Assessment of Water Quality Variation of River: a Case Study of Beas River, Punjab

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Abstract:Rivers are lifeline of Punjab. But due to urbanisation, industralisation and sewage sludge, the rivers of Punjab have become extremely polluted. This study was conducted to evaluate physio-chemical status of Beas River in Punjab state. The assessment of water quality of the river the water quality is done at five sampling points from 2002 to 2015 in pre-monsoon and post-monsoon season. The physiochemical parameters such as pH, EC, DO, BOD, COD, T. Coli, F. Coli and NO_3 have been analysed. The results were compared with water quality standards prescribed by Bureau of Indian Standards (BIS) and World Health Organization (WHO)[17]. It has been evaluated that the water quality at Beas is good as it enters Punjab at Talwara town, but due to the discharge of industrial effluents and sewage, it depreciates near the town Mukerian, Goindwal and Beas town[1]. But, the quality of water improves at Harike due to self-purification process of the river. The river has high Dissolved Oxygen but is deficient in BOD and COD. According to PPCB (2014), the water quality of River Beas conforms to Class B water category (Outdoor Bathing)[16].

Index Terms: Physio-chemical analysis, Pollution, Chemical Oxygen Demand.

I.INTRODUCTION

Rivers are arteries of human civilization. The river water quality has considerate importance as they sustain urbanisation, industrialization, agriculture, transportation and tourism purposes. But there has been continuous degradation of river water quality due to contamination of river water due to human activities. Availability of fresh water is important for the human life and also for the economic wealth. Societies are depended heavily on rivers, lakes and undergrounds reservoir to supply water for irrigation, drinking and for the industrial unit process. Economically and biologically hydrological ecosystem gives valuable goods and services to the society[2][14][15]

Rivers have become terminating point for urban domestic, industrial and agricultural waste.The Water of acceptable quality is requisite not only for drinking and domestic purposes but also for agriculture, industrial and commercial uses. Surface water is the collection of water on the ground or in a stream, river, lake, wetland, or ocean. Surface water is naturally replenished by precipitation and naturally lost through discharge to evaporation and sub surface seepage into ground water [13]. This pollution has not only affected flora and fauna of river aquatic system but has also affected fresh drinking water resources of our earth[3]. The releases of untreated water in rivers are posing serious health problems to humans like cancer, neurological disorders and stomach disorders. Fertilizers and pesticides used for agricultural lands are washed away by a rain which also, which increases concentration of heavy metal in river water and proliferate algae. Domestic and sewage waste is discharged into rivers in an untreated condition which includes detergent and fecal matter. The contamination of surface water resources leads to alterations in physical and chemical properties of water which has far-reaching inferences on our ecosystem.Thus,to evaluate river water quality, various physiochemical parameters need to be identified with their acceptable limits prescribed by Bureau of Indian Standards and World Health Organization[4][5].

II.THE STUDY AREA

River Beas was also called Hyphasis in Greek and Vipasa in Vedas. Its Origin Lies in Beas kund in the Southern Face of Rohtang Pass of Dholadhar Range at the altitude of 4060 meters, from here it flows in the famous towns of Kullu and Manali. A barrage is constructed at Pandoh in Mandi District. It enters Kangra at an altitude of 630 meters. The left tributaries of Beas are Parvati and Suketri and right tributaries are Uhal and Lambi. The rivers enter Punjab at Talwara district, where Pong dam has been constructed.Many Choes and Khads join river Beas near Talwara.Kandi Canal at MukerianHydal Channel has also been taken off. The river forms boundary between Amritsar and Kapurthala. The River Beas joins River Satluj at Harikewhere many marshes and swamps are found near River Beas like KahnuwalChamb, Mukerian and kalabaghChamb. The total length of the river is 470 Kilometers[7][8].

III. BEAS RIVER

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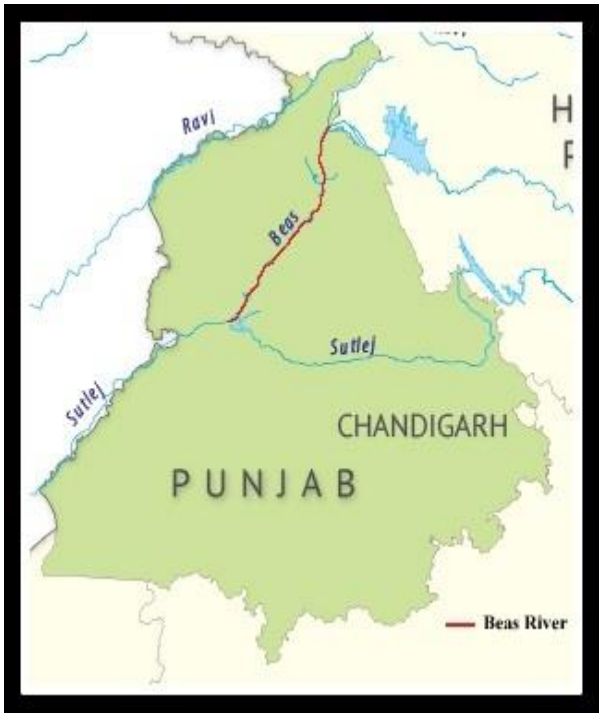


Source: Maps of India

Table 1: Water Quality Monitoring Locations at River Beas.

