quality and Health Status during Construction of Hydropower projects in the Hilly Region of Kullu Valley, Himachal Pradesh

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Abstract

The present study is focused on two major hydropower projects Parbati Stage II (800 MW) and Stage III (520 MW) in the Kullu district of Himachal Pradesh. Assessment of ambient air quality on surrounding environment and health status of the local communities were assessed during construction period. The monthly mean TSP concentration from July, 2005 to September, 2007 was 66.4 µg m-3 ranging from 10.7 µg m-3 on October 13, 2005 to 239.7 µg m-3 on January 6, 2007. The monthly mean SO2 concentrations was 2.83 µg m-3 ranging from 0.25 µg m-3 on June 22, 2007 to 9.65 µg m-3 on November 18, 2005. While monthly mean concentration of NO2 is 2.81 µg m-3 ranging from 0.04 µg m-3 on November 18, 2005 to 19.36 µg m-3 on March 24, 2006. Present study unfolds that the ambient air quality were deteriorating and number of patients are increasing due to ongoing construction activities in the region.

Keywords : *Ambient air, hydropower, local community, health, impacts*

Introduction

The traditional sources of energy are not so environment friendly and beneficial for human health. Over a period of time, much concern has been expressed upon increasing amount of carbon dioxide (CO2) in the earth's atmosphere. This is due to excessive burning of fossil fuels and biomass which are considered to be the major sources of air pollution (Gajananda et al., 2005; Kuniyal et al., 2007). Government of India has planned to supply electric power to all households by 2020 (Prasad, 2004). For this purpose, the currently existing three major options for power production are hydro, thermal and nuclear (Sharma et al., 2000). Hydropower plants, except during construction, emit negligible amounts of airborne pollutants mainly methane (CH4) from reservoirs. It can be one of the major substitutes for conventional energy sources. Hydropower projects have some serious negative impacts on its surrounding environment especially during construction period (Sharma et al., 2007). These negative impacts have mainly been reflected in both biotic and abiotic environment. The dust originated from construction activities of hydropower projects coat vegetation during dry seasons and cause risks to health (Singh, 2003). During construction of hydropower projects and related activities considerable amount of ambient air pollution increased. These air pollutants remain in the form of suspended particulates matter (SPM), oxides of nitrogen, sulphur dioxide and hydrocarbons etc. During construction period of hydropower projects, these activities

release dust and pollutants which in due time may cause immediate ill-health impacts on construction workers directly being exposed to the dust. This dust constitutes a variety of particulates matter. A large quantity of dust is transported from one place to other. As a result, human survival becomes difficult due to many respiratory problems in human being. Therefore, the present study was conducted to know the impacts of under construction hydropower projects on the ambient air quality and health of the local community. This is pioneering and unique work conducting during construction period in the mountain environment and based on experimental work, perception survey of the local communities and secondary data related to total registered patients from the Government health department.

Objectives

The objectives of this study were:

1. to present the phyio-climatic status of the study region by calculating metrological data
2. to know the local community perception about ambient air quality and their health status
3. to assess the ambient air quality status, rain water chemistry and to observe air pollution episodes to see external sources for polluting local environment
4. and to assess the health status and prevailing major diseases of the local communities.

Study Area

Kullu district of Himachal Pradesh extends between 30° 20' 25" N to 32° 25' 0" N and 76° 56' 30" E to 77° 52' 20" E. It is bordered in the north by Lahaul and Spiti district, in the south-east by Kinnaur district, in the south by Shimla district, in the south-west and in the north-west by Mandi district. The Kullu valley forms specifically the study region which is intersected almost at centre by 31° 38' N and 77° 60' E. The altitude of the valley ranges from 957 m at Largi to 4038 m at Rohtang crest above mean sea level (amsl). The maximum width of this valley is up to 2 km and length is 80 km (Kuniyal, 2002; Kuniyal, et al. 2004; Sharma et al,. 2007). The present study, however, mainly focuses on the Parbati Stage II (800 MW) and the Parbati Stage III (520 MW) hydropower projects which administratively fall within Kullu district (Fig. 1). Thirty seven villages (25 from Parbati Stage II and 12 from Stage III) of the study area were selected on altitude basis (1120m asl to 2286m asl) in the three sub-valleys (i.e., the Garsa, the Parbati and the Sainj sub-valley) of the Kullu Valley. The drainage area of all rivers and streams of hydroelectric projects under study lies between latitude 31° 40' N to 32° 15' N and longitude 77° 15' to 77° 30' E (HPSEB, 1998).

