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# EVALUATION OF MICROBIAL LOAD AND SELECTED HEAVY METALS CONTAMINATION IN THE RIVER BEAS (PUNJAB) INDIA

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**Research Article**

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## ABSTRACT

**Aim:** To analyse the heavy metal contamination and microbial load in upstream (Talwara), midstream (Urmar Tanda) and downstream (Harike Pattan) stretches of the river Beas in Punjab.

**Methodology:** Month-wise samples were collected in triplicate during the period of May to December, 2019. Heavy metal parameters such as Arsenic, Cadmium, Nickel, Lead and Zinc were analysed by Atomic Inductively Coupled Plasma Mass Spectrometry following standard protocol. Microbial load in water samples was calculated in terms of Total Plate Count, Total Coliform and Faecal Coliform as per following standard protocol. Statistical analysis involved calculating Analysis of Variance at 5% significant level ($p<0.05$).

**Results:** The study revealed that heavy metal parameters like Arsenic, Cadmium, Nickel, Lead and Zinc ranged in $mgl^{-1}$ from 0.0 to 0.009, 0.0 to 0.02, 0.0 to 0.004, 0.0 to 0.001, and 0.0 to 0.036 respectively. Total Plate Count ranged from 0.32 $x10^4$ to 3.2 $x10^5$ cfu $ml^{-1}$ whereas, Total Coliforms and Faecal Coliforms ranged from 4.0 to 1100 MPN 100 $ml^{-1}$ and 0.0 to 460 MPN 100 $ml^{-1}$ respectively. The mean concentrations of analysed metals were recorded in the order of Zinc > Cadmium > Arsenic >Nickel >Lead; and most of them were under the permissible limits; however, the presence of faecal coliforms in the water is alarmingly high at Harike Pattan.

**Interpretation:** This investigation revealed that the river Beas water is suitable for supporting aquatic life, bathing, irrigation and other purposes. The microbial load and the heavy metal parameters need to be monitored regularly, so that their adverse effects on living beings or aquatic organisms may be minimized. River stretch near Harike Pattan and Urmar Tanda being an important habitat of endangered freshwater Dolphin (*Platanista gangetica minor*), Smooth-Coated Otter (*Lutrogale perspicilliata*) and Ghariyal (*Gavialis gangeticus*) is more vulnerable to the toxic levels of heavy metals and contamination of faecal coliform.

**Keywords:** Beas river, Coliforms, Heavy metals, Microbial load.

## INTRODUCTION

Freshwater is essential for the survival of life on earth. It is not only fundamental for human beings, but also for plants and animals. Moreover, the rivers provide irrigation, potable water, cheap transportation, hydroelectricity, and livelihood to a large population on the earth (Smith and Gleick, 2012). With the continuous growth of population, rapid developments in agriculture, mining, urbanization, industrialization, hydro-electrical generation activities, and motor vehicle pollution, river water contamination with hazardous waste is becoming a common phenomenon (Shivayoginath et al., 2012; Sharma and Walia, 2016). Human interference, inadequate freshwater supply, and inappropriate management are the major causes that lead to an increase in the pollutant load of a water body (Shankhwar et al., 2015; Ingole et al., 2015). In the state of

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Punjab, the continuous development of agriculture and the growth of small-scale industries have led to an increase in water, air, and noise pollution. Moreover, the broad and intensive use of agrochemicals, ultimately lead to their runoff into the natural waters and thus pollute the available water resources. The rate of discharge of pollutants into the water is far higher than the rate of purification (Chauhan and Sagar, 2013). Any pollution incidence in the rivers will greatly affect the hydrogeological systems (Weng and Chen, 2000; Celik, 2001). If the river water is polluted, it is bound to affect the groundwater and vice versa (Edet and Worden, 2009).