Sr. No	Sampling Points	Station
1	Beas at Talwara H/W	B1
2	D/S Pathankot	B2
3	Beas 1 Km D/S effluent discharge point at Mukerian	B3
4	Beas at 100 meters. D/S Industrial discharge point Goindwal	B4
5	Beas at Harike	B5

IV. MATERIAL AND METHODS

Effective monitoring of parameters in river water is an important step for controlling the river pollution. River Beashas been monitored for pre-monsoon season and post-monsoon season from the year 2002 to 2015. The data is sourced from Punjab Pollution Control Board (PPCB), Patiala.On various locations, industrial effluents and domestic sewage waste are discharged into the rivers. For this, various strategic points are selected to analyse various parameters in the river. Five sampling stations have been selected from river Ghaggar. The description of sampling stations has been given in **Table 1**. The physio-chemical parameters such as pH, Electrical Conductivity (EC), Dissolve Oxygen(DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), T. Coli (Total Coliform), F. Coli (Faecal Coliform) and Nitrate (NO_3) have been analysed in the present study.The results were compared with water quality standards prescribed by Bureau of Indian Standards (BIS) and World Health Organization (WHO). Descriptive statistics were employed foranalysing the data like mean, standard deviation, minimum and maximum values of the parameters were used for describing the data.

Therefore, the monitoring of physiochemical quality of water helps to keep vigil on water deterioration.The study was carried out with the following objectives:

1. To explore the physio-chemical characteristics of RiverBeas.
2. To quantify and study theseasonal distribution of various parameters of River Beas.
3. To understand the quality of water spatially and temporally at different sampling points.

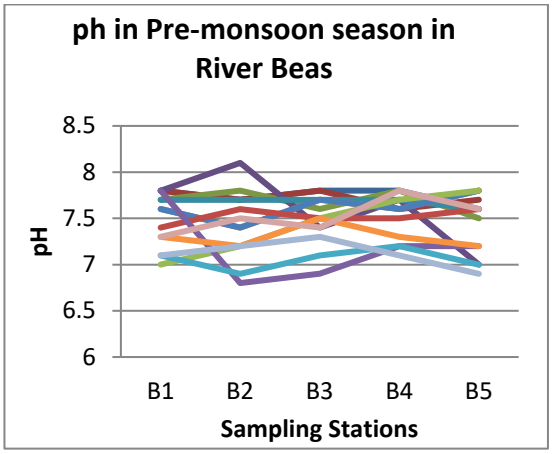
V.RESULTS AND DISCUSSIONS

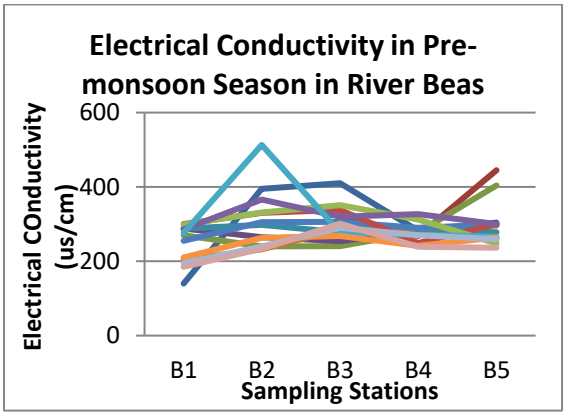
Physiochemical Analysis of River Beas: The statistical results with respect to Mean and Standard Deviation for surface water quality of River Beas with the standard parameters prescribed by WHO and BIS standards are summarized in **Table 2**. The graphical spatial and temporal variation of physio-chemical parameters of Beas River is represented in **Figure 1.** The detailed results of physio-chemical parameters are represented as follows:

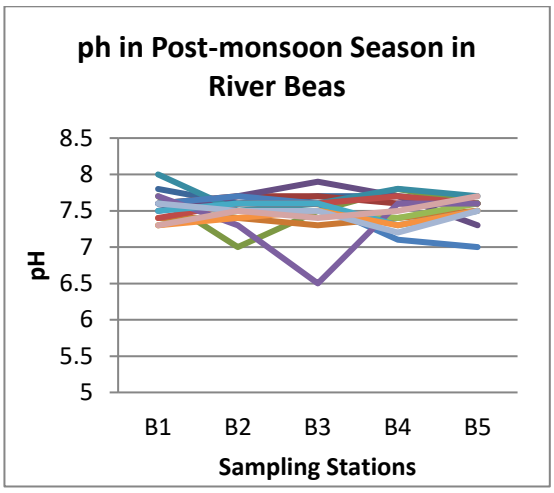
Table 2. Descriptive Statistics of Water Quality Parameters of River Beas.

