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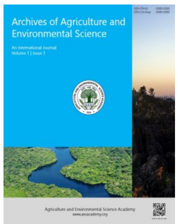

ORIGINAL RESEARCH ARTICLE

Impact of tourism on water quality characteristics of Lidder Stream at Pahalgam, (J&K), India

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ABSTRACT

The present study was conducted to assess the impact of touristic activities at Lidder stream in Pahalgam, (J&K), India. The main reasons for the deterioration of the water quality of Lidder stream are increase in tourist flow, which increases the concentration of nutrients due to sewage disposal, bathing and washing in the vicinity of the stream. The physico-chemical analysis shows variations in most of the water quality parameters such as pH changes gradually, whereas EC, F.CO_2, BOD, Cl^-, NO_3^-N, NH_4^+N, OPP, TA and TP increased, while DO decreased. The water of Lidder stream serves domestic, agriculture, irrigation and other commercial sectors (including hotels at Pahalgam), which have a directly impact on the water quality of Lidder stream. It is contingent from the present study that pollution load due to tourism increased.

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INTRODUCTION

Perched securely among the lofty snow-sprinkled mighty Himalayan mountain chain, the emerald blue skies peeping through the chinks of the clouds, the tall Chinar trees swaying to the rhythm of the gusts of wind, all condense into a kindly smile, forming the lovely state of Jammu and Kashmir (Rashid and Romshoo, 2013). The tall mountains that surround the valley rising up to 16,000 feet ensure that the weather here is pleasant for most of the year and attract tourists from all over the world. But according to present scenario due to overpopulation, rapid soil erosion, inadequate tourism management and intensive deforestation have caused major destruction of environment. The alarming situation has aroused in the urban areas due to careless disposal of industrial waste and faulty drainage system that has badly affected the environmental quality and tourism industry. Although, tremendous work has been done on the various aspects of the Pahalgam, but hardly any information is available on the impact of tourism on the Pahalgam valley (Rashid and Romshoo, 2013).

Tourism has emerged as one of the most important segment of the world economy. It is a major activity not only for developing countries but also for most developed countries. Today tourism is one of the world's largest industries. Tourism has emerged as one of the chief industries in the world economy over the last Decade. Its total contribution comprised of 9% global GDP (US $6.6 trillion) and generated over 260 million jobs, 1 in 11 i.e. 10% of new job creation in the world's total job market. Tourism industry showed faster growth than other notable industries such as manufacturing, financial services and retail (WTTC, 2013). Tourism can be a major tool for economic development but, if not properly planned, it can have destructive effects on biodiversity and pristine environments and can result in the misuse of natural resources such as freshwater, forests and marine life (Rabbany *et al*., 2013).

The Lidder or the "Yellow" stream is formed by two mountains torrents which flowing from the north and north east, unite near Pahalgam and flow rapidly over the big boulders with milky color. Lidder stream comprising two streams flowing from Kolhoi Glacier and Sheshnag Lake make confluence at Nunwan. The stream is rich with indigenous brown trout fish attract the Anglers throughout the world. Rafting in Kolhoi Nallah is a charming activity of adventurous tourists. The Lidder valley opens into the south east end of Kashmir valley, giving passage to the Lidder stream. It extends in the northerly direction from near Islamabad to Pahalgam, a distance of about 35 km. At Pahalgam, the valley divides into defiles, which stretched obliquely, one towards the north-west towards the Sindh valley and one can foot the distance from Pahalgam to Sind valley following the course of the Lidder water stream, the other towards the north-east leading up to Sheshnag on the sacred Amarnath cave. Lidder stream serves as a drinking water source to a huge population lying in its catchment. Besides, Lidder stream is important for agriculture as it serves as a source of irrigation for the same. The stream also harbours rich resource of fisheries particularly brown trout. Hence, the stream is socioeconomically important for the population in its catchment (Rabbany *et al*., 2013; Rashid and Romshoo, 2013).

