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Strategies of Water Quality Monitoring in Western Himalayan Region

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STRATEGIES OF WATER QUALITY MONITORING IN WESTERN HIMALAYAN REGION

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INTRODUCTION

The recent years have witnessed an ever increasing awareness for the impact of human activities on nature. The major thrust has been on the adequacy of the quality and quantity of water for preserving human livelihood and well being. The recent developments throughout the world have led to more restrictive laws on disposal of residual waste materials into water bodies. As a result, the need for detection of certain materials in water, in sediment/soil interacting with water, or as these materials affect aquatic life has increased. A good number of parameters both physical and chemical are able to characterize the quality of water. However these parameters are affected by a large number of natural, climatological, geochemical and biological processes along with the human activities. The human activities are usually a result of use of water or discharge of residual waste in water.

The primary objective of this article is to briefly discuss general strategies to be adopted for monitoring of water quality. Considering the multi facets aspects of water quality monitoring, a unique strategy is not immediately feasible, the paper presents a discussion on which one can elaborate upon to finalize the methodology to be followed in specific cases for achieving efficient and effective monitoring of water quality. The paper relies upon the experience gained through field work in last one year and excellent literature and methodologies suggested by Steele (1971), Rodda (1980), US Environmental Protection Agency, (1975, 1977), Cheremisinoff (1990) and Miller (1981).

OBJECTIVES OF WATER QUALITY MONITORING

The objectives of monitoring water quality in a region can be broadly sub-divided into three cases i) spatial monitoring, ii) temporal monitoring, and iii) accounting monitoring (combination of spatial and temporal monitoring). In spatial monitoring, emphasis is laid on areal assessment of variability in parameters and these serve as a basis for future monitoring of selected variables in long run or serve to pin-point the geographical areas having similar water quality characteristics so that the areal coverage could be reduced in future. The temporal monitoring basically concentrates upon measurement of water quality parameters at limited sites at frequent intervals (daily to seasonal) for fulfilling time trend analysis. Such a monitoring is usually associated with studies which ensure compliance of standards in a water resources system or where assessment of impacts of pollution /

pollution control processes on water quality is required. Whereas accounting type of monitoring, which is a combination of earlier two types of monitoring, is carried out when emphasis is in between defining areal and temporal variability.

MONITORING NETWORK DESIGN

A monitoring network is defined as a set of sites in an area where samples are collected for field / laboratory analysis according to a time schedule, to derive information as per the pre-decided objectives, is necessary as it helps in clear specification of the objectives of the study which in turn decides the frequency of sampling. The general outline for designing a water quality monitoring network should consist of basic considerations on planning, data collection, analysis and evaluation. The planning considerations in designing a water quality monitoring network is essential before start of data collection because it highlights formulation of clear objectives of the study and thereby the strategy to be adopted for data collection.

While designing a network, the most important task is selection of sites since this largely influences all other considerations in the entire water quality monitoring programme. In general, the idea of having large number of sampling sites (more areal coverage) prevails, however, this is only justified to an extent for the administrators or layman (Steele, 1985). From the point of view of scientific study, the due weightage should be given to the frequency and parameters selection at the selected sites. As such, if the objectives of the study and the planning considerations have been taken care of, the selection of sites is then governed by the facts of accessibility and resources availability. In recent times, a large number of water quality parameters have been identified with the reason being increased awareness of ill effects of residual wastes entering into the hydrologic cycle. Thus, the decision on parameters to be monitored in a water quality monitoring network is relatively important. This problem can be solved to an extent by the consideration that several type of functional relationships are available or can be developed for various parameters. Therefore, if the monitoring is being done for surveillance only, the number of parameters can be reduced. Once these decisions have been made, the time schedule and procedures for data collection and laboratory analysis can be worked out.

For analysis of data collected in a water quality monitoring network, use of statistical methods can be used to make recommendations on screening of data, setting up priorities for site selection, parameters selection and sampling frequency selection. These methods may not necessarily reflect the causes of observed values, neverthless these can certainly provide probable reasons for the causes. The analysis of data can also guide on addition / deletion of certain sites, parameters or even frequency of sampling because the analysis may provide that with reasonable errors for given use of the results to be made, the number of sites or the number of parameters or the frequency of sampling

being followed is not required.