Data Sources and Research Methodology

The present attempt is based on the primary informations collected through field and perception survey of the local communities surrounding hydropower projects under construction. 37 villages around hydropower projects activities sites were selected for field survey in the Kullu valley. Field survey was conducted with the help of a well structured questionnaire with more than a dozen of questions from the head of the households. The main purpose of the field survey was to know local community observation about the ambient air quality and their health status after introducing hydropower projects in the

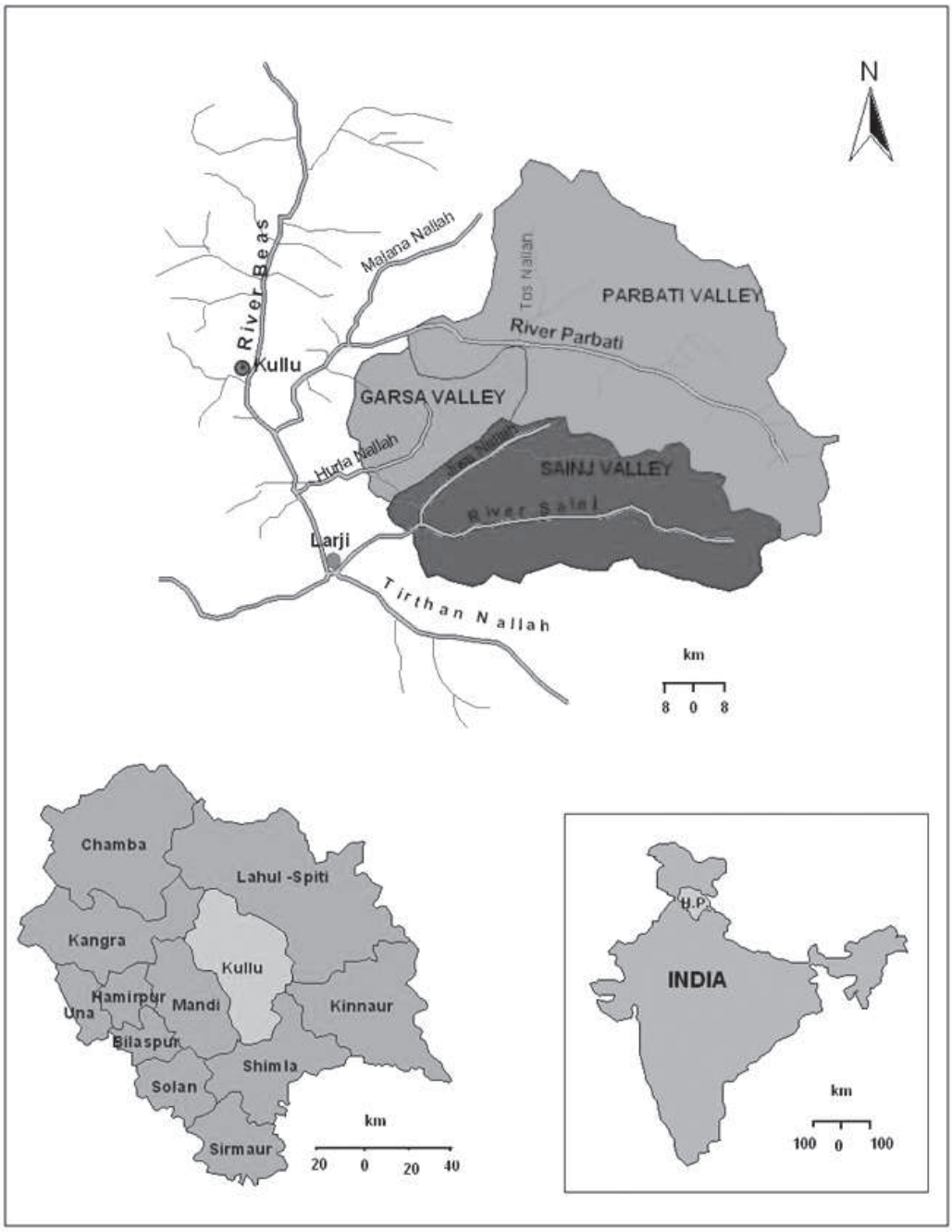

Fig. 1 : Location map of the study area

region. Meteorological data were obtained from Automatic Weather Station (AWS) installed at Mohal, Kullu at the central point of study area. The recording of data was done from January, 2005 to December, 2007 during study period. Ambient air quality was monitored by High Volume Sampler (HVS, APM-430, Envirotech make) which is the basic instrument used to monitor the concentration of suspended particulates matter (SPM) for assessing ambient air quality. The SPM usually ranges from 1 μ to approximately 100 μ in size and may be in ambient air environment in the form of solid, liquid and gases were monitored. Air borne particulate matters were measured by passing air at high flow rate of 1.1 m-3 to 1.7m-3 per minute through a high efficiency Whatman Filter-41 with a gravimetric method. The sampler was operated at least for 24 hours from mid-night to mid-night basis twice a weak. The TSP or SPM was calculated by measuring the mass of collected particulates and the volume of air sampled. Air pollution episodes were also observed to see external sources of pollutants using the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model (version 4) developed by Draxler and Rolph at Air Resource Laboratory, National Oceanic and Atmospheric Administration (NOAA), (Draxler and Rolph 2003). Samples of SO2 were analysed by modified West and Gaeke (1956) method (Potassium Tetrachloromercurate (TCM) method) and samples of NO2 was analysed by Jacob and Hochheiser (1958) method. Rain water quality, was collected on 24 hourly basis near the power house site of Stage II and/ or reservoir site of Stage III at Suind in the Sainj valley. Rainwater was analyzed in the laboratory for measuring pH through pH Analyzer (LI-612, Elico Ltd.), and electrical conductivity (EC) as well as total dissolved solids (TDS) using the TDS Analyzer (CM 183, Elico Ltd.). Rainfall in mm was also calculated manually from these collected samples.