Lots of recreational activities are on the offer in Pahalgam, such as horse riding, golf and fishing**.** The Lidder stream has excellent fishing beats for brown trout. The fishing season stretches from April-September. Fishing equipment can be hired in Srinagar. Live baits and spinning are not allowed for permits contact the Directorate of Fisheries, Tourist Reception Centre, Srinagar. The environment of Pahalgam offer exciting trekking opportunities, the best know are Pahalgam- Chandanwari-Sheshnag-Panchtarni-Amarnath cave temple-Sonnamarag trekking can be undertaken as the 35 km trailed traverses through pine woods to the spectacular Kolahoi Glacier which is very beautiful via Aru village a charming meadow. Pahalgam originally a sphered village is naturally known for products made of wool, Gabbas and Namdas can be purchased from Local shops (Rabbany *et al*., 2013; Rashid and Romshoo, 2013).

The most important tourism resources are the natural beauty of the place, their distinctive or exotic character, their recreational possibilities and the cultural interest of the people. The hotels, resorts, transportation networks, recreational facilities and other tourism infra-structure can complement but never completely replaced the dependence on environmental resources (Aggarwal and Arora, 2012). The disadvantages of haphazard and unplanned development of tourism are well illustrated by many areas of the world. Similarly Pahalgam valley in Kashmir is facing environmental problems (Kumari *et al*., 2013; Rashid and Romshoo, 2013). Keeping in view the varied dimensions of the proposed problems, the present study has been carried out to study the tourist flow in the Pahalgam valley during study period and to assess the impact of tourism on the surfaces water of Lidder stream at Pahalgam (J&K), India.

MATERIALS AND METHODS

Study area: Present study was carried out at different sampling sites located nearby Lidder valley, Anantnag (J&K) India in order to record the physico-chemical parameters of water quality of Lidder stream (Figure 1). The following sites were selected for the present study:

Site I: - Aru village; Site II: - Outer Pahalgam; Site III: - Inner Pahalgam

Climatic variables: The state of Jammu and Kashmir including Ladakh is peculiar, in having a varied climate. The variability in climate in these diverse territories of the state is so marked than even for a small area, it is not possible to depend on the averages for purposes of the study of climate conditions. The weather in Pahalgam is alpine. Summers (April-June) are mild while winters (November- February) are cold. The temperature in the summer months reaches as high as 25^0C and the temperature in winter goes as low as -10^0C.This is because the valley is located at an altitude of 2130 meters above sea level and is covered by dense forests. More over the Lidder River also influence the climate of Pahalgam and keep it moderate in hot summer. In Pahalgam one needs light woollen clothes even in summer and heavy woollen clothes in winter. Pahalgam receives the large amount of precipitation in the form of snow which is also a mark of attraction for adventurous tourist and those who enjoys the games of skiing and skating. Summer is the best in Pahalgam valley. However, the place can be visited during the annual Amarnath yatra in July-August.

Water quality analysis: The impact of tourism on water quality of Lidder stream is assessed mainly through the physic-chemical study of water quality because it is an outstanding indicator of human utilization of the ecosystem. Tourism data were acquired from Jammu and Kashmir Tourism Department to analyse the seasonal variation in tourist flow. Tourism data were correlated with water quality results in order to assess the impact of tourism on water quality. Present study was carried out at different sampling sites located nearby Lidder valley, Anantnag (J&K) India in order to record the physico-chemical parameters of water quality of Lidder stream.

Three water sampling sites were taken along the length of the river for physico-chemical analysis. The physico-chemical characteristics of water have been monitored on monthly basis. The surface water samples were collected 10.00 am to 1.00 pm from each of sampling sites in one liter plastic bottles for the laboratory investigations. The parameters including air temperature (AT), water temperature (WT), pH and electrical conductivity (EC) were analyzed on the spot, while the rest of parameters such as total alkalinity (TA), free carbon dioxide ($F.CO_2$), chloride (Cl^-) dissolved oxygen (DO), biological oxygen demand (BOD), Nitrate nitrogen (NO_3^-N), ammonical nitrogen (NH_4^+N), orthophosphate (OPP) and Total Phosphorus (TP) were determined in the laboratory within 24 hours of sampling. The analysis was done by adopting standard methods of APHA (2012).