To illustrate upon the strategies for monitoring of a water quality network, a few case studies carried out are presented with brief results. The importance of design considerations has been highlighted and the outline of a few proposed studies are also provided.

GROUNDWATER QUALITY MONITORING FOR JAMMU AND KATHUA DISTRICT

Under the spatial monitoring category, groundwater samples from 53 wells spread over in Jammu and Kathua Districts (Figure 1) were collected for monitoring of groundwater quality in the year 1993-94. Various physio-chemical parameters of water quality were determined in field and laboratory for examining suitability of water for drinking and irrigation purposes for two years (Omkar et al 1996). The sampling was carried out initially in summer, winter and rainy seasons. Since the values of various parameters were well within the permissible limits, in 1995-96, the number of sites was subsequently reduced to 37 and the sampling was limited to pre-monsoon and post-monsoon periods only. The details of chemical analysis carried out are presented in Table 1. In Jammu district wells, calcium hardness, bicarbonate and chloride concentration are increasing in post monsoon season in comparison to pre-monsoon while other parameters are nearly at the same level. On the other hand, in Kathua District wells, calcium hardness and chloride concentrations are higher during post-monsoon season as compared to pre-monsoon values (Table 1). Increasing trend of calcium hardness, bicarbonate and chloride concentration during post monsoon season indicates higher amount of groundwater recharge from rainfall. Fluoride concentration is also within the permissible limit.

WATER QUALITY STUDIES IN BALAL NALA

The Balal nala draining water and waste water of the industrial township of Jammu (Figure 2) carries large amount of foul smelling industrial effluent. During the preliminary visits, it was observed that their are a few wells / tubewells / handpumps located nearby to the banks of the nala and this water is used by local people. It was, therefore, planned to carry out temporal monitoring of the water quality in the nala and the adjoining wells. In this context, detailed field survey of the Nala cross-sections and wells location were completed in the first phase. On the basis of survey, 5 wells were selected within the 500 m distance of present stream course. To monitor the contamination in ground water wells due to effluent flowing in the stream, monthly sampling have been carried out from the selected wells and Balal stream for chemical analysis. The pH, Electric conductivity, Temperature, Total Dissolved Solids, Hardness, Alkalinity, Sodium, Potassium, Carbonate, Nitrate, Phosphate, Sulphate and Chloride parameters have been analyzed in the collected samples. For the trace elements analysis, the work is in progress. A questionnaire survey was conducted to identify the health problems of the people who are using water from wells for domestic and irrigation purposes.

trace elements = 9

The monthly variation of chemical parameters in Balal Nala is presented in Table 2. The Hardness of nala water is varying between 192 mg/l (October) to 284 mg/l (November) while in wells it is 126 mg/l (June) to 406 mg/l (July). The concentration of major cations calcium, magnesium, sodium and potassium ranges between 52 to 93 mg/l, 13 to 54 mg/l, 7 to 136 mg/l and 1 to 8 mg/l respectively and in wells these cations occurs between 41 to 161 mg/l, 6 to 54 mg/l 25 to 104 mg/l and 0.7 to 7 mg/l, respectively. In the wells, calcium and magnesium are in higher amount in comparison to maximum limit of Indian Standard Specification for drinking water. Like major anions bicarbonate, chloride, sulphate, phosphate and nitrate in wells are varying in wide range during different months as in Nala. Wide range of variations in these cations and anions as in Nala may be due to contamination from Nala.