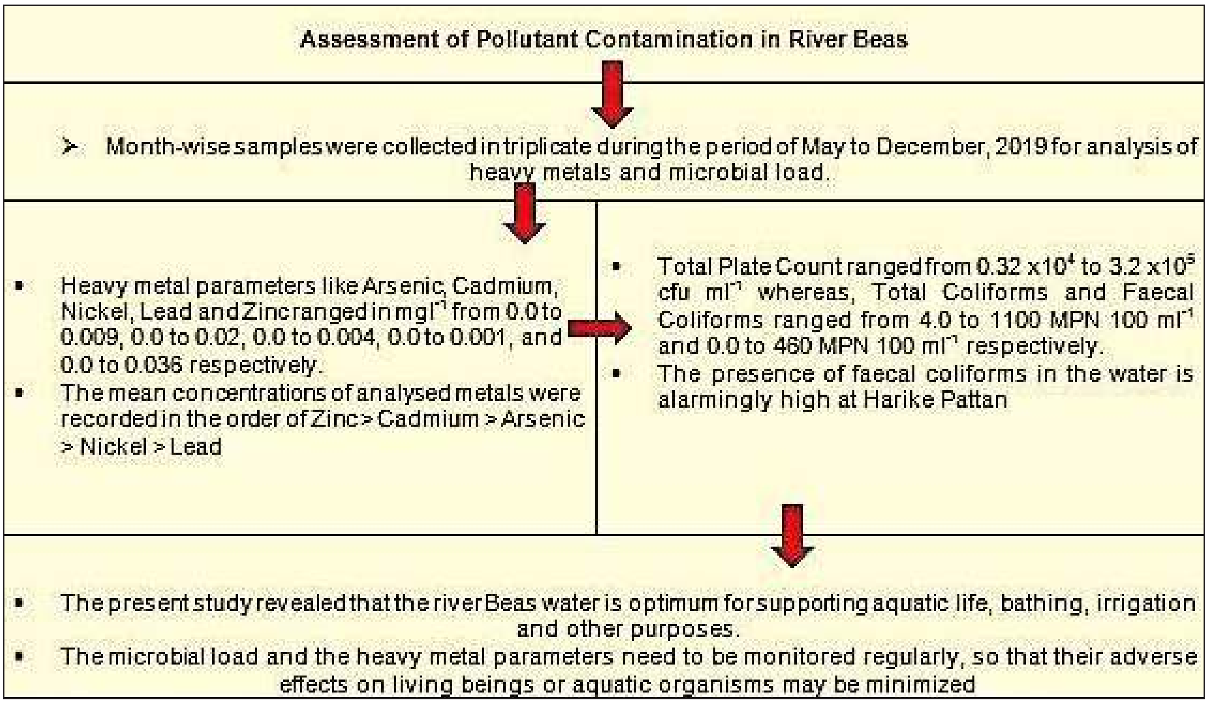


**Fig.1: Sampling of the Beas River at Talwara.**

**Fig.2: Sampling of the Beas River at Harike Pattan.**

The river Beas is 470 km long and it is one ofthe major tributaries of the Indus River system. It flows for about 256 km in Himachal Pradesh and for about 214km in Punjab. It originates in the Himalayas in central Himachal Pradesh about 2050 m above mean sea level on the southern slope of Rohtang pass from two sources Beas Kund and Beas Rishi at a latitude of 32º2′ N and a longitude of 77°05′ E in central Himachal Pradesh adversely affected the pristine purity of water, ecology and biodiversity of river along with a massive killing of different types offish species. Restoration programme of the river Beas was undertaken by the Punjab state government and different NGO`s along with a ban on fish harvesting and the regular biomonitoring of the river. In the year 2019, a 185 km long stretch of the river Beas was included in the list of International Ramsar Site as “Beas Conservation Reserve”. Presently, river Beas is passing through a critical phase of ecological transition due to climate change, anthropogenic pollution, and waste discharge from the industries.

Among the natural trace components of an aquatic environment, heavy metals constitute an integral part. Nowadays, the levels of heavy metals have increased manifold due to agricultural and industrial activities. Micro, small and medium scale industries are daily releasing their effluents into the water bodies and are deteriorating the quality of water. Like-wise, lead a toxic heavy metal which is absorbed through food, water and inhalation (Ferner 2001) while arsenic is organized in the environment through natural processes and a range of anthropogenic activities (Kinniburg and Smedley 2001; Kapaj *et al* 2006, and Walter and Carter 1995). Sufficient quantities of heavy metals get accumulated in river water and soil, and these are ultimately absorbed by the aquatic organisms present in the water, which can easily be biomagnified through the food chain. This can lethally impact the aquatic organisms and can also inflict mortality in the resident fish stocks (Almeida *et al* 2002; Megeer *et al* 2000; Xu *et al.,* 2004). Rivers also play a major role in transporting municipal and industrial wastewater and runoff from agricultural and mining land (Hussain *et al.,* 2017). The bacteriological examination of water has a special significance in pollution studies as it is a direct measurement of hazardous effect of contamination and pollution on human health. Atlas and Bartha (1993) considered that bacteria are fated determinants of pollution released into the environment whereas Clark and Pagel (1977) pointed bacteria as reliable indicators of contamination. The coliforms are the major microbial indicator of monitoring water quality (Brenner et al., 1993; Craun, 1978; Grant, 1997). The Total coliform and faecal coliform counts are the mainly used bacteriological procedures for the assessment of water quality (Geldreich and Clarice, 1966; Gleeson and Gray, 1997. Mcdaniels *et al*., 1985, Sood *et al.*,2008) and the detection of *Escherichia coli* provides definite evidence of faecal pollution (Kataria et al.1997; Pathak and Gopal 2001, Kistemann *et al.* 2002). However, more MPN of coliforms are indicating heavy bacterial contamination (Matta and Bisht 2018, Spancer & Ramsay 1978.).

In view of the above works and to fill the research literature gap, the present study was conducted with the objectives of analysing the heavy metal contamination and microbial load in upstream, midstream and downstream stretches of the River Beas in Punjab. Furthermore, this research was vital for evaluating the ecological status of the river andits database generation. The study also helped to check the suitability of the usage of river water for anthropogenic activities like irrigation, bathing, and fisheries purposes, and the ability of the river water to support aquatic fauna. Additionally, the assessment of heavy metals and microbial load in the river Beas water is also poorly documented.

## MATERIALS AND METHODS

**Study area:** Samples were collected from three sampling sites in River Beas; one each from upstream, midstream and downstream stretches in Punjab. Talwara (31º57'09"N, 75º53'43"E) stretch of the river was selected for upstream (Site-1), whereas Urmar Tanda (31º41'36"N, 75º31'29"E) for midstream (Site-2) and Harike Pattan (31º9'2"N, 74º57'5"E) site for downstream (Site-3) during the present study.

**Collection of water samples:** Sampling was done during 2019-20 at 3 sampling sites seasonally during pre-monsoon (May-June), monsoon (July-September) and post-monsoon seasons (October-December). The samples were collected at monthly interval basis in triplicate in 1 litre sterilized polyvinyl plastic bottles for the analysis of heavy metals parameters and in 100 ml capacity sterilized plastic vials for the analysis of microbial load. All the bottles and vials were properly labelled and were carried in white trays. Samples were brought in insulated corrugated boxes to the College of Fisheries, GADVASU, Ludhiana. Water was stored at 4°C till further analysis.

**Assessment of heavy metals and microbial load:** Heavy metal parameters such as Arsenic (As), Cadmium (Cd), Nickel (Ni), Lead (Pb) and Zinc (Zn) were estimated by Atomic Inductively Coupled Plasma Mass Spectrometry (The Agilent 7700 series ICP-MS) following standard protocol (APHA, 2017). Microbial load in water samples was estimated in terms of Total Plate Count (TPC), Total Coliform and Faecal Coliform as per following standard protocol

(APHA, 2017).

**Data analysis:** Significant statistical variations between different heavy metals and microbial load parameters through Analysis of Variance in SPSS v25 at 5% significant level ($p<0.05$) were calculated.

## RESULTS AND DISCUSSION

### Heavy metals in water

The aim of the present study was to visualize and determine the water quality status of river Beas concerned with the concentrations of heavy metal (Arsenic, Cadmium, Lead, Nickel and Zinc). The research work was performed during May, 2019 to December, 2019.Month-wise variations in average values of heavy metals in the river Beas water (Mean±S.E.) are given in Table 1. The site-wise variations in average values of heavy metals in river Beas water (Mean±S.E.) are depicted in Table 2. The maximum and minimum values of heavy metals at different sampling sites in the river Beas are mentioned in Table 3.