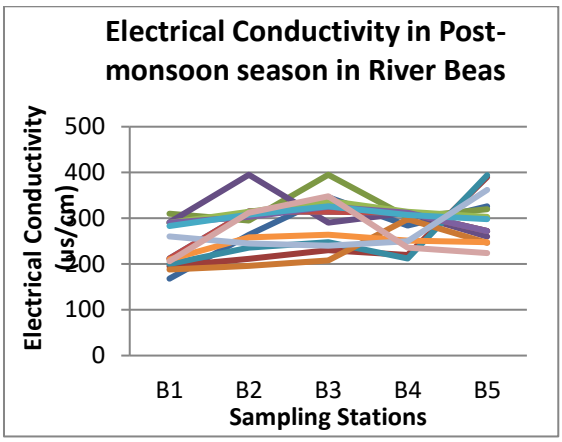
Parameters	Pre-monsoon Season		Post-monsoon Season		Parameter Standards	
	Mean	Standard Deviation	Mean	Standard Deviation	WHO	BIS
pH	7.514	.178	7.485	.10737	7-8.5	6.5-8.5
DO	7.3688	.5288	7.303	.459	6	6
EC (µs/cm)	288.24	56.448	286.87	47.693	-	-
COD (mg/l)	4.161	1.539	4.155	1.969	10	-
BOD (mg/l)	1.1071	0.643	1.169	0.939	6	2
T.Coli (MPN/100 ml)	921.45	828.23	1130.77	1009.17	-	-
F.Coli (MPN/ 100 ml)	177.92	115.69	189.01	178.29	-	-
NITRATE (mg/l)	1.368	0.576	1.2160	0.442	45	45

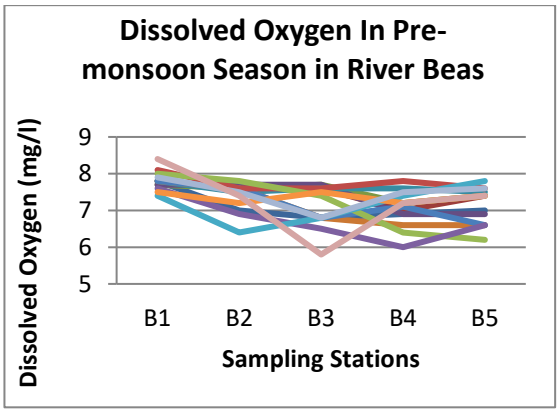
Figure1. Graphs showing the variation of parameters at all sampling stations in River Beas in Pre-monsoon and Post-monsoon season (2002-2015).

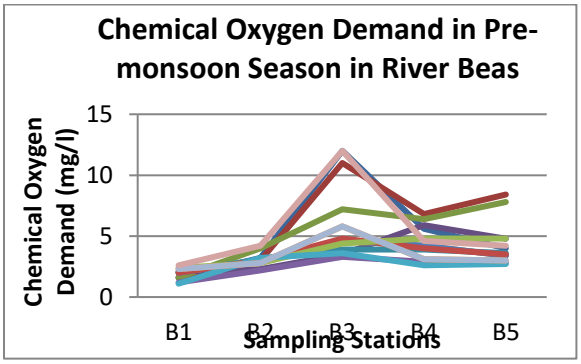

ph in Pre-monsoon season in River Beas
pH
8.5
8
7.5
7
6.5
6
B1
B2
B3
B4
B5
Sampling Stations

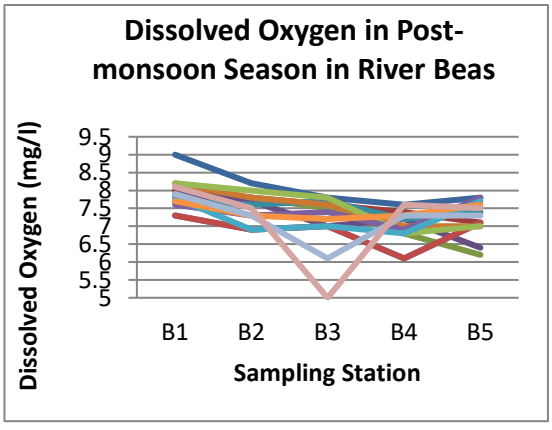

Electrical Conductivity in Pre-monsoon Season in River Beas
Electrical COnductivity (us/cm)
600
400
200
0
B1
B2
B3
B4
B5
Sampling Stations