WATER QUALITY STUDIES OF MANSAR LAKE

Mansar Lake, situated near Jammu (Figure 3) and famous as a tourist spot, is also known for its aquatic animal life. In the beginning, quarterly samples were collected from the surface of lake through boat at different locations using grab method. Various physio-chemical parameters e.g. Temp., pH, Ec, TDS, Ca, Mg, K, Na, Nitrate, Phosphate, bicarbonate, Sulphate, Chloride, DO and Hardness were determined following standard method. In general, the parameters are within the ranges prescribed. Further, to investigate depth-wise variation in chemical parameters, the sampling was carried out at various depths during 1996-1997. The pH values in the lake at surface is varying between 8.3 to 8.7, revealing that lake is alkaline in nature. Other chemical parameters are varying within the Indian Standard specifications for drinking water and variation of concentration in different months are very less (Table 3) while depthwise variation in chemical parameters are very significant. Calcium hardness, chloride and sulphate are showing decreasing trend from surface to bottom. On the other hand sodium, bicarbonate and nitrate are in increasing order. Variation of these parameters within the lake is mainly controlled by the geology of lake catchment and hydrodynamics of lake. Variation of dissolved oxygen and temperature with depth reveals the hydrodynamics of the lake. Table 3 also reveals that lake remains stratified in non winter months (March to November) and it becomes homogeneously mixed in winter months (December to February). Recently, the phenomenon of sudden death of fishes was noticed in the lake. This has attracted attention of various agencies but no satisfactory explanation is yet available. During the visit by the staff of NIH it was noticed that apart from sudden death of the fish in the lake, their was heavy amount of a oily/greasy dirty layer on the lake surface. Though quite a many reasons like inflow of insecticides/chemicals from nearby agricultural fields and homogeneous mixing of lake have been put forward, a suitable explanation is still not available. Owing to these facts a full fledged study on Mansar lake is being proposed to look into all of these aspects.

CONCLUSION

The environmental degradation due to anthropogenic activities usually results into pollution of surface and groundwater. The monitoring of water quality parameters of ground water as well as surface water needs a specific strategy because it requires time and energy. Within the specified time and with limited resources to cover whole system, few base guidelines are proposed to cover easily the entire system according to the areal and temporal coverage needed. In each type of coverage, the sampling frequency and water quality parameters can be selected according to objectives of the study. Three case studies, namely, ground water study in Jammu and Kathua District, Mansar lake and Balal Nala studies represents the spatial, temporal and accounting monitoring, respectively. On the basis of the results of these studies it can be inferred that more such studies should be taken up. The results of Mansar lake have created need for hydrodynamic and water balance studies. In addition it is also required to prepare inventory of watre bodies in the region along with details of kind of polluting agents, if any.

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Table 1 : Variation of chemical parameters in the wells of Jammu and Kathua District.

Parameter	Jammu						Kathua					
	Pre-monsoon			Post-monsoon			Pre-monsoon			Post-monsoon		
	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
pH (6.5-8.5)	8.1	9.1	8.5	7.4	8.2	7.8	6.7	8.0	7.4	6.6	7.8	7.2
Temp. ^{0}c	23	27	25	18	26	22	23	28	25.5	19	23	21
Ec	480	3600	2040	470	4780	2625	360	2880	1620	410	2470	1440
TDS (500mg/l)	337	2268	1303	305	2663	1484	231	1668	950	216	1537	877
Hardness (300 mg/l)	140	362	251	242	1250	746	118	630	374	110	966	538
Ca^{++} (75 mg/l)	6	94	50	32	449	240	6	183	95	31	356	194
Mg^{++} (30 mg/l)	13	56	35	5	51	28	5	72	39	10	19	15
Na^+	4	81	43	4	47	26	5	277	141	5	118	62
K^+	0.2	250	125	0.2	200	100	1.1	132	67	1	132	67
HCO_3^-	162	672	417	110	946	528	108	722	415	122	526	324
Cl^- (250 mg/l)	0	370	185	0	776	388	6	204	105	0	284	142
SO_4^{--} (150 mg/l)	7	250	128	7.0	345	176	8	173	91	11	173	92
NO_3^{--} (45 mg/l)	0	20	10	0	19	9	0	66	33	0.1	67	34
PO_4^{--}	0	0.5	0.25	0	0.48	0.24	0.03	0.5	0.4	0.03	0.3	0.17
F (0.6-1.2 mg/l)	0	1.0	0.5	0	1	0.5	0	1.0	0.5	0	1.0	0.5

Table 2 : Variation Of Chemical Parameters In The Balal Nala And Adjoining Wells.