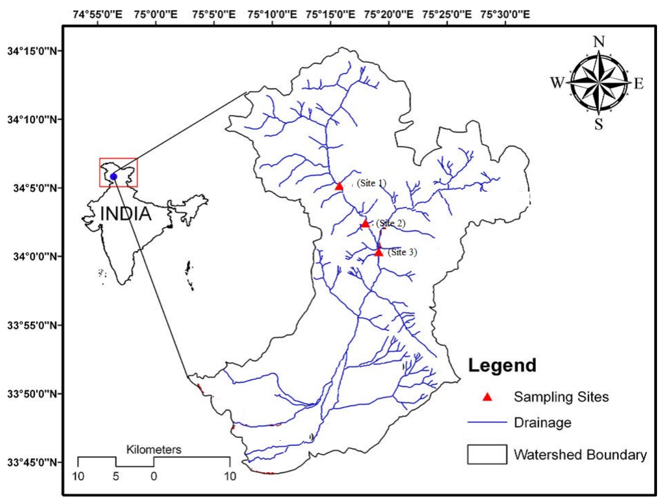

Figure 1. *View of drainage system at Pahalgam and study sites.*

Statistical analysis: All the data obtained subjected to statistical analysis. In statistical analysis, a correlation developed between tourist flow and parameters by using Karl Pearson's coefficient of correlation for data analysis of Lidder stream water to measure the variations between Site I, Site II and Site III parameters. MS Excel, 2013 was used to measure the Mean and Standard deviation (SD) of the data.

RESULTS AND DISCUSSION

The Mean±SD values of various physcio-chemical characteristics of different sites of Lidder valley were given in Tables 1-4. Results assess the variation in physico -chemical characteristics which are of paramount importance for accessing the quality of water, which may be influenced by tourism in the river. The findings of the present study are described as follows.

Temperature is one of the most significant characteristic that influence nearly all the physical, chemical and biological characteristics of water and thus the water chemistry. It never remains steady in rivers due to varying environmental conditions (Kumari *et al*., 2013). Change in air temperature naturally affects the water temperature and cause thermal variations in water.

In the present study minimum WT (5.60 ^{0}C) were recorded at Site (I-II) and maximum WT (6.40 ^{0}C) was recorded at Site III. Lower temperature was recorded in January, while higher was recorded in May. This may be due to change in air temperature, which naturally affects the water temperature and cause thermal variations in water. Khan *et al.* (2012) reported minimum air temperature was recorded in the month of January, with the lowest recorded temperature as (2.12^{o}C) at site A, while as the maximum in the month of July, with the highest 35.42^{o}C at site C. Overall the temperature was high in summer and low in winter on an average. There was a moderate increase in temperature while moving downstream of the river Jhelum at J&K (India).

During the present study gradual increase (7.30-7.81) in pH from Site (I-III) was related to increasing pollution pressure resulting because of tourist and agricultural activities in the catchment of Lidder valley. A similar result for pH (7.50-7.83) was recorded by Khanna *et al.* (2008) in the water of stream Nalhota at Guchupani, Dehradun (India) due to the effect of touristic activity. Chauhan *et al*. (2016) also recorded an increased pH (6.88-7.90) in the water of Mansar lake, (J&K) India due to activities of tourism like boating and fishing.

The EC is measured to assess the total nutrient level of media and used to indicate the tropic status of the water bodies. In the present study maximum EC (127µs/cm) was recorded at Site III, while minimum EC value (108.80 µs/cm) recorded at Site-I. The present study was in accordance with Rashid and Romshoo, (2013) who reported EC (90-130µS/cm) in water quality of Lidder River at Kashmir Himalayas. Carbon dioxide is fundamental in the existence of plants and microorganisms. It is produced due to respiration of aquatic organisms.