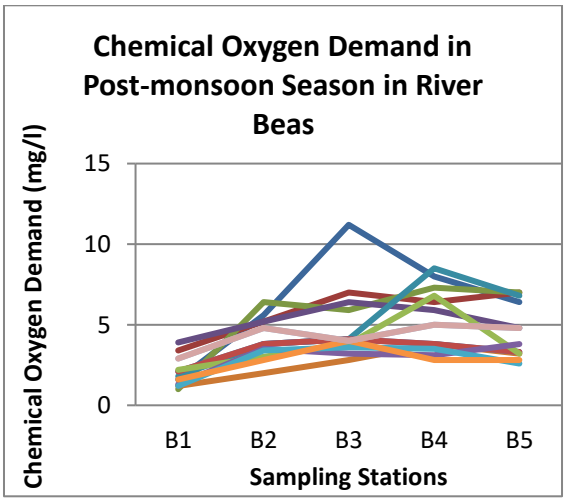

ph in Post-monsoon Season in River Beas
pH
8.5
8
7.5
7
6.5
6
5.5
5
B1
B2
B3
B4
B5
Sampling Stations

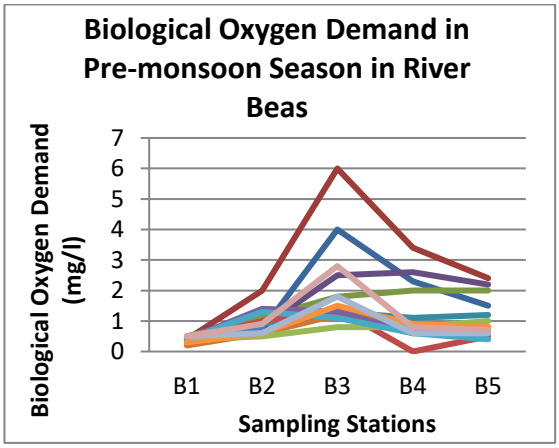

Electrical Conductivity in Post-monsoon season in River Beas
Electrical Conductivity (us/cm)
500
400
300
200
100
0
B1
B2
B3
B4
B5
Sampling Stations

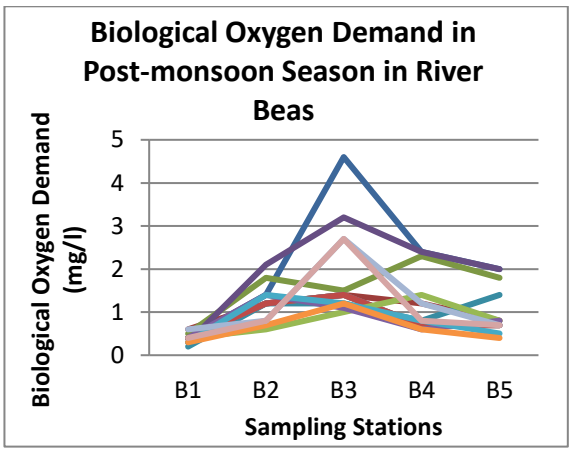

Dissolved Oxygen In Pre-monsoon Season in River Beas
Dissolved Oxygen (mg/l)
9
8
7
6
5
B1
B2
B3
B4
B5
Sampling Stations

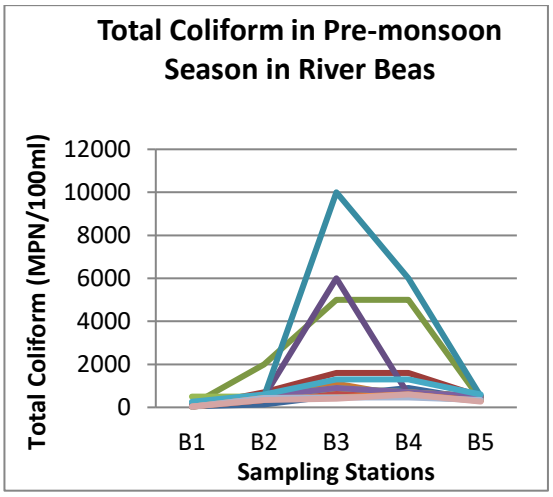

Chemical Oxygen Demand in Pre-monsoon Season in River Beas
Chemical Oxygen Demand (mg/l)
15
10
5
0
B1
B2
B3
B4
B5
Sampling Stations