Parameter	June		July		September		October		November	
	Nala	Wells	Nala	Wells	Nala	Wells	Nala	Wells	Nala	Wells
pH (6.5-8.5)	7.86	7.7-8.3	7.3	8.02-8.31	8.18	6.6-8.4	8.33	7.6-8.4	7.71	7.3-8.00
Ec	1110	920-1540	1150	860-1920	1050	780-1400	1030	730-1360	1060	900-1170
Hardness (300mg/l)	200	126-318	230	114-406	216	130-204	192	156-312	284	210-428
Ca^{++} (75 mg/l)	72	84-88	52	42-122	63	27-67	53	41-82	93	71-161
Mg^{++} (30 mg/l)	44	22-37	24	32-54	15	9-23	15	14-26	13	6-30
Na^{+}	88	25-74	7	32-76	68	28-110	136	28-104	120	29-104
K^{+}	8.0	0.7-3.0	18.5	1-6	6	2-6	11	1-7	6	2-7
HCO_3^{--}	302	274-424	196	298-460	280	223-390	228	266-368	384	230-464
Cl^{-} (250 mg/l)	102	28-162	12	30-152	46	16-194	30	22-208	130	18-162
SO_4^{--} (150 mg/l)	31.8	14-25	155	20-30	39	20-36	190	21-36	82.7	20-30
NO_3^{--} (45 mg/l)	0.3	0-1.4	0	0.1-7.5	0.20	0.2-9.0	3.0	0.1-7.0	1	1-7
PO_4^{--}	0.06	0.03-0.06	0.05	0.01-0.16	0.06	0.02-0.40	0.06	0.06-0.40	0.22	0.04-0.16
F (.6-1.2mg/l)	0.44	0-0.77	0	0-0.4	0.22	0-0.2	0	0-0.3	0	0-0.5

Table 3 : Variation Of Chemical Parameters In The Mansar Lake Near Jammu.

Parameter		At Surface		At Various Depth		
	Min.	Max.	Av.	Surface	Middle	Bottom
pH (6.5-8.5)	8.3	8.7	8.5	8.5	7.7	7.6
Temp. ^{0}c	24.1	26.7	25.4	26.7	16.3	13.0
Ec	210	210	210	217	323	313
TDS (500mg/l)	133	144	139	141	209	197
Hardness (300 mg/l)	62	76	69	76	115	100
Ca^{++} (75 mg/l)	16.0	20.0	18.0	18.0	33.0	29.0
Mg^{++} (30 mg/l)	4	7	5.5	8	8	7
Na^+	9	13	11	9	12	11
K^+	2	4	3	3	3	3
HCO_3^{--}	76	80	78	82	124	118
Cl^-(250 mg/l)	2	6	4	10	7	6
SO_4^{--} (150 mg/l)	0	38	19	21	12	4.5
NO_3^{--} (45 mg/l)	0	0	0	0.03	0.03	0.05
PO_4^{--}	0	0.04	0.02	0	0	0