### Arsenic (As)

In present study, the arsenic concentration ranged from 0-0.008 mg $l^{-1}$ (Figure3). The maximum mean value of arsenic was found in the month of June at sampling site Harike Pattan (0.008 mg $l^{-1}$), Urmar Tanda (0.0073 mg $l^{-1}$) and Talwara (0.007 mg $l^{-1}$). The average minimum values of arsenic was recorded to be nil in December at all three sampling sites (0.0 mg $l^{-1}$) followed by 0.0 mg $l^{-1}$ at Talwara & Harike Pattan and 0.0013 mg $l^{-1}$ at Urmar Tanda during the month of November (Figure 3). Arsenic values for all the three sampling sites varied significantly as per site-wise as well as month-wise observation. The arsenic concentration recorded throughout the study period were within the permissible limit of arsenic (0.2 mg$l^{-1}$) as recommended by Water Quality Standards in India (Source IS 2296:1992) whereas 2 mg $l^{-1}$ prescribed by WHO (2004) and 0.01 mg $l^{-1}$ by BIS 10500 (2012) in drinking water

### Cadmium (Cd)

In the present study, the cadmium traces in the river Beas water ranged from 0.00- 0.016 mg $l^{-1}$. The maximum mean values of cadmium were recorded at Urmar Tanda (0.016 mg $l^{-1}$) in the month of July followed by 0.013 mg $l^{-1}$ at Talwara during June &

**Table 1: Month-wise variations in average values of heavy metals and microbial load in the river Beas water (Mean±S.E.) during the study period (May 2019 –December 2019).**

| Month-wise variation | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Parameters** | **Unit** | **May** | **June** | **July** | **August** | **September** | **October** | **November** | **December** |
| **Heavy metals** | | | | | | | | | |
| Arsenic (As) | mg $l^{-1}$ | 0.0027± 0.0004 | 0.0074± 0.0005 | 0.0028± 0.0003 | 0.0042± 0.0003 | 0.0034± 0.0003 | 0.0032± 0.0002 | 0.0004± 0.0003 | 0±0.000 |
| Cadmium (Cd) | mg $l^{-1}$ | 0±0.000 | 0.013± 0.001 | 0.013± 0.00 | 0.011±08 0.00 | 0.012±08 0.00 | 0.011± 0.002 | 0±0.000 | 0±0.000 |
| Lead (Pb) | mg $l^{-1}$ | 0±0.000 | 0±0.000 | 0±0.000 | 0±0.000 | 0.0003±0.00 | 0±0.000 | 0±0.000 | 0±0.000 |
| Nickel (Ni) | mg $l^{-1}$ | 0.001± 0.0001 | 0.002±1 0.000 | 0.001±1 0.000 | 0.001± 0.0001 | 0.001± 0.0001 | 0.001± 0.0001 | 0.000± 0.000 | 0.0004± 0.0001 |
| Zinc (Zn) | mg $l^{-1}$ 0.0007 | 0.0103± 0.0009 | 0.0103± 0.0005 | 0.0083± 0.0005 | 0.0056± 0.0004 | 0.0167± 0.0007 | 0.0088± 0.003 | 0.0036± 0.00053 | 0.004± 0.0001 |
| **Microbial assays** | | | | | | | | | |
| Total Plate Count (TPC) | cfu $ml^{-1}$ | $1.13\times10^5$ ±0.11 | $3.67\times10^4$± 0.09 | $1.28\times10^5$± 0.21 | $1.34\times10^5$± 0.13 | $5.5 \times10^5$± 0.19 | $4.67\times10^4$ ± 0.48 | $3.64\times10^4$± 0.13 | 4.5×104± 0.07 |
| Total Coliform (LST) | MPN/ 100ml | 198.44± 17.29 | 128.11± 30.0 | 9.0±1.28 | 172.22± 30.58 | 24.44 ± 7.08 | 453.55 ± 6.22 | 275.33± 31.0 | 99.0± 9.15 |
| Faecal Coliforms (EC) | MPN/ 100ml | 39.66± 1.78 | 15.21±3.28 | 3.44±0.91 | 5.77±0.83 | 4.88±0.89 | 169.77±0.44 | 36.99±5.89 | 14.77±2.46 |

**Table 2: Site-wise variations in average values of heavy metals and microbial load in the river Beas water (Mean±S.E.) during the study period (May 2019 –December 2019).**

| | | | Sampling sites | |
|---|---|---|---|---|
| Parameters | Unit | Talwara | Urmar Tanda | Harike Pattan |
| | | Heavy metals | | |
| Arsenic (As) | mg $l^{-1}$ | 0.0026±0.0002 | 0.0028±0.0003 | 0.0037±0.00028 |
| Cadmium (Cd) | mg $l^{-1}$ | 0.007±0.0005 | 0.008±0.0005 | 0.007±0.0006 |
| Lead (Pb) | mg $l^{-1}$ | 0±0.000 | 0±0.000 | 0.00013±0 |
| Nickel (Ni) | mg $l^{-1}$ | 0.001±0.0001 | 0.001±0.0001 | 0.001±0.0001 |
| Zinc (Zn) | mg $l^{-1}$ | 0.0071±0.0003 | 0.0073±0.0006 | 0.011±0.0006 |
| | | Microbial assays | | |
| Total Plate Count (TPC) | cfu $ml^{-1}$ | 3.56×104 ± 0.21 | 4.32 ×104 ± 0.15 | 1.09 ×105 ± 0.16 |
| Total Coliform (LST) | MPN/100ml | 54.25 ± 6.44 | 141.0 ± 17.75 | 314.79 ± 25.54 |
| Faecal Coliforms (EC) | MPN/100ml | 15.28 ± 1.17 | 20.91 ± 3.15 | 72.74 ± 1.85 |