Besides generating primary data through field survey as well as experimental studies conducted for assessing the ambient air quality status secondary sources to support and strengthen the primary informations were also used. Secondary data related health status on prevailing major diseases among the people and number of registered patients in the Parbati, the Sainj and the Garsa valley were collected from the Chief Medical Office, Kullu and Primary Health Centre in the Valley.

Results

Physio-climatic Status

The monthly mean average temperature from January 2005 to December 2007 was calculated as 18.1°C. The highest temperature was recorded as 36.9 ºC in the month of June in 2005 and minimum temperature was 2.3 °C in January 2006. The monthly mean relative humidity varied from one month to other and also from one year to other during 2005 to 2007. The average monthly mean relative humidity was 67%. It was highest (99%) in July 2005 and lowest (24.5%) in September 2007. Rainfall and temperature in different seasons play a major role in determining the level of humidity. The monthly mean wind speed was registered 2.8 km h-1. Highest monthly mean wind speed was registered in the month of September 2006 and minimum 0.1 km h-1 in December 2007. The wind direction shows that monthly mean average

wind blew from south-western direction (i.e., 192.2°). The maximum winds blew from the northwestern direction (i.e., 358.6°) in the month of February 2006 and minimum (calm days) in November 2006 based on three years from January 2005 to December 2007.

Local Community Perception about Ambient Air Quality

In response to a perception survey of the native residents more than 73% of the total respondents around both hydropower projects in the region (78.3% respondents from the Parbati Stage II and more than 56% from the Parbati Stage III) perceived that the air quality has deteriorated alarmingly. At village level, there were more than hundred per cent of the respondents from 15 villages out of the 37 villages surrounding both hydropower projects raised concern about deterioration in ambient air quality due to these projects in the valley. These villages were Jiwa, Tichna, Rumera, Shaindhar, Salga, Kothiari, Shetitol, Saindhar, Bupan, Kalga and Sharaan from the Parbati Stage II in the sub-valley of Sainj of the Parbati Valley. These villages are close to the powerhouse site, reservoir site and in the vicinity of 'Adit IV' and 'Adit V' of the Parbati Stage II where air quality has deteriorated most. More than 75% of the total respondents in the villages such as Saroh, Sharan, Raila and Ghatseri also voiced their concern about air quality. All the respondents in Shalah, Berwa, Soti and Kharora villages located closed to the reservoir site of Parbati Stage III within the distance of less than 1 km observed increase in air pollution due to dust from tunnel boring and other blasting operations.