During the present study the minimum mean value of F.CO_2 (7.00 mg/L) was recorded at Site II, whereas maximum mean value (7.40 mg/L) was recorded at Site III. Lower F.CO_2 was recorded in winter, while higher was recorded in summer month.The increase in carbon dioxide level during the present study at Site III may be due to decay and decomposition of organic matter released during anthropogenic activities, which was the main causal factor for increase in carbon dioxide in the water bodies. Kumar *et al.* (2014) reported higher concentration of Free CO_2 (1.58-4.29 mg/L) in kali river Pithoragarh district of Uttarakhand, India. Lower concentration of Free CO_2 was recorded in winter and higher in monsoon seasons.

In the present study there was much variation in the total alkalinity of Lidder stream. At site III, maximum mean value of TA (87.4 mg/L) was recorded, whereas minimum mean value (74.4 mg/L) was recorded at Site II. Lower TA was recorded in winter, while higher was recorded in summer month. Agarwal and Arora (2012) recorded higher concentrations of alkalinity than the present study, which was ranged between 234mg/L and 330mg/L in Kaushalya River at submountaneous Shivalik region. The high value of alkalinity indicates the presence of weak and strong base such as carbonates, bicarbonates and hydroxides in the water body. The high values of alkalinity may also be due to increase in free carbon dioxide in the river which ultimately results in the increase in alkalinity. Matta and Kumar (2015) recorded the lower mean concentration of alkalinity than the present study with 39.2± 6.26 to 44.1 ± 3.53 mg/L in winters followed by summer and monsoon season with 39.5± 15.2 to 43.9 ± 6.18 mg/L and 28.9 ± 0.96 to 50 ± 5.0 mg/L in Ganga river water at Haridwar.

Oxygen is the regulator of metabolic processes of plant and animal communities and indicator of water condition. The oxygen is most important gas, produced during photosynthesis by the phytoplankton in aquatic environment. During the present study minimum mean DO value (7.86 mg/L) was recorded at Site III, while as maximum mean DO value (8.80 mg/L) was recorded at site I. In the present context DO reduces during the summer season as compared to winter it may be due to huge amount of organic matter being released by the tourist in the river in the form of polythene plastic bottles, rappers of synthetic items or it may be due to seasonal variation. Similar trend in DO was reported by Bhadula *et al.* (2014), who reported the overall lowest and highest mean value of DO were observed 7.0 mg/L and 10.8 mg/L in the month of June and January at the Site-II and Site-I, respectively at Sahashtradhara Stream, Dehradun. BOD is the amount of oxygen required for the oxidation of organic matter by micro-organisms in aerobic condition. Kumar and Chopra (2012b) also reported the reduction in the DO content of Old Ganga Canal at Haridwar (Uttarakhand) India due to disposal of sewage effluent.

In the present study a site II, the minimum mean value of BOD (12.74 mg/L) was recorded, whereas maximum mean value of (14.18 mg/L) was recorded at Site-III during study period at Lidder stream. During the present study, there is gradual increase in BOD from January to May.

Similarly, Bhadula and Joshi (2011) recorded lowest and highest mean value of BOD (1.0 mg/L and 3.0 mg/L) in the month of January and June at the Site 1 and Site 2, respectively at Sahashtradhara Stream, Dehradun and concluded that various anthropogenic activities increased the BOD of the river water. Liu *et al.* (2014) also recorded higher ranged BOD (5.1–49 mg/L) in the samples of urban streams at Guangzhou, China. Chlorides concentration is an important ion required by photosynthesizing cells. The water from human excreta is rich in chlorides. Human body discharge about 8.0 gm to 15.0 gm chloride per day. Therefore chlorides concentration serves as an indicator of pollution.

During the present study minimum mean value of Cl^- (26.4 mg/L) was recorded at Site (I and II), while maximum mean value (30.6 mg/L) was recorded at Site III. In the present study an increased was observed in Cl^- concentration in summer month with rise of tourist flow that raises the Cl^- concentration. Tripathi *et al.* (2014) reported maximum concentration of Cl^- (81.36±3.84 mg/L) in summer and minimum in winter season at Ganga River, (Allahabad) India. Matta *et al.* (2015) also reported maximum concentration of Cl^- (5.70 mg/L) in summer and lower in winter season at Ganga canal system, (Haridwar) India.