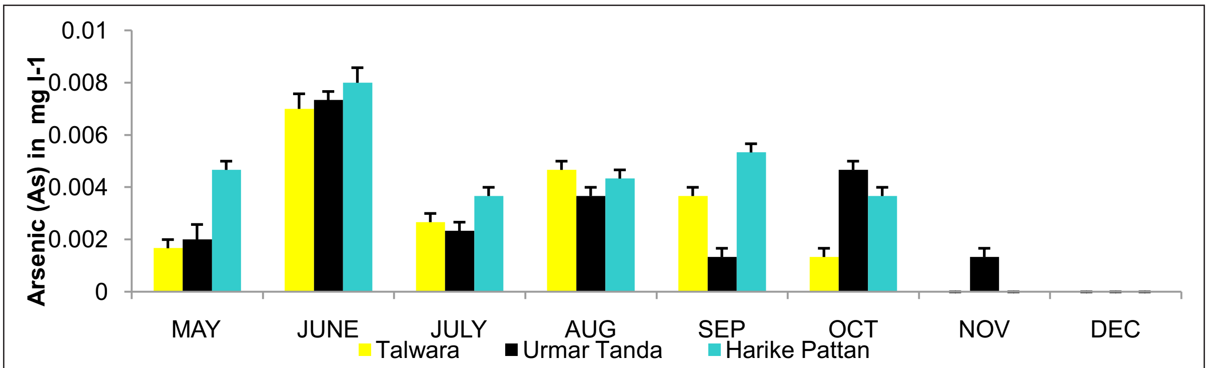


**Figure 3: Monthly variations in Arsenic (As) in mg $l^{-1}$ in water at different stretches of the Beas River during the study period (May 2019-December 2019).**

September and Harike Pattan (during June, July, September and October) (Table-3). The minimum traces of cadmium were noticed to be nil in the month of May, November and December at all the three stretches studied. As per site-wise sampling observations, Urmar Tanda site was reported with maximum traces of Cd followed by Harike Pattan and Talwara site. As per the permissible limit of cadmium 0.01 mg $l^{-1}$ (WHO 2008), the cadmium concentration at all three sampling sites was reported as slightly beyond limit (0.013 to 0.016mg $l^{-1}$) (Figure 4). The higher concentration of cadmium in river Beas water was recorded during monsoon and it was not detected in May, November and December at all three sampling sites. In the present study, high concentration of cadmium in the month of July might be due to increased run-off from catchment area as cadmium generally enters in water with agricultural run-off which consists of fertilizers, pesticides and other agro-chemicals. Pollution status of cadmium level in River Beas was found below the permissible limit as reviewed by Kumar et al. (2017).

Cadmium values recorded at Talwara site were almost equal to permissible limit in the month of July. Brraich and Jangu (2015) reported average concentration of cadmium in Harike wetland as 0.01 mg L-1 which is in corroboration with the present investigation. The higher concentration of cadmium was also reported from surface water of river Sutlej by Setia et al. (2020). The variations in cadmium concentrations were significantly different among the months with in the

**Table 3: Maximum and minimum values of heavy metals and microbial load at different sampling sites in the river Beas during the study period (May 2019 –December 2019).**

| Values/Sites | Talwara | Urmar Tanda | Harike Pattan |
|---|---|---|---|
| Arsenic (mg/l) | | | |
| Maximum | 0.008 | 0.008 | 0.009 |
| Minimum | 0.000 | 0.000 | 0.000 |
| Average | 0.0026 | 0.0028 | 0.0037 |
| (±)SE | 0.00028 | 0.00032 | 0.00027 |
| **Cadmium (mg/l)** | | | |
| Maximum | 0.02 | 0.02 | 0.02 |
| Minimum | 0.000 | 0.000 | 0.000 |
| Average | 0.0073 | 0.0080 | 0.0078 |
| (±)SE | 0.00056 | 0.00057 | 0.00069 |
| **Lead (mg/l)** | | | |
| Maximum | 0.000 | 0.000 | 0.001 |
| Minimum | 0.000 | 0.000 | 0.000 |
| Average | 0.000 | 0.000 | 0.00013 |
| (±)SE | 0.000 | 0.000 | 0.000 |
| **Nickel (mg/l)** | | | |
| Maximum | 0.004 | 0.002 | 0.003 |
| Minimum | 0.001 | 0.000 | 0.000 |
| Average | 0.0017 | 0.0012 | 0.0013 |
| (±)SE | 0.00012 | 0.00009 | 0.00008 |
| **Zinc (mg/l)** | | | |
| Maximum | 0.018 | 0.014 | 0.036 |
| Minimum | 0.000 | 0.000 | 0.000 |
| Average | 0.0071 | 0.0074 | 0.011 |
| (±)SE | 0.0004 | 0.0007 | 0.0006 |
| **Total Plate Count (cfu/100ml)** | | | |
| Maximum | 7.4×104 | 5.9×104 | 3.3 ×105 |
| Minimum | 0.32×104 | 2.5×104 | 3.1×104 |
| Average | 3.56×104 | 4.32 ×104 | 1.44×105 |
| (±)SE | 0.209 | 0.158 | 0.165 |
| **Total Coliforms (MPN/100ml)** | | | |
| Maximum | 460 | 460 | 1100 |
| Minimum | 4 | 9 | 4 |
| Average | 54.25 | 141 | 314.7917 |
| (±)SE | 6.44 | 17.75 | 25.55 |
| **Faecal Coliforms (MPN/100ml)** | | | |
| Maximum | 11 | 48 | 460 |
| Minimum | 0 | 0 | 3 |
| Average | 15.29 | 20.91 | 72.75 |
| (±)SE | 1.18 | 3.16 | 1.86 |

sites while among the sites it was noticed significant variation ($p<0.05$).