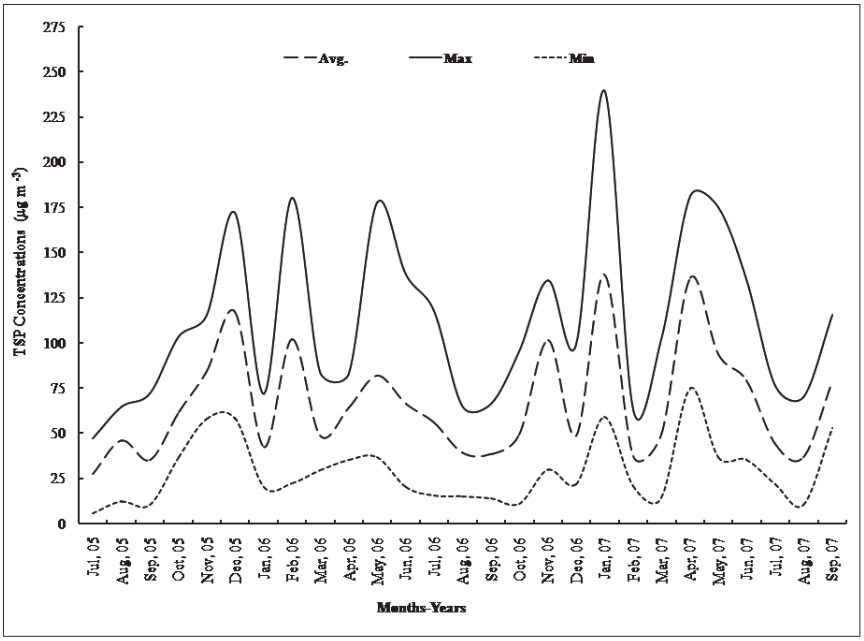

Fig. 2 : Ambient air quality status around the Parbati Stage II and III hydropower projects in the Kullu Valley, Himachal Pradesh

Total Suspended Particulates (TSP)

TSP concentration below 75 µg m-3 varied from one place to other depending on emission sources at a location (Fig. 2). The monthly mean TSP concentration from July, 2005 to September, 2007 was 66.4 µg m-3 ranging from 10.7 µg m-3 on October 13, 2005 to 239.7 µg m-3 on January 6, 2007. TSP concentrations annually varied from one year to other. In 2005, average TSP concentration was 62.5 µg m-3, in 2006 it was 58.03 µg m-3 and in 2007 it increased