In the present study minimum mean value of NO_3^-N (198.40 µg /L) was recorded at Site I and maximum mean value (222.00 µg /L) was recorded at Site II, whereas minimum mean value of NH_4^+N (137.20 µg/L) was recorded at Site II and maximum mean value (156.60 µg/L) was recorded at Site III. Nitrate-nitrogen (NO_3^-N) and Ammonical Nitrogen (NH_4^+N) in surface water may result from anthropogenic activities such as bathing and use of soaps and detergents. The non-point sources such as fertilized cropland, parks, golf courses, lawns, gardens and naturally occurring sources of nitrogen also increased the concentrations of nitrogen. This was in accordance with Rashid and Romshoo (2013), they reported maximum increased in NO_3^-N/NH_4^+N (180.00 µg/L/112.00 µg/L) in summer months and (160.00 µg/L/94.00 µg/L) in winter months at Lidder stream water samples at different sites in Kashmir region respectively. Phosphorus is obtained from the rocks converting then in to its soluble forms and may also occur, in agricultural runoff, industrial wastes, municipal sewage and synthetic detergents. The high concentration of phosphorus is always indicative of eutrophication.

During the present study OPP was recorded minimum (31.40 µg/L) at Site I, while it was recorded maximum (46.40 µg/L) at Site III. TP was recorded minimum (48.60 µg/L) at Site II, while it was recorded maximum (50.80 µg/L) at Site III. Maximum concentrations of OPP/TP were recorded in summer months at all the three sites due to high anthropogenic pressure at Lidder valley. Rashid and Romshoo (2013) reported maximum concentrations of OPP/TP (32 µg/L/54 µg/L) in summer month and minimum concentrations (18 µg/L to 36 µg/L) in winter month at various sites of Lidder stream I Kashmir region, respectively.

Correlation study: The correlation coefficients (r) value among the flow of tourists and water parameters are presented in Tables 1-4. During the present study correlation coefficient (r) at different sites revealed that Water temperature were positively correlated with tourist flow, while pH and EC are also positively correlated with Site 1 and Site 3. At Site 2 both pH and conductivity are negatively correlated with the tourist flow. Free carbon dioxide and Alkalinity are positively correlated with tourist flow at all the sites, while as dissolved oxygen is negatively correlated with the tourist flow at all the sites. The other parameters BOD, Cl^-, NO_3^-N, NH_4^+N, OPP and TP are positively correlated with the tourist flow. NH_4^+N showed significant ($P<0.05$) positive correlation close to 1 at all the sites. Kumar and Chopra (2012a) also reported the significant alteration in the water quality of sub Canal of Upper Ganga Canal at Haridwar (Uttarakhand), India due to discharge of textile effluent. Moreover, Joshi *et al.* (2009) also reported an appreciable significant positive correlation was found for Free CO_2 with Cl^- , TDS, TSS; turbidity with Cl^-, EC, TSS; Cl^- with EC, Free CO_2, TSS; EC with Cl^-, TDS, TSS. A significant negative correlation was found for DO with Free CO_2, COD, turbidity, Cl^-, EC, TDS and TSS.

Table 1. Correlation coefficient (r) between WT, pH and EC with tourist flow in Lidder stream at three sites.

Months	TF	WT			pH			EC		
		Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
January	6740	2	3	3	7.1	7.2	7.96	90	130	96
February	8200	6	5	5	7.13	7.48	7.92	120	128	98
March	15262	7	6	8	7.6	7.6	7.8	130	112	116
April	26032	6	5	7	7.35	7.5	7.7	146	116	112
May	60826	7	9	9	7.36	7.5	7.7	149	120	122
Mean±SD		5.60± 2.07	5.60± 2.19	6.40± 2.40	7.30± 0.20	7.45± 0.15	7.81± 0.12	108.80± 11.36	121.20± 7.69	127.00± 23.83
r value		0.51	0.89	0.76	0.74	-0.34	0.81	0.74	-0.34	0.81

Table 2. Correlation coefficient (r) between DO, BOD and F.CO_2 with tourist flow in Lidder stream at three sites.