**Lead (Pb)**

In the present investigation, the average value of lead concentration was recorded to be 0.001 mg $L^{-1}$ in the month of September only at Harike Pattan site (Figure 5), whereas it was nil in all the remaining months.Lead was also absent in the other two sampling sites

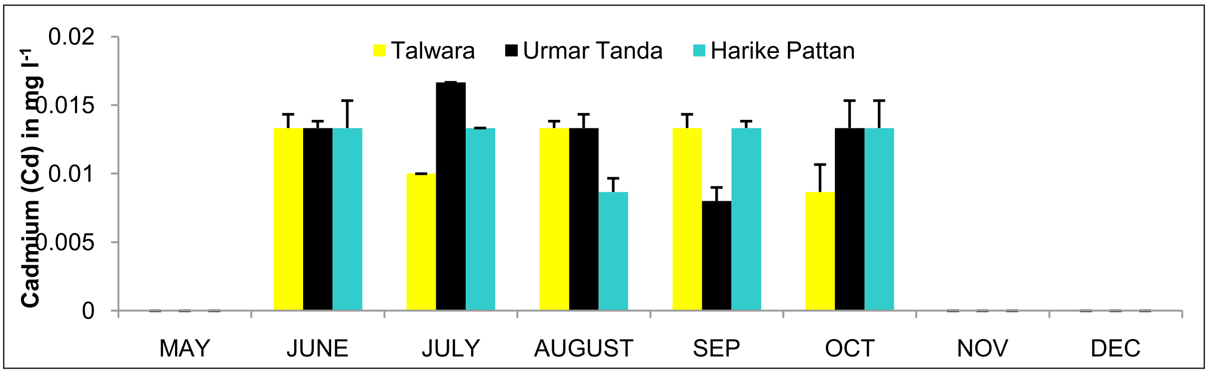


**Figure 4: Monthly variations in Cadmium (Cd) in mg l-1 in water at different stretches of the Beas River during the study period (May 2019-December 2019).**

throughout the study. Thus, absence of lead content in most of the water sampling sites is good indicator that the river Beas water still maintaining a good quality. The results obtained in present study regarding presence of lead were not in agreement with the previous investigation reported by Kaur *et al.* (2019) in river Sutlej, Kumar *et al.* (2020) in river Sutlej, Beas and Harike wetland and Brraich and Jangu (2015).

**Nickel (Ni)**

In present study, the traces of nickel in water ranged from 0.0 to 0.003 mg $L^{-1}$ The maximum value of nickel was observed in the month of June at Talwara site (0.003 mg $L^{-1}$)followed by Harike Pattan (0.002 mg $L^{-1}$) during the month of August and September. The

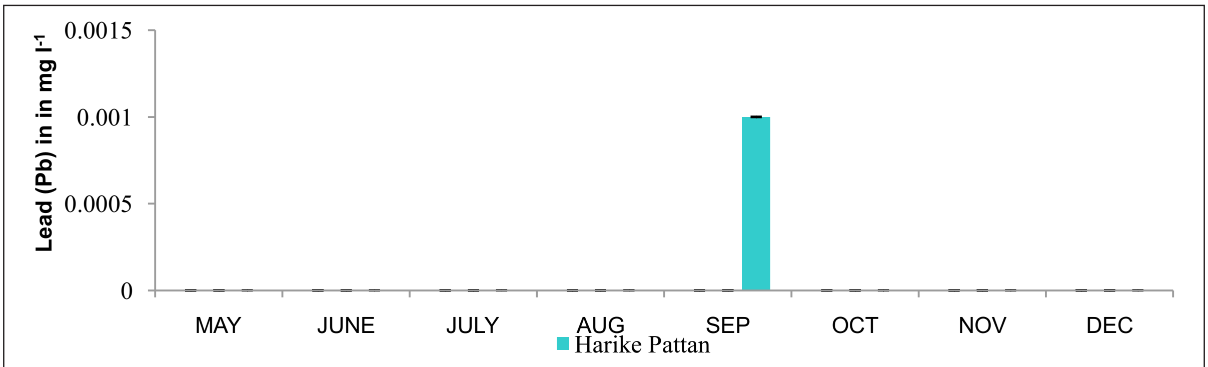


**Figure 5: Monthly variations in Lead (Pb) in water in mg l-1 at different stretches of the Beas River during the study period (May 2019-December 2019).**

maximum value of nickel concentration at Urmar Tanda was recorded to be 0.001 mg $L^{-1}$ in most of the months except in May and December months, where it was nil (Figure 6). The minimum values showed inverse trend as minimum in November and December at Harike Pattan site. The variations in values of nickel were significantly varied among the months as well as among the sites in post monsoon months of November and December ($p<0.05$). In spite of the fact, the acceptablelimit of nickel is 0.02 mg/L recommended by BIS (Bureau ofIndian Standard) (2012) & WHO (1993) and the values of nickel in Beas water recorded during present investigation were within the prescribed limit.

**Zinc (Zn)**

In present study, the trace of zinc ranged from 0.0 to

0.033 mg $l^{-1}$. The maximum mean value of zinc (0.033 mg $l^{-1}$) was recorded at Harike Pattan site in the month of September followed by 0.017 mg $l^{-1}$ at Talwara in May and 0.013 mg $l^{-1}$ at Urmar Tanda during July and

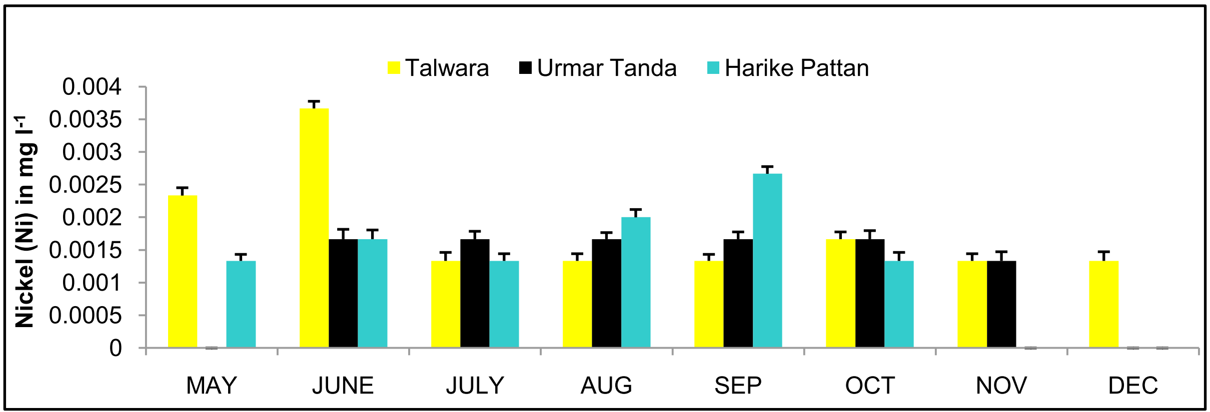


**Figure 6: Monthly variations in Nickel (Ni) in mg $l^{-1}$ in water at different stretches of the Beas River during the study period (May 2019-December 2019).**