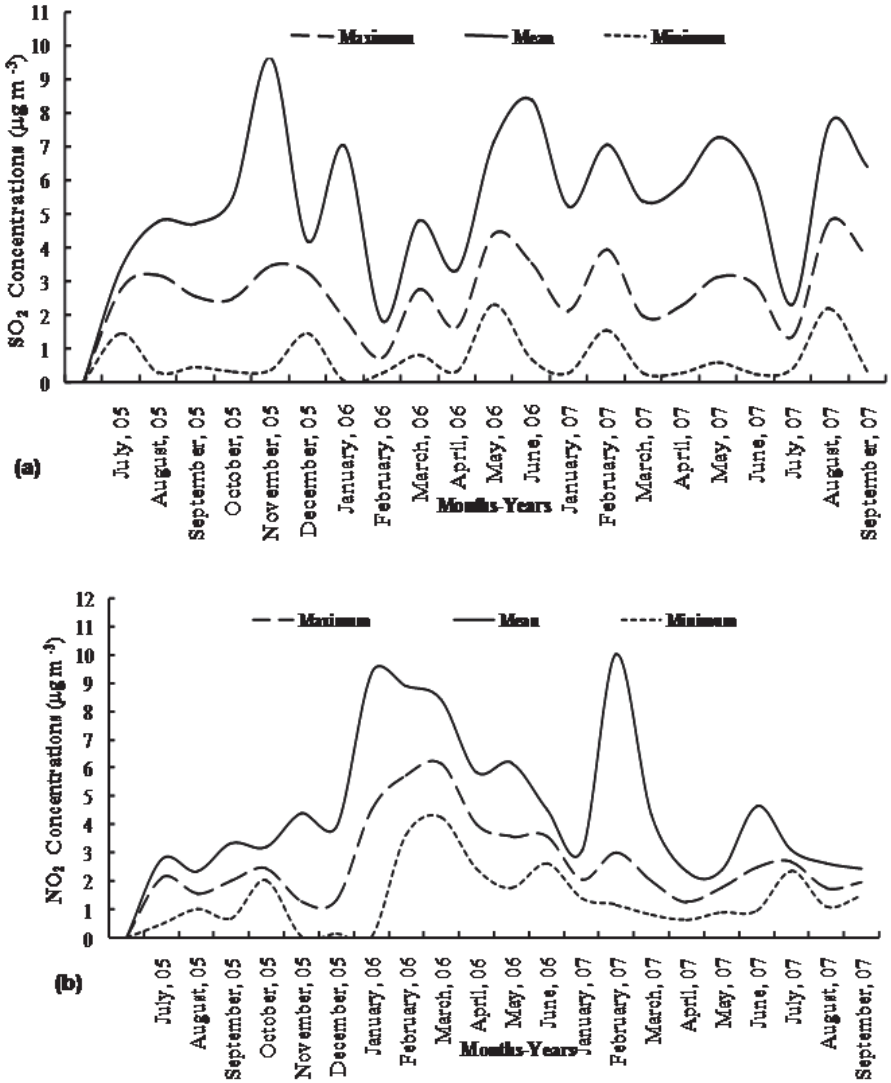

Fig. 3 : Monthly mean (a) SO2, and (b) NO2 concentration (µg m-3) around the Parbati Stage II and III hydropower projects from July, 2005 to September, 2007 in the Kullu Valley, Himachal Pradesh

up to 81.62 µg m-3. While year wise maximum TSP concentration was observed in 2005 with 172.3 µg m-3 (20th December), it remained up to 180.2 µg m-3 in 2006 (4thFebruary). However, in 2007, TSP value was at its highest level with 239 µg m-3 (6thJanuary). The monthly mean, maximum and minimum TSP concentrations are shown in Fig. 3. There were more than 193 exposed 24 hourly TSP samples; which were observed from July, 2005 to September, 2007. Out of these eleven samples (26.8%) in 2005, 24 samples (26.4%) in 2006 and 19 samples (31.1%) in 2007, were identified beyond its permissible limit (i.e., 75 µg m-3 for sensitive area) set under National Ambient Air quality Standards (NAAQS) by Central Pollution Control Board (CPCB) (CPCB, 2007).