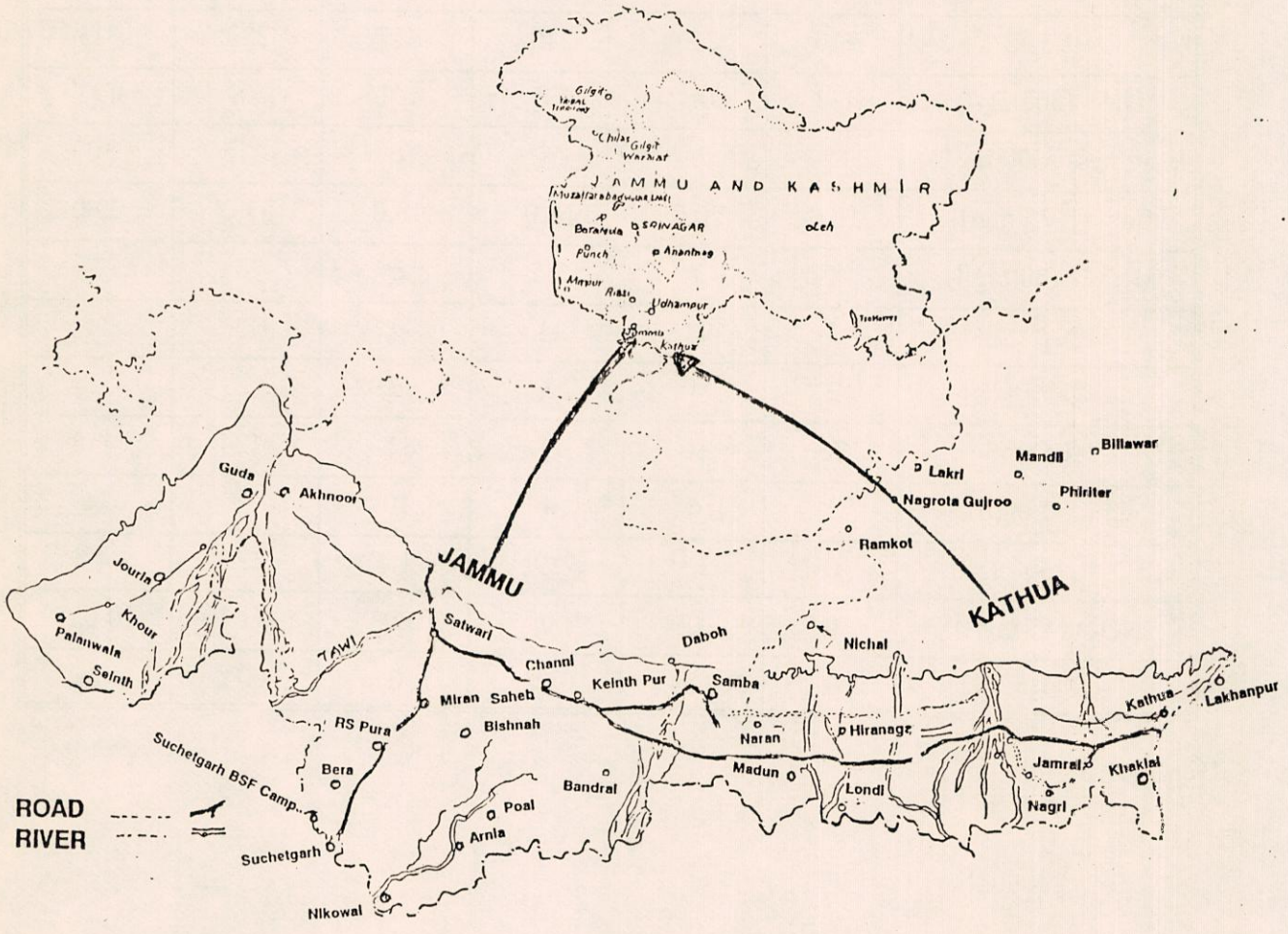

Figure 1. Location map of the wells selected from the Kathua and Jammu Districts.