September. Minimum values of Zn (0.001 mg $l^{-1}$) were recorded in post-monsoon months at Talwara and Urmar Tanda site in November and December, whereas at Harike Pattan it was minimum (0.005 mg $l^{-1}$) in the month of October (Figure 7). The concentration of zinc was reported nil in the month of November at Talwara site. The value of zinc varied insignificantly among the sites in all the months except post monsoon months when significant variation was reported. The minimum value of zinc during post-monsoon months might be ascribed due to rainfall and highwater velocity which caused river water dilution. Kaur *et al.* (2019) recorded zinc contamination in the range of 0.47 – 0.96 mg $l^{-1}$ in river Sutlej, which was higher as compared to the present investigation. The permissible limit of zinc as per Water Quality Standards in India (Source IS 2296:1992) &BIS (Bureau of Indian Standard) 10500 (2012) is 15 mg $l^{-1}$,whereas WHO (1993) recommended health based guidelines is 3.0 mg $l^{-1}$. Zinc concentration observed during the present investigation was under the permissible limit.

The mean concentrations of all the metals analysed during the present study were found to be within the permissible limit at Talwara, Urmar Tanda and Harike Pattan sites of the river Beas except one metal i.e., cadmium (Cd) which showed the slightly higher values as compared to its permissible limit. The values of

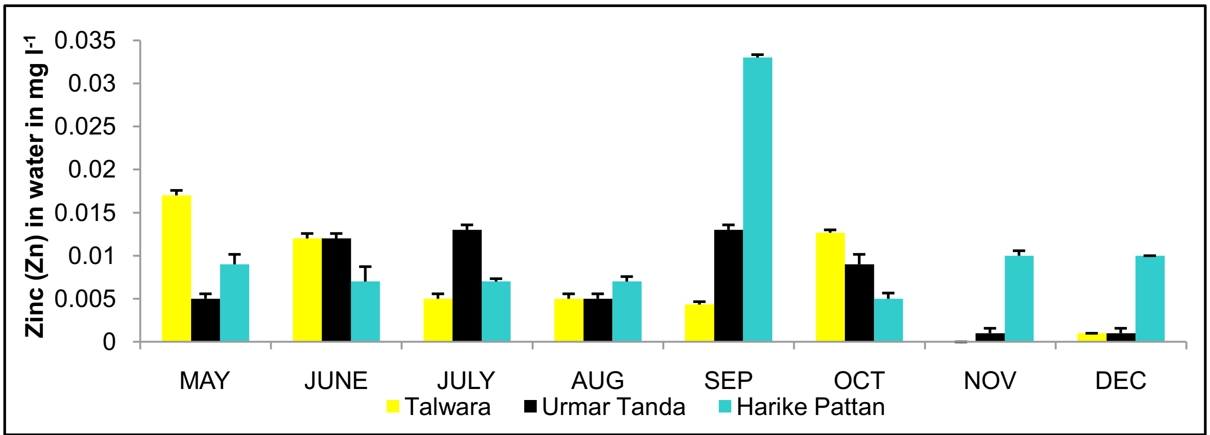


**Figure 7: Monthly variations in Zinc (Zn) in water in mg $l^{-1}$ at different stretches of the Beas River during the study period (May 2019-December 2019).**

different metal concentration during the present study were recorded in decreasing order as Zn> Cd> As>Ni> Pb with negligible traces of Lead from all the sites except in the month of September at Harike Pattan.

**Microbiological assays**

Month-wise variations in the average values of microbial load in river Beas water (Mean±S.E.) are depicted in Table 1. Site-wise variations in average values of microbial load in the river Beas water are mentioned in Table 2. Maximum and minimum values of microbial load at different sampling sites in the river Beas are presented in Table 3.

**Total plate count (TPC)**

Total plate count (TPC) ranged from 0.32 $x10^4$ to 3.2 $x10^5$ cfu $ml^{-1}$ at different sampling points of the river Beas water. The maximum mean value (3.1 $x10^5$ cfu $ml^{-1}$) of TPC was detected in monsoon months at Harike Pattan followed by Talwara (6.9 $x10^4$ cfu $ml^{-1}$) and Urmar Tanda (5.5 $x10^4$ cfu $ml^{-1}$). The average minimum value (0.33 $x10^4$) was observed in post monsoon month at Talwara site followed by 2.7 $x10^4$cfu $ml^{-1}$in August at Urmar Tanda and 3.3 $x10^4$cfu $ml^{-1}$in June at Harike Pattan. Site-wise mean maximum value of TPC was recorded form Harike Pattan (14.37 $x10^4$ cfu $ml^{-1}$) followed by Urmar Tanda (4.32 $x10^4$ cfu $ml^{-1}$) and Talwara (3.56 $x10^4$ cfu $ml^{-1}$) (Figure8). The mean values differed significantly during different months within the sites and also among the sites ($p<0.05$). The number of total plate count (TPC) varied greatly depending on water origin and across the tested growth conditions. TPC is a bacteriological substrate used for the determination of aerobic, mesophilic organisms that grow in aerobic conditions under moderate temperature.