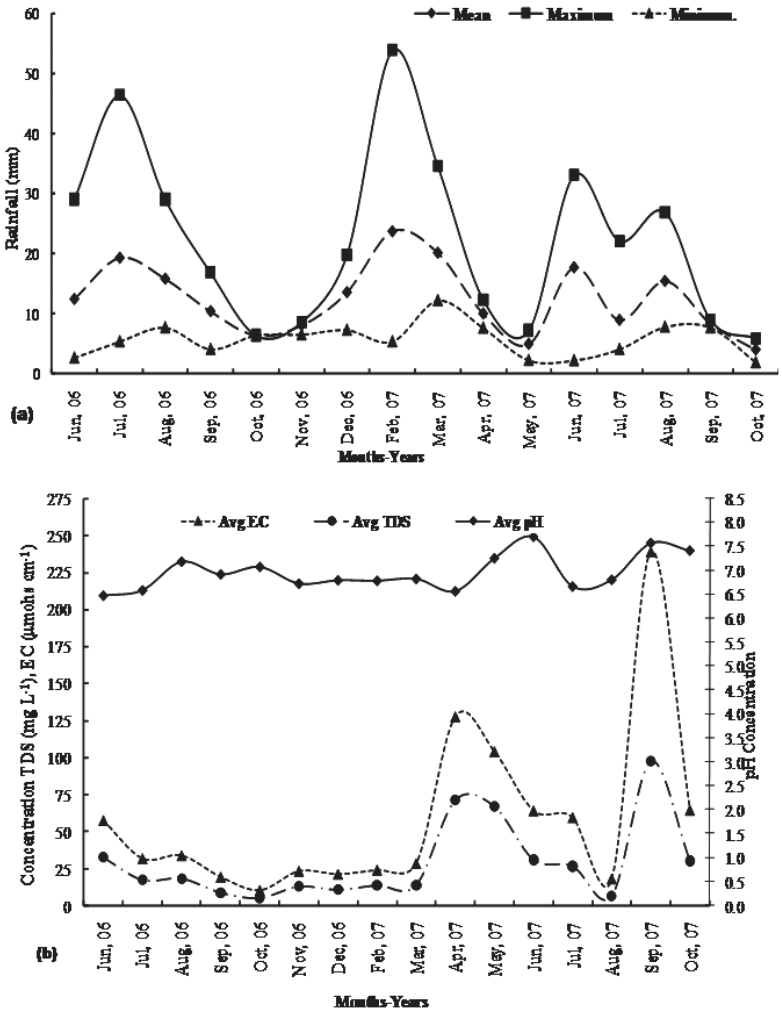

Fig. 4 : (a) Monthly mean, maximum and minimum rainfall, (b) pH, EC and TDS concentrations in rainwater (June, 2006 to October, 2007) surrounding the Parbati Stage II and III hydropower projects

Sulphur dioxide (SO2) and Nitrogen dioxide (NO2) concentrations around hydropower projects

The concentration of SO2 and NO2 has not been analysed for more than six months from July, 2006 to December, 2006 due to technical problems near the powerhouse site of Parbati Stage II and the reservoir site of Parbati Stage III in the Sainj valley (Fig.3a&b). More than 150 numbers of exposed samples were analysed in the laboratory of the Institute at Mohal. The observations show that monthly mean SO2 and NO2 concentrations recorded at the experimental site are within NAAQS given by its regulatory body; CPCB. The monthly mean SO2 concentrations was 2.83 µg m-3 ranging from 0.25 µg m-3 on June 22, 2007 to 9.65 µg m-3 on November 18, 2005 (Fig.3a). While monthly mean concentration of NO2 was 2.81 µg m-3 ranging from 0.04 µg m-3 on November 18, 2005 to 19.36 µg m-3 on March 24, 2006 (Fig. 3b).

Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT)

The five day back trajectories were drawn using Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) from National Oceanographic and Atmospheric Administration (NOAA) to indicate long range transport sources during pollution episodes by airmass. The back trajectories were drawn on four different pollution episode days (i.e., November 18, 2005; December 26, 2005; February 4, 2006 and May 12, 2006) ending at Kartah village near Suind powerhouse site of hydropower project at Parbati Stage II and reservoir site of the Parbati Stage III, at three different heights 1.5, 2.5 and 3.5 km above ground level. The highest ever TSP was measured as ~115.68 µg m-3 on November 18, 2005 when back trajectory was observed coming from the Saudi Arabia at 3500 m asl altitude; at 2500 m asl from Tajikistan and at 1500 m asl from Russia through Siberia Plain (Fig. 4a). The second highest ranking TSP episode was more than 172.26 µg m-3 on December 26, 2005 when the back trajectory was observed coming from Saudi Arabia (2500 m asl) and from Egypt (1500 m asl) through Red Sea (Fig.4b). The third highest ranking TSP concentration was as much as 180.24 µg m-3 on February 4, 2006 when back trajectories were coming mainly from Algeria through Great Indian Desert (Fig.5c). The fourth highest TSP was ~177.62 µg m-3 on May 12, 2006 when five day back air masses seemed to be coming from Algeria (2500 m asl) and Libya and Tunsia passing through Mediteranean Sea which add the existing TSP values in the region (Fig. 5d). It is clear that all these three air masses brought the fine dust coming from this desert regions contributing to pollution episodes along with the local sources like hydropower activities in the region.

