SYNOPSIS

Water is of vital importance to all the living creatures and organisms on the earth. Ecological balance and economic development in all the civilizations depend on the judicious utilization of the precious natural resource. Although more than 2/3rd of earth’s surface is covered by water yet only 0.62 % is available in rivers, surface and under the earth’s crust as fresh water, which is suitable for human consumption (Bourmgartner 1975). The water quality of rivers has deteriorated all over the world due to the disposal of huge volumes of effluents. The water quality of Indian rivers has also deteriorated rapidly in post independence era as urbanisation and industrialisation led to discharge of large volumes of untreated effluents and sewage into the rivers. The water quality of the rivers originating in Himachal Pradesh has not deteriorated in the upper areas, as no industrial development has taken place and sufficient dilution and turbulence is available in the rivers in these stretches.

The rapid development of industrial estates and population influx in the lower catchments of the rivers is affecting the water quality and one such River is Sirsa, which is a tributary of Satluj. The River Sirsa originates in lower Shivalik Ranges in the Panchkula (Haryana). The catchment area of the river falls in Doon Nalagarh valley in Solan District of Himachal Pradesh and Kalka Tehsil of Panchkula District of Haryana. More than 50 large and medium scale units and 300 small and tiny units are operating in twin industrial complex of Baddi-Barotiwala in this catchment. More industries are coming up due to special tax holiday extended by Government of India. The wastes being generated from the various types of industries such as pulp & paper, textile dyeing, chemical, beverages, engineering industries and also domestic sewage are being disposed off with or without treatment in the River Sirsa. During the last 10 years, the effluent generation has increased by more than five times in volume and three times in BOD load and the disposal of these effluents have deteriorated the water quality of the river further.

The climate of the area is subtropical. The catchment area is essentially rural in nature and is enclosed by Shivalik ranges on both sides. The top soil characterized by clay-loam with sparse intermix of gravel and sandy-loam with fractured rock is available at relatively deeper strata.
The present work has been undertaken with the aim of studying the impact of industrialisation on the water quality of River Sirsa, in river stretch of 23.0 Km (2.0 Km in Haryana and 21 Km in Himachal Pardesh). Eleven monitoring stations have been selected in the study stretch starting from upstream of Sito Majari Nalla to downstream of Nalagarh Bridge (S1 to S11). The first station S1 is before the addition of any point pollution load and thus the water here is of good quality. The second monitoring station S2 is selected after the confluence of Sito Majari Nalla, the first point pollution load. Two monitoring stations S3 and S4 have been established before the confluence and one S5 after the confluence of Sandholi Nalla, the second point pollution load. Monitoring stations S6 and S7 have been established before the confluence and S8 after the confluence of Housing Board Nalla, the third point pollution load. The S9, S10 and S11 are the last three monitoring stations over a stretch of 15 Km.

The water quality of River Sirsa is being monitored for Dissolved Oxygen (DO), Biochemical Oxygen demand (BOD), pH, Total Coliforms (TC) and Sodium Absorption Ratio (SAR). The analysis of the data set has been carried out for the period from 1997-2002 for annual and seasonal values. Statistical parameters like mean, range (minimum, maximum, median) mode, standard deviation, variance, skewness and kurtosis have been computed. The trends in annual and seasonal values to ascertain the water quality with reference to Use-Classification as per Central Pollution Control Board (CPCB) guidelines for Indian conditions has been analysed. The Use-Classification classifies water from Class-A to Class-E; the Class-A being the water of purest quality and Class-E is of the most polluted.

To assess the temporal and spatial water quality trends, the datasets for the mean annual values is plotted in terms of sequence charts for each of the parameters. The water is of the highest quality and falls in Class-A at S-1. The Sito Majari Nalla discharges domestic sewage and effluents from Barotiwala industrial area into the River Sirsa. At S2 the DO levels drop down to 5.5 mg/l. The BOD levels are in excess of 3 mg/l. The TC levels are in the range of 740 to 2880 MPN/100 ml. The water quality of the River Sirsa thus falls in Class-E. The domestic and industrial effluents from the Baddi industrial area are disposed off through Sandholi Nalla. Thereafter the domestic sewage from the housing board colony and industries established outside the industrial area of Baddi discharge their effluents through Hosing Board Nalla. The river water quality thus deteriorates further. From S4 to S8, DO levels fluctuate from 3.2mg/l to 7.2 mg/l, TC levels continue to fluctuate in the range of 640 MPN/100 ml to 9648 MPN/100 ml, BOD levels are
above 3 mg/l in the range of 4.5 to 28.3 mg/l and the SAR values are in the range of 10.94 to 77.34. The water quality in this entire stretch thus falls in Class-E. The water quality at S11, however, improves as between S8 to S11 over a distance of 15 Km there is no more point load discharge and falls in Class-D. The self-purification effect is visible as DO levels increase and are in the range of 7.1 to 8.5 mg/l, BOD levels decrease and are in the range of 1.8-3.3 mg/l. The water quality also improves in terms of TC and SAR being in the range of 216 to 1132 MPN/100 ml and 6.02 to 15.07 respectively. The similar trends are visible over all the years from 1997 to 2002.