Seasonal fluctuations revealed that TPC was highest during monsoon month at Harike Pattan and lowest during post-monsoon month at Talwara due to contamination problem emerged from various sources like ill managed waste water treatment plant, sanitary sewer pipes leakage etc. Sood et al (2008) also collected samples from 32 sites in the river Ganga for physico-chemical and microbiological analysis during different season. It was found that the total viable counts (TVC) were in order of magnitude of $10^6$ $ml^{-1}$, which is substantially higher than those prescribed by Bureau of Indian Standards (BIS 2012). The present results obtained for Total plate count and Most probable number were similar to the results obtained by Okonoko et al. (2008). According to ICMSF (1986), TPC level of about $10^7$ is the maximum limit under which a product is considered to be good. However, Lakhmanan et al. (1984) reported TPC above $10^5$ is considered as poor quality. The counts increased gradually from upper stretch to lower stretch, and the Harike Pattan spot (lower stretch) were found to be more contaminated.

**Total Coliform**

The numbers of total coliform bacteria were ranged from 4.0 to 1100 MPN 100 $ml^{-1}$ at different sampling sites of the river Beas throughout the study period. The month of October (post-monsoon) were noticed with maximum numbers (1100 MPN 100 $ml^{-1}$) of total coliform bacteria at Harike Pattan site (Table-3, Figure-9). The lower values (7.0 MPN 100 $ml^{-1}$) of coliforms were reported in monsoon month at Talwara and Harike Pattan followed by 12.33 MPN 100 $ml^{-1}$ at

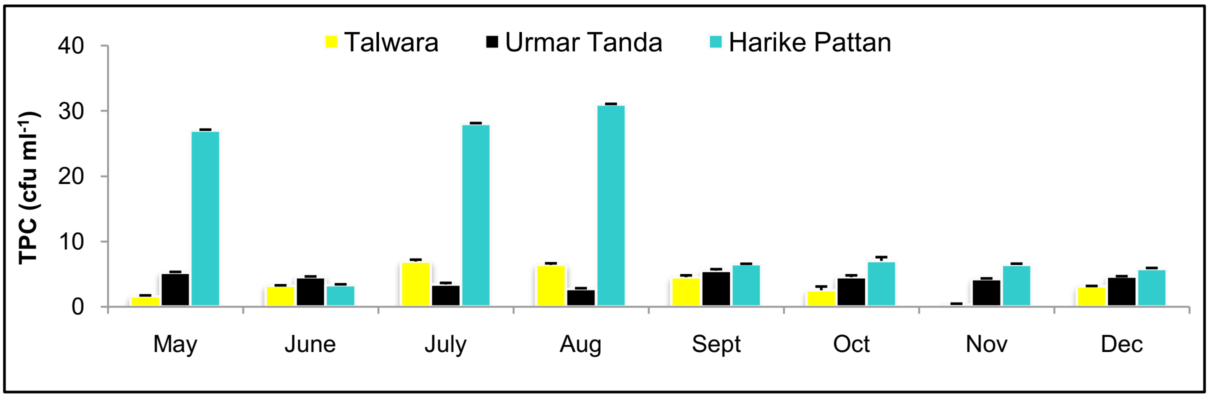


**Figure 8: Monthly variations in Total Plate Count (TPC) (cfu $ml^{-1}$) in water at different stretches of the Beas River during the study period (May 2019-December 2019).**

Urmar Tanda. Overall monthly average coliform abundance (453.55 MPN 100 $ml^{-1}$) was reported in the month of October (post-monsoon). Site-wise average maximum coliforms (314.79 MPN 100 $ml^{-1}$) was recorded at Harike Pattan followed by 141.0 MPN 100 $ml^{-1}$ and 54.25 MPN 100 $ml^{-1}$ at Urmar Tanda and Talwara respectively(Figure9).The mean values differed significantly during different months within the sites and also between the sites ($p< 0.05$).

The maximum recorded value of coliforms at Harike Pattan (lower stretch) during the study period may be attributed to discharge of effluent from thermal power plant located in the vicinity of river Beas as total coliforms also represent the thermo-tolerant bacteria. Presence of thermotolerant coliforms always indicates faecal contamination. Usually, more than 95 per cent of thermotolerant coliforms isolated from water are the gut organism *Escherichia coli*, the presence of which is definitive proof of faecal contamination (Bartram and Balance 1996). Sharma and Walia (2016) reported presence of coliform and *E. coli* during winter in all sampling spots in river Beas in Himachal Pradesh. The permissible limit of total coliform is selected as 5000 MPN $ml^{-1}$ for class C category of water designated for drinking after conventional treatment and disinfection as recommended by CPCB (2012). However, there is no prescribed limit for category D water preferred for propagation of fisheries and wildlife. During the present investigation, total coliform was reported within the recommended limit of CPCB for class C water. Kumar et al.(2017) investigated pollution status in river Beas water, their findings also corroborate with the present study. According to EPA (2003), the permissive level for coliforms should be 0 MPN 100$ml^{-1}$. The BIS (2012) and WHO (2011) has prescribed the nil presence of coliform and *E. coli* in drinking water. Chandran et al. (2009) found that the presence of coliform was higher in sediment than in overlying water of Vembanadu Lake at Kumarakom region.

**Faecal Coliform**

During the study period, the numbers of coliform bacteria ranged from 0.0 - 460 MPN 100 $ml^{-1}$, at different sampling sites of the river Beas. The month of October (post-monsoon) was noticed with maximum

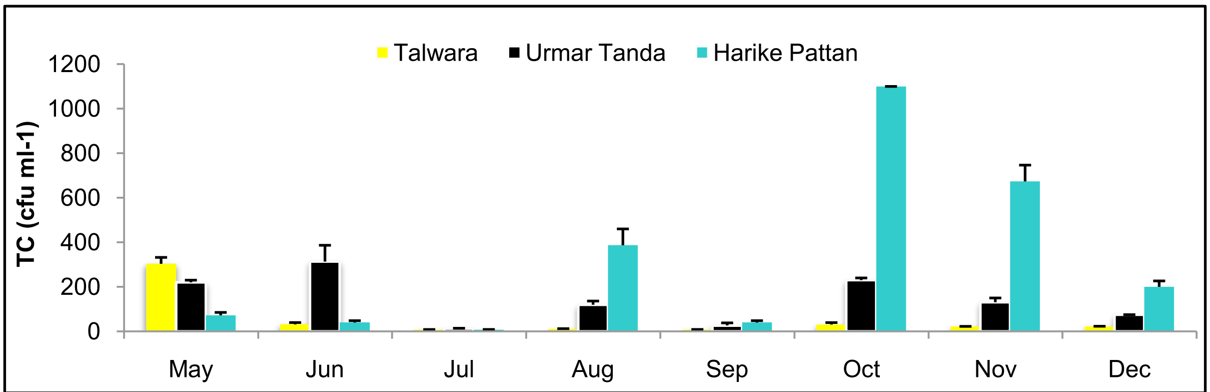


**Figure 9: Monthly variations in Total Coliform (TC) (cfu $ml^{-1}$) in water at different stretches of the Beas River during the study period (May 2019-December 2019).**