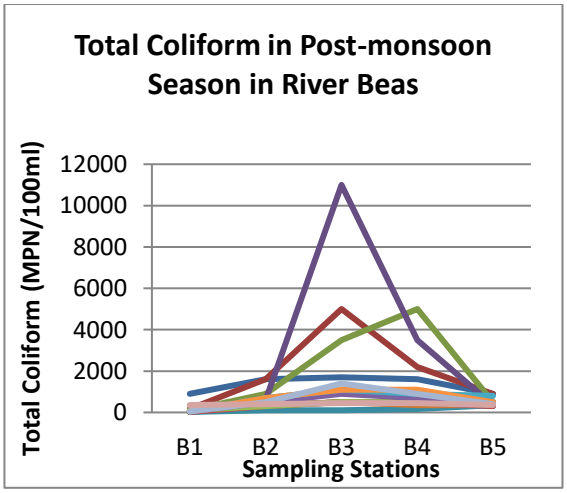

Dissolved Oxygen in Post-monsoon Season in River Beas
Dissolved Oxygen (mg/l)
9.5
8.5
7.5
6.5
5
B1
B2
B3
B4
B5
Sampling Station

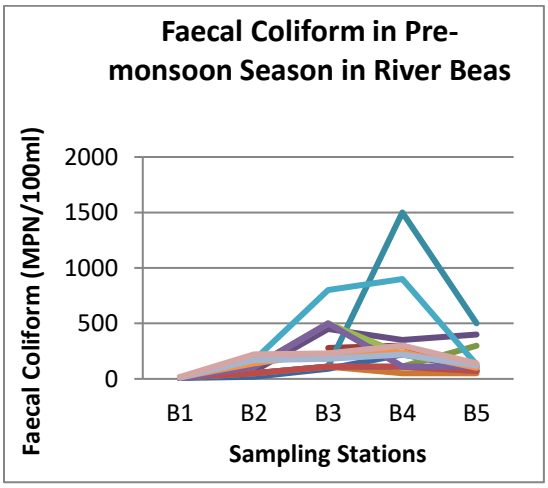

Chemical Oxygen Demand in Post-monsoon Season in River Beas
Chemical Oxygen Demand (mg/l)
15
10
5
0
B1
B2
B3
B4
B5
Sampling Stations

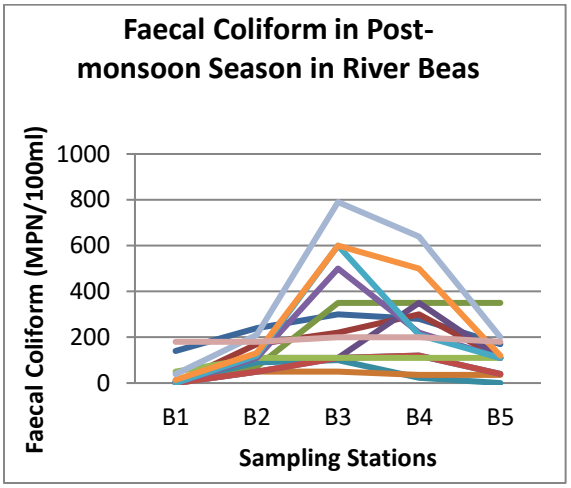

Biological Oxygen Demand in Pre-monsoon Season in River Beas
Biological Oxygen Demand (mg/l)
0
1
2
3
4
5
6
7
B1
B2
B3
B4
B5
Sampling Stations

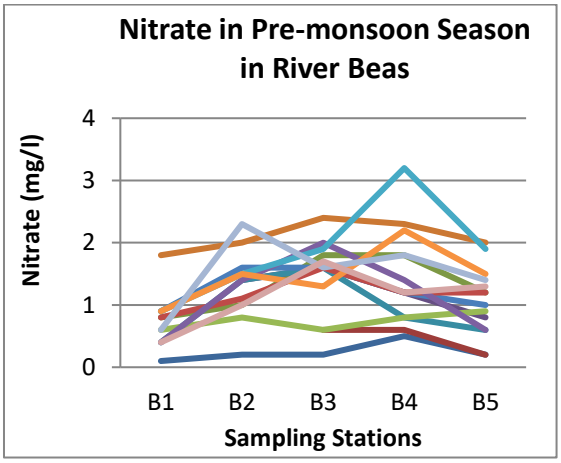

Biological Oxygen Demand in Post-monsoon Season in River Beas
Biological Oxygen Demand (mg/l)
0
1
2
3
4
5
B1
B2
B3
B4
B5
Sampling Stations