Months	TF	DO			BOD			F.CO_2		
		Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
January	6740	10.40	10.20	9.60	11.00	10.10	12.60	4.00	5.00	5.00
February	8200	7.80	8.20	8.60	12.60	11.00	14.10	6.00	5.00	6.00
March	15262	7.80	7.70	8.20	14.60	14.00	14.20	8.00	7.00	9.00
April	26032	6.80	7.00	9.60	15.00	14.60	15.10	9.00	8.00	8.00
May	60826	6.50	7.40	8.00	15.00	14.00	14.90	9.00	10.00	9.00
Mean±SD		8.80± 0.76	8.10± 1.25	7.86± 1.53	13.64± 1.77	12.74± 2.03	14.18± 0.98	7.20± 2.16	7.00± 2.12	7.40± 1.81
r value		-0.69	-0.55	-0.49	0.67	0.61	0.64	0.64	0.73	0.71

Table 3. Correlation coefficient (r) between TA, Cl and NO_3^-N with tourist flow in Lidder stream at three sites.

Months	TF	TA			Cl			NO_3^-N		
		Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
January	6740	88.00	62.00	75.00	18.00	20.00	22.00	11.00	10.10	12.60
February	8200	82.00	75.00	66.00	24.00	30.00	20.00	12.60	11.00	14.10
March	15262	80.00	87.00	99.00	34.00	24.00	32.00	14.60	14.00	14.20
April	26032	92.00	68.00	78.00	20.00	24.00	37.00	15.00	14.60	15.10
May	60826	95.00	80.00	79.00	36.00	34.00	42.00	15.00	14.00	14.90
Mean±SD		79.40± 12.09	74.40± 9.81	87.40± 6.38	26.40± 8.17	26.40± 5.54	30.60± 9.47	198.40± 11.26	222.00± 29.99	208.20± 23.01
r value		0.75	0.32	0.09	0.62	0.70	0.87	0.67	0.61	0.64

Table 4. Correlation coefficient (r) between TA, Cl and NO_3^-N with tourist flow in Lidder stream at three sites.

Months	TF	NH_4^+N			OPP			TP		
		Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
January	6740	112.00	124.00	136.00	24	28	44	38	46	44
February	8200	118.00	130.00	142.00	34	44	48	52	48	49
March	15262	122.00	138.00	149.00	38	48	48	54	50	52
April	26032	167.00	143.00	169.00	36	38	38	56	52	52
May	60826	188.00	151.00	187.00	25	48	54	52	47	57
Mean±SD		141.40± 33.96	137.20± 10.61	156.60± 21.05	31.40± 6.46	41.20± 8.43	46.40± 5.89	50.40± 7.12	48.60± 2.40	50.80± 4.76
r value		0.93	0.90	0.95	-0.34	0.48	0.50	0.62	0.70	0.87

Conclusions

The present study concluded that touristic activities in the catchment of Lidder stream have deteriorated the water quality. From the analysis and discussion of the results, it is concluded that the main reasons for the deterioration of the water quality of Lidder stream are increase in tourist flow, which increases the concentration of nutrients due to sewage disposal, bathing and washing in the vicinity of the stream. This information has been depicted by the physico-chemical characteristics of the stream. The physico-chemical analysis shows variations in most of the water quality parameters such as pH changes gradually whereas EC, F.CO_2, BOD, Cl^-, NO_3^-N, NH_4^+N, OPP, TA and TP increased, while DO decreased. Due to the increased concentrations of these nutrients, the water quality of the stream is altering and negatively deteriorating the distribution of aquatic flora and fauna therein. The direct disposal of sewage from the nearby areas into the Lidder stream has increased the nutrient load. Due to higher nutrient enhancement, reduction in the DO content has been observed. The water of Lidder stream serves domestic, agriculture, irrigation and other commercial sectors (including hotels at Pahalgam) sectors, which have a directly impact on the water quality of Lidder stream. It is contingent from the present study that pollution load due to tourism increased. Therefore, there should be appropriate management and disposal of wastes emerging from tourism sector. It is suggested that suitable mechanism should be adopted for continuous monitoring of the Lidder stream for the conservation of this important stream.

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