Rainfall and its chemistry

Besides studying air quality through particulates and gaseous pollutants concentration, air quality in liquid substances of air surrounding the hydropower projects rainwater was collected and analysed. The total rainfall from June 16, 2006 to October 20, 2007 was 1052.37 mm. The monthly mean rainfall was recorded 14 mm, while maximum rainfall was 53.85 mm on February 2, 2006 and minimum 1.86 mm on October 3, 2007. During a period of 430 days, rainfall days were more than 75 days. The lowest rainfall day was up to 0.5 mm rainfall. The sample wise

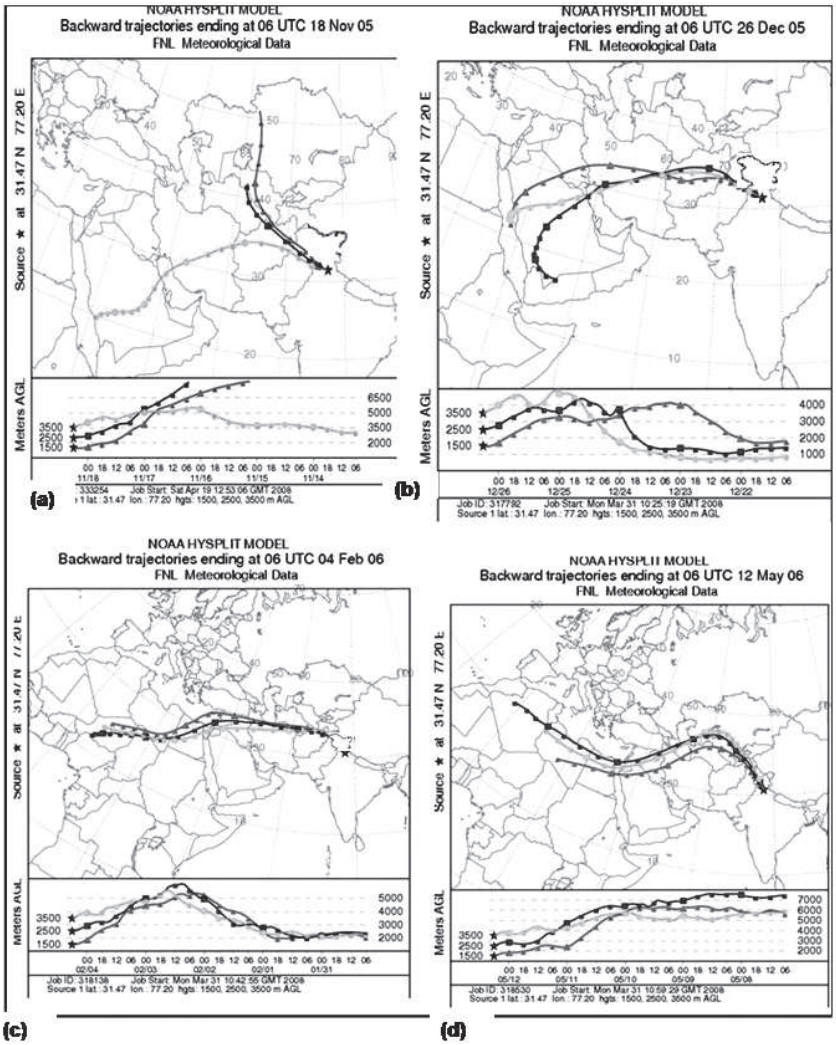

Fig. 5 : Back trajectories using HYSPLIT Model to relate pollution episodes with air masses around the Parbati Stage II and Stage III hydropower projects in the Kullu Valley, Himachal Pradesh (maps are not showing any physical or political boundary)

pH, EC and TDS values are shown in Fig. 6a. On an average, pH was recorded 6.9. The sample wise highest pH value of rain was 8.4 showing alkaline nature on July 01, 2007 and lowest 5.9 indicating acidic nature on March 12, 2007. Acidic pH values reveal that the presence of strong acids in rainwater, while neutral or alkaline pH values are attributed to the effect of soil dust, predominately CaCO3 and MgCO3 and ammonia (Satsangi, 1998; Naik et al., 2002). Fig. 6b clearly reveals that alkaline values of the rainwater are due to dust originating from different construction activities of hydropower projects in the Kullu Valley under present study. The average TDS value

Table - 1 : Number of registered patients in the Parbati, the Sainj and the Garsa Valley (2003-04 to 2006-07)