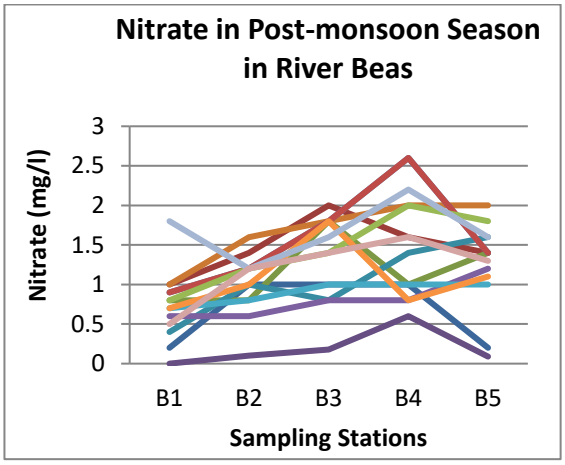

Total Coliform in Pre-monsoon Season in River Beas
Total Coliform (MPN/100ml)
0
2000
4000
6000
8000
10000
12000
B1
B2
B3
B4
B5
Sampling Stations


Total Coliform in Post-monsoon Season in River Beas
Total Coliform (MPN/100ml)
0
2000
4000
6000
8000
10000
12000
B1
B2
B3
B4
B5
Sampling Stations


Faecal Coliform in Pre-monsoon Season in River Beas
Faecal Coliform (MPN/100ml)
0
500
1000
1500
2000
B1
B2
B3
B4
B5
Sampling Stations


Faecal Coliform in Post-monsoon Season in River Beas
Faecal Coliform (MPN/100ml)
0
200
400
600
800
1000
B1
B2
B3
B4
B5
Sampling Stations


Nitrate in Pre-monsoon Season in River Beas
Nitrate (mg/l)
0
1
2
3
4
B1
B2
B3
B4
B5
Sampling Stations



Source: Table 2

A. pH in River Beas: The mean value of pH in river Beas in pre-monsoon season in river Beas lies between 7.3 to 7.6. The minimum value of 7 has been observed in River Beas at Talwara Headwork in 2002. The maximum value of pH of 8.2 has been observed in River Beas at 100 meters downstream industrial discharge point, Goindwal Sahib in 2005. The standard deviation of pH in pre-monsoon season lies between 0.1 to 0.8. The mean value of pH in river Beas in post-monsoon season in river Beas lies between 7.06 to 7.72. The minimum value of 6.8 of pH has been observed at downstream of Pathankot in 2011. The maximum value of pH of 8.1 has been observed at downstream of Pathankot in 2005. The standard Deviation of pH in post-monsoon season lies between 0.08 to 0.4 It has been observed that pH is within permissible limits at all sampling stations of Beas.

B. Dissolved oxygen in River Beas: The mean Dissolved Oxygen values in pre-monsoon season for 2002-2015 in River Beas lies between 6.72 mg/l to 7.5 mg/l. The maximum value of Dissolved Oxygen of 8.4 mg/l has been observed at Talwara headwork in 2015, whereas the minimum value of Dissolved Oxygen of 5.8 mg/l has been observed at the Beas 1 km downstream effluent discharge point at Mukerian in 2015. The standard Deviation of Dissolved Oxygen of river Beas ranges from 0.2 mg/l to 1.22 mg/l in pre-monsoon season. The mean Dissolved Oxygen values in the post-monsoon season for 2002-2015 in River Beas lies between 6.8 to 8.08 mg/l. The maximum value of Dissolved Oxygen of 9mg/l has been observed at Talwara headwork, whereas, the minimum value of Dissolved Oxygen of 5mg/l has been observed at 1 km downstream, effluent discharge point at Mukerian in 2015. The standard deviation of Dissolved Oxygen of river Beas ranges from 0.2 to 1.22 mg/l in post-monsoon season. The data shows that decrease in Dissolved Oxygen is observed at B3 and B4 sampling stations as; these sampling stations receive an industrial discharge from Mukerian and Goindwal Sahib, which increases the demand of oxygen in the water. The high value of Dissolved Oxygen at B1, B2 and B5 point as these sampling stations do not receive any impurity and discharge, which leads to good oxygen levels in water.

C. Electrical Conductivity in River Beas: The mean Electrical Conductivity in pre-monsoon season for 2002-2015 in River Beas lies between 260 um/cm to 323 um/cm. The maximum value of Electrical Conductivity of 513 um/cm has been observed at downstream Pathankot in 2002, whereas, the minimum value of Electrical Conductivity of 140 um/cm has been observed at the Talwara Headwork in 2002. The standard Deviation of Electrical Conductivity of river Beas ranges from 8.3 to 110.2 um/cm. The mean Electrical Conductivity in post monsoon season for 2002-2015 in River Beas lies between 227 um/ cm to 580 um/cm. The maximum value of Electrical Conductivity of 862 um/cm has been observed at Beas Harike, whereas the minimum value of Electrical Conductivity of 168 um/cm has been observed at the Talwara Headwork in 2002. The standard Deviation of Dissolved Oxygen of river Beas ranges from 15.6 us/cm to 199 us/cm. Electrical Conductivity represents dissolved impurities, which is high at B2 and B3 sampling stations due to the discharge of domestic and industrial effluents.