The seasonal data set has also been analysed to assess the water quality trends. The seasonal water quality trends indicate that at S1 the DO is above 6 mg/l, BOD of the river water is less than 2 mg/l, SAR levels are between 0.09 – 0.86 and the TC levels are below 50 MPN/100 ml. The water quality at S1 in all the seasons thus falls in Class-A. From S2 to S8 the DO levels range from 3.5 to 7.9 mg/l, BOD levels are in the range of 1.6 to 53.6 mg/l, the TC levels range from 122 to 13273 MPN/100 ml and SAR is in the range of 4.95 to 77.9 during Spring, Summer and Winter seasons. The water quality over this 6.4 Km of stretch falls in Class-E. During monsoons as there is plenty of dilution, the water quality although improves in terms of DO levels being more than 6.0 mg/l, BOD levels are in the range of 0.3 to 4.8 mg/l, the TC values are in the range of 112 to 606 mg/l and SAR values does not exceed 26 and falls in Class-D. The water quality at downstream of Nalagarh Bridge at S11, which is located 15 Km downstream of the last point pollution load falls in Class-D in all the seasons and has thus improved slightly due to self-purification.

Large variation in the water quality values has been observed due to (i) shock loads from industries (ii) influx of population (ii) variation in runoff and (iv) withdrawal of water from the Nallas from time to time for irrigation and drinking purpose. The water, however, remains unfit for human consumption in the entire stretch. The color of water also is brown which gives very poor aesthetic look.

The Water Quality Modeling for the study stretch has been undertaken for the planning of allocation of waste loads to maintain the river water quality in higher user-designated class. In the last couple of decades number of complex multi-parameter water quality models have been proposed and are finding extensive usage to forecast the pollution levels in natural water bodies. One example of such models is QUAL (Duke,1973) which is one of the versatile models originally developed by the “Water Resource Engineers
Inclusive” for US Environment Protection Agency (USEPA). This model is a deterministic, one dimensional and steady state, being used by the various researchers all over world for quantification and prediction of various parameters of river water quality. QUAL2E is a further improved version of this model developed by Brown et. al. (1985) and has been applied.

The QUAL2E model has been calibrated with the pre-monsoon dataset for the year 2003. The validation of model has been carried out for the post-monsoon dataset of year 2003 and pre-monsoon dataset of year 2004. The efficacy of model has been evaluated by comparing the predicted and observed data’s by applying the statistical techniques. The model has been run for prediction of water quality of river in the year 2005, 2010 and 2020 discharge at 5% flow increase per annum with base year 2000 and for the various BOD concentrations that is at treatment level of 2000, present prescribed standard of 30 mg/l and various lower levels of BOD concentration that is 20 mg/l, 15 mg/l and 10 mg/l to allocate the waste loads. It has been observed that even at the present prescribed standard of 30 mg/l for discharge of BOD in inland surface water bodies, in the year 2005, the BOD load is 748.12 Kg and the water quality falls in Class-E. To maintain the river water quality in User-designated Class-C in all the stretches, the minimum Class of water quality as required as per CPCB guidelines the Total Maximum Daily Loads (TMDLs) discharge to the river should not increase beyond 482.12 Kg/day of BOD. The linear regression model has been presented to assess the incremental increase in river water BOD with increase of point pollution loads for decision making.

The socio-economic impacts of industrial development have been evaluated by conducting a first hand door-to-door primary survey in the main impact area by using a comprehensive questionnaire as per guidelines (Ministry of Environment and Forests, Government of India, 2001) for environment impact assessment. The impacts have been also assessed by analyzing the secondary data collected from various Government and non-Government agencies. It can be concluded that the industrial development in the area have helped in economic growth, but at the same time there is environmental degradation and burden on the public utilities.