numbers (460 MPN 100 $ml^{-1}$) of coliform bacteria at Harike Pattan site followed by 48 MPN 100 $ml^{-1}$ at Urmar Tanda (Table-1, Figure-10). Singh and Singh (2014) investigated the bacteriological profile of river Gomti in Jaunpur at different spots and reported higher count of TC and FC with the conclusion of higher discharge of faecal organic matter in the river.

The minimum mean values (1.33 MPN 100 $ml^{-1}$) of coliforms were reported in October at Talwara followed by 2.33 MPN 100 $ml^{-1}$ in September at Urmar Tanda, whereas minimum value of 3.33 MPN 100 $ml^{-1}$ was recorded at Harike Pattan. Overall monthly average faecal coliform abundance (169.77 MPN 100 $ml^{-1}$) was reported in the month of October (post-monsoon). Site-wise average maximum faecal coliforms (72.74 MPN 100 $ml^{-1}$) was recordedat Harike Pattan followed by 20.91 MPN 100 $ml^{-1}$ and 15.28 MPN 100 $ml^{-1}$ at Urmar Tanda and Talwara respectively (Figure10). Harike Pattan site is the meeting point of river Beas and Sutlej and is also an inhabited area which is receiving comparatively higher faecal matter resulting into faecal pollution. High level of faecal coliform in Harike Pattan site is due to the discharge of untreated sewage in the river which is a matter of grave concern. Faecal coliform levels in Harike Pattan sampling site, which is a majortourist attractiondue to it being a hotspot of migratory birds, Gharial,Smooth-Coated Otter, and freshwater Dolphin, needs to be examined diligently.

The faecal coliform abundance was recorded in the order as post-monsoon>monsoon>pre-monsoon, which was not in agreement with the results of Chandra *et al.* (2006) who studied bacteriological contamination in river Gola water. The values of faecal coliform at different sites during the study period are presented in (Table-2 & 3, Figure-10).The mean values differed significantly during different months within the sampling sites and also between the sites ($p< 0.05$). The higher faecal coliform has indicated the tolerant of high temperature. The result coincides with observation reported by Ravichandran and Ramanibai (1988). Increased numbers of faecal coliforms designate high level of faecal contamination and upgrade risk of water-borne diseases viz; cholera, typhoid, dysentery etc.(Hodegkiss, 1988 and Vaidya *et al.*,2001).

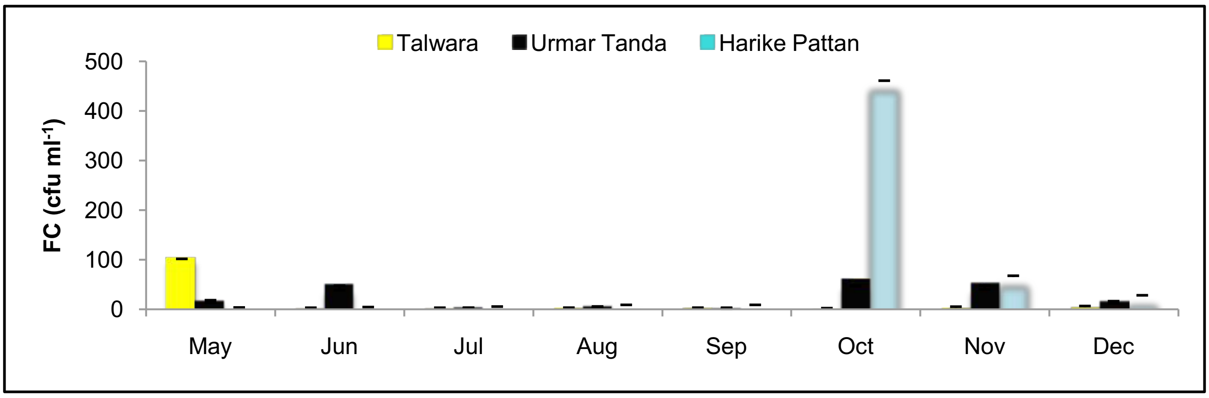


**Figure 10: Monthly variations in Faecal Coliform (FC) (cfu ml$^{-1}$) in water at different stretches of the Beas River during the study period (May 2019-December 2019)**

## CONCLUSION

The ecological evaluation of the river Beas was diligently measured for different selected heavy metalsand microbial load parameters. Overall study revealed that although, water quality at selected sampling sites is suitable to support aquatic life, yet it is recommended that the levels of different heavy metals parameters as well as the microbial load, needs to be monitored regularly. River stretch near Harike Pattan and Urmar Tanda being an important habitat of freshwater Dolphin (*Platanista gangetica minor*) and Ghariyal (*Gavialis gangeticus*) and Smooth-Coated Otter (*Lutrogale perspicilliata*) is more vulnerable to the detrimental levels of heavy metals and the high number of faecal coliform. Talwara had a better water quality as compared to Urmar Tanda and Harike Pattan, which may be attributed to the fact that it is an upstream site of the Kandi area of Punjab state. The pollution load increases in the river as it traverses through the plains of Punjab, up to its emergence into the River Sutlej at Harike Pattan. There is a significant need to create a mass awareness programme among the people in riparian zone of the river Beas regarding water purity, cleanliness, biodiversity conservation and proper management of solid/liquid waste discharge of pollution causing materials including point and non-point sources of pollution.

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