D. Chemical Oxygen Demand in River Beas: The mean Chemical Oxygen Demand in pre-monsoon season for 2002-2015 in River Beas lies between 2.4 mg/l to 8.45 mg/l. The maximum value of Chemical Oxygen Demand of 14.4 mg/l has been observed at Beas at Harike in 2003, whereas the minimum value of Chemical Oxygen Demand of 1.1 mg/l has been observed at the Talwara Headwork in 2012. The standard Deviation of Chemical Oxygen Demand of river Beas ranges from 0.7 mg/l to 5.8 mg/l. The mean Chemical Oxygen Demand in post monsoon season for 2002-2015 in River Beas lies between 2 mg/l to 6.5mg/l. The maximum value of Chemical Oxygen Demand of 14 mg/l has been observed at Beas 1 Km downstream, effluent discharge point at Mukerian in 2015, whereas the minimum value of Chemical Oxygen Demand of 1 mg/l has been observed at the Talwara Headwork in 2002. The standard Deviation of Chemical Oxygen Demand of river Beas ranges from 0.7 to 4.3mg/l. But, according to WHO (2004), the permissible limits of Chemical Oxygen Demand in drinking water is 10mg/l. The high COD values are detected B3 and B4, due to contamination of water by industrial discharge by Mukerian and Goindwal Sahib.

E. Biological Oxygen Demand in River Beas: The mean Biological Oxygen Demand in pre-monsoon season for 2002-2015 in River Beas lies between 0.7 mg/l to 1.7 mg/l. The maximum value of Biological Oxygen demand of 4 mg/l has been observed at Beas 1 Km downstream, effluent discharge point at Mukerian in 2002, whereas the minimum value of Biological Oxygen Demand of 0.2 mg/l has been observed at Talwara in 2007. The standard deviation of Biological Oxygen Demand of river Beas ranges from 0.3 to 2.3. The mean Biological Oxygen Demand in post monsoon season for 2002-2015 in River Beas lies between 0.6 mg/l to 2.16mg/l. The maximum value of Biological Oxygen demand of 4.6 mg/l has been observed at Beas 1 Km downstream effluent discharge point at Mukerian in 2002, whereas the minimum value of Biological Oxygen Demand of 0.2 mg/l has been observed at Talwara in 2006.

The standard deviation of Biological Oxygen Demand of river Beas ranges from 0.3 to 1.06 mg/l. Higher values of BOD are witnessed at B3 and B4

F. sampling stations, as high demands of oxygen representpresence of organic material, which consumes oxygen for decomposition of organic matter. At B3 sampling station, Biological Oxygen Demand exceeds the permissible limits.

G. Total Coliform in River Beas: The average values of T.Coli in 2002-2015 lie between 152 to 2002 MPN/100ml in pre-monsoon season. The maximum Value of T.Coli of 5,000 MPN/100ml lies at the Beas 1 km downstream effluent discharge point at Mukerian, whereas the minimum value of T.Coli 23 MPN/100ml lies at Talwara in 2006. The standard deviation of T. Coli in River Beas lies between 45 MPN/100ml to 2137 MPN/100ml in pre-monsoon season. The increasing trend of Total Coliform has been observed at the sampling stations sampling station points of B3 and B4, where, there is high discharge. High values of Total Coliform represent the presence of bacteria which are harmful to drinking water. The average values of Total Coliform in 2002-2015 lie between 398 to 3,542 MPN/100 ml in post-monsoon season. The maximum Value of Total Coliform of 11,000 MPN/100 ml lies at the Beas 1 km downstream, effluent discharge point at Mukerian in 2006, whereas the minimum value of Total Coliform 28 MPN/100 ml lies at Talwara in 2006. The standard deviation of Total Coliform in River Beas lies between 178 to 4,602 MPN/100 ml.The increasing trends observed, has been observed at sampling points B3 and B4. Higher values of Total Coliform represent the bacteria which are harmful to drinking water. According to BIS (2012), there should be no presence of Total Coliform in drinking water.