	2003-04					2004-05				
Classification of the diseases	**CHC Jarri**	**PHC Sainj**	**PHC Garsa**	**Total**	**%**	**CHC Jarri**	**PHC Sainj**	**PHC Garsa**	**Total**	**%**
Dysentery and Diarrhoea	1000	2187	4206	7393	14.92	38	147	170	355	11.18
Eye diseases	489	906	502	1897	3.83	24	62	21	107	3.37
Injury	498	1500	618	2616	5.28	27	113	45	185	5.83
T.B.	9	-	-	9	0.02	2	-	-	2	0.06
Typhoid	-	-	-	-	-	-	-	-	-	-
Respiratory diseases	2644	4215	6110	12969	26.18	124	298	231	653	20.57
Minor operation	110	405		515	1.04	5	-	-	5	0.16
Other	10452	7384	6312	24148	48.74	811	498	558	1867	58.82
Total	**15202**	**16597**	**17748**	**49547**	**100.00**	**1031**	**1118**	**1025**	**3174**	**100.00**
	2005-06					**2006-07**				
	CHC Jarri	**PHC Sainj**	**PHC Garsa**	**Total**	**%**	**CHC Jarri**	**PHC Sainj**	**PHC Garsa**	**Total**	**%**
Dysentery and Diarrhoea	715	1772	3454	5941	11.50	1165	1987	1987	5139	10.24
Eye Diseases	579	535	488	1602	3.10	549	510	510	1569	3.13
Injury	609	0	601	1210	2.34	520	1226	1226	2972	5.92
T.B.	-	-	-	-	-	22	-	-	22	0.04
Typhoid	-	-	-	-	-	7	-	-	7	0.01
Respiratory Diseases	2606	3143	4457	10206	19.76	1920	3531	3531	8982	17.90
Minor operation	80	175	21	276	0.53	74	233	233	540	1.08
Other	12405	11113	8909	32427	62.77	12794	9076	9076	30946	61.67
Total	**16994**	**16738**	**17930**	**51662**	**100.00**	**17051**	**16563**	**16563**	**50177**	**100.00**

CHC=Community Health Centre; PHC=Primary Health Centre; T.B. = Tuberculosis

'-' Indicates nil

in the rainwater was 25.6 mg L-1. It was highest with 98.5 mg L-1 on September 20, 2007 and lowest 3.6 mg L-1 on August 4, 2006. EC values were in a range of 240.2 µmhos cm-1 on September 28, 2007 to 5.60 µmhos cm-1 in July 9, 2006. While average EC value was noted to be 49.2 µmhos cm-1 .

Health status of the local communities

The status of environmental quality also influences the health condition of the residents. The number of registered patients in local health centre in the valley varied from 3174 in 2004-05 to 51,662 in 2005-06. The major prevalent diseases were dysentery and diarrhoea, eye diseases, injuries, tuberculosis, typhoid, respiratory and other diseases like cold, fever and skin diseases. The number of patients suffering from dysentery, diarrhoea and respiratory diseases were high compared to other diseases identified during 2003-04 to 2006-07.

Discussion and Conclusions

Study revealed that villages located surrounding hydropower projects were highly affected adversely due to various types of on-going constructional activities. Villagers also perceived that cough, respiratory diseases, breathing problems, irritation in eyes and noses were increasing due to increasing dust. Visual inspection shows that dust blows around the construction site. As the adverse impacts, the quality and quantity of crops in the fields due to coating of the leaves of vegetation with dust hamper photosynthesis process and cause ill-health problems especially in the residential areas surrounding both the selected hydropower projects in the region under study. The emissions from diesel operating generator sets, bulldozers, crushers, concrete mixers, blasting and plying vehicles on unmetalled roads is mainly responsible for increase in air pollution. The results show that ambient air quality away from immediate construction sites is under control in the rainy season and during off working days. But these values go beyond its permissible limit in dry winter season (January, February, November and December) followed by summer season (April, May and June). The TSP values have remarkably been low during rainy season simply because of washout effect due to rain. A significant positive correlation ($r=1.141$, $P<0.01$) between monthly mean rainfall (mm) and TSP concentration (µg m-3) is observed in the experimental site. Owing to this effect, suspended particulates matter and gaseous pollutants settle down close to the earth surface. On the contrary during summer and dry winter, TSP concentrations remain relatively high. The alkaline values of the rainwater are due to dust originating from different construction activities of hydropower projects in the Kullu Valley under present study. Data for registered patient in various health centre and hospital from 2004 to 2007 indicates that water and air quality in the study region is deteriorating as a result number of patients with respiratory diseases and diarrhoea is increasing. At the same time however, the local communities feel that better and modern health facilities are also available due to hydro projects in the area.

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