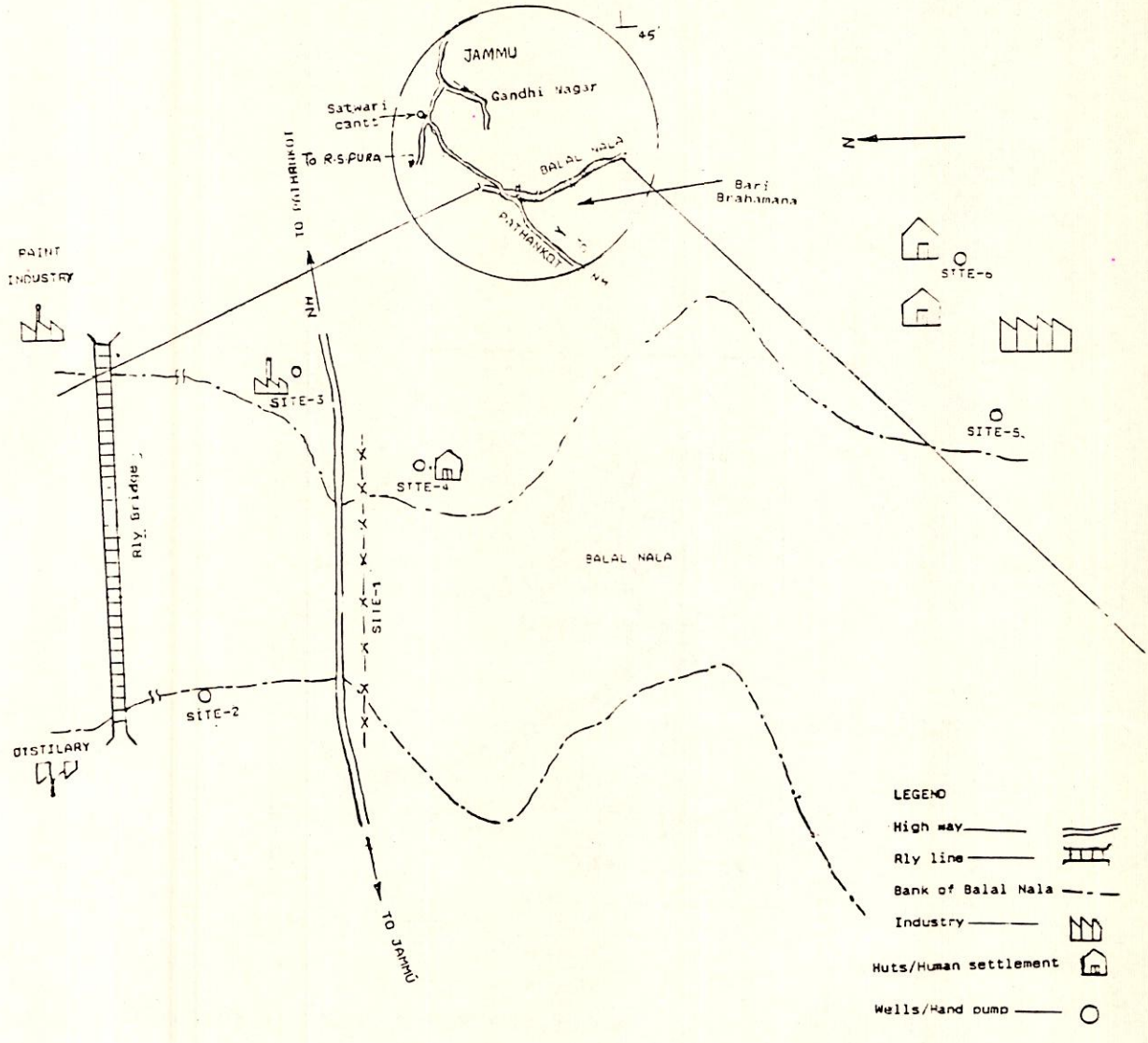

Figure 2. Location map of the Balal Nala sites.

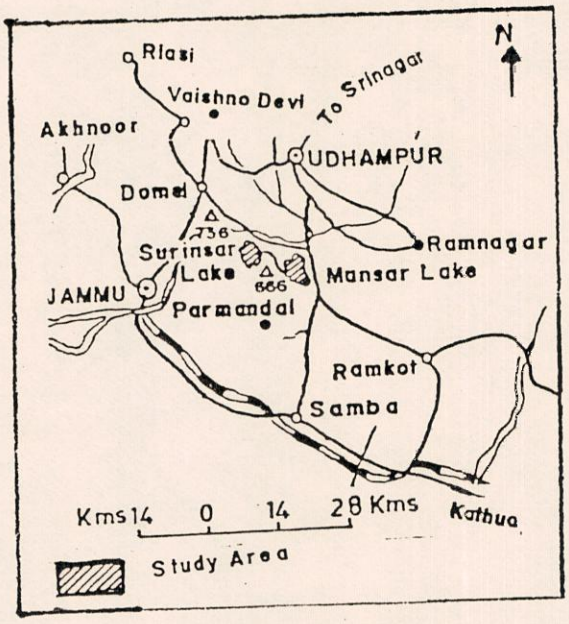

Figure 3. Location map of the Mansar Lake in District Jammu.