H. Faecal Coliform in River Beas: The mean values of F. Coli in river Sutlej from 2002 to 2015 lies between 70.6 MPN/100ml to 433.6 MPN/100ml in pre-monsoon season. The minimum values of F. Coli in pre-monsoon season of 8 MPN/100ml is observed at Talwara Headwork in 2012, whereas the maximum value of 900 MPN/100ml is observed at Beas at 100 meters, downstream industrial discharge point Goindwal in River Beas. The standard deviation of F. Coli in pre-monsoon season in River Sutlej lies between 35 MPN/100ml to 415 MPN/100ml. The mean values of Faecal Coliform from 2002 to 2015 lies between 42 MPN/100 ml to 375 MPN/100 ml in post-monsoon season. The minimum value of 2 MPN/100 ml in Faecal Coliform has been observed at Talwara in 2003, whereas, the maximum value of 790 MPN/100 ml has been observed at downstream of Beas 1 km downstream effluent discharge point at Mukerian in 2014. The standard Deviation of F. Coli in River Beas lies between 8.66 MPN/100 ml to 321.4 MPN/100 ml. The increasing trends of F. Coli are observed at B3 and B4 sampling stations. The presence of F.Coli bacteria in drinking water does not have any permissible limits, as it can cause gastrointestinal problems. The **fig. 7.2.** shows that at the sampling stations B3 and B4, domestic and municipal effluents are discharged, which signifies the presence of Faecal Coliform at these sampling stations.

I. Nitrate in River Beas: The mean value of Nitrate in river Beas in pre-monsoon season in river Beas lies between 0.2 to 2.12 mg/l. The minimum value of 0.1 mg/l of Nitrate has been observed at River Beas at Talwara Headwork in 2002. The maximum value of Nitrate of 3.2 mg/l has been observed at 100 meters downstream, industrial discharge point Goindwal in 2014. The standard deviation of Nitrate has been observed between 0 to 0.4 mg/l in river Beas. The nitrate levels in River Beas are within permissible limits as prescribed by BIS (2012). But the high concentration of Nitrate is visible at B3, B4 and B5 points due to industrial discharge at Mukerian and Goindwal Sahib, which contaminates the river water. The mean value of NO_3 in River Beas in post-monsoon season in River Beas lies between 0.68 mg/l to 3.42 mg/l. The minimum value 0.09 mg/l of Nitrate has been observed at Harike in 2005. Whereas, the maximum Nitrate value of 4.9mg/l has been observed at downstream of Pathankot in 2014. The standard deviation of Nitrate has been observed between 0.1 mg/l to 1.13 mg/l in river Beas. Nitrate levels in River Beas are within permissible limits as prescribed by BIS (2012). But the high concentration of Nitrate is visible at B3, B4 and B5 sampling points due to industrial discharge at Mukerian and Goindwal Sahib, which contaminates the river water.

VI.SUMMARY OF THE FINDINGS

According to Kumar V. et al. (2017) reviewed the pollution status of River Beas, India. They prepared water quality index using nine parameters, which was found to be 60.93. Higher values were observed of Dissolved Oxygen, Biological Oxygen Demand, Chemical Oxygen Demand, and Total Coliform were found above permissible limits of BIS for drinking water. The ranges of Pb, Cr, Ni, Fe and Mn exceed the permissible limits of BIS for drinking water, whereas, Cd, Cu, and Zn have been found below the permissible limits. The Water Quality Index of River Beas has been rated as medium quality 6].

Sharma and monitored the water quality status of Himachal Pradesh in the summer season in Himachal Pradesh. The parameters such as alkalinity, conductivity, pH, Biological Oxygen Demand, T.Coli, and E.Coli were analysed at Beas Kund, Shamshi, Pandoh Dam, Dharmpur, Nadaun and Pong Dam. All physio-chemical parameters were found within prescribed limits of WHO except Cadmium, Iron, E. Coli and T.Coli in all sampling station In another study investigated the water quality status of River Beas in Himachal Pradesh in the winter season Himachal Pradesh. They observed physical, chemical and biological parameters during the winter season. All parameters were found within the prescribed limits of WHO and BIS, except pH at. The data also revealed that turbidity, cadmium, and lead, were found beyond acceptable limits prescribed by Bureau of Indian Standards (BIS), 2012 for drinking water in India.The metal content in River Beas was analysed by Sharma and in Himachal Pradesh. They estimated that Ca, Mg, K, Na, Cu were found to be within permissible limits prescribed by WHO and BIS. However, Cd and Pb were found to be higher than permissible limits. They concluded that River Beas needs bio-monitoring as both Cd and Pb can lead to toxicity in

drinking water, thus, affect flora and fauna of ecosystem 9][10][11][12].

VII. CONCLUSION

Therefore, it can be concluded that the water quality of river Beas is good as it enters Punjab at Talwara town, but due to the discharge of industrial effluents and sewage, it depreciates near the town Mukerian, Goindwal and Beas town. These problems are mainly from anthropogenic factors like encroachment by the industrialists and local people for their personal needs (Solanki and Joshi, 2017). But, the quality of water improves at Harike due to self-purification process of the river. The river has high dissolves Oxygen and less BOD and COD. Increase in F.Coli is evident at 1 km downstream effluent discharge from Mukerian town. The water quality upgrades as it reaches Harike, due to self- purification process. According to PPCB (2014), the water quality of River Beas conforms to Class B water category (Outdoor Bathing).

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