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Correlation Study on Physicochemical Parameters of River Ganga during Different Seasons in Haridwar

Vani Sharma* and Padma Singh
Department of Microbiology, KanyaGurukul Campus, GurukulKangriVishwavidhyalaya, Haridwar- 249407
Email: vanisharma1988@gmail.com, drpadmasingh06@gmail.com

Abstract: River Ganga was considered to be the holy river in India and Haridwarconsidered to be a holy city due to the presence of holy river Ganga. A study was conducted to check the water quality of river water by taken under consideration 8 physicochemical parameters i.e. pH, Temperature, Total Dissolved Solid (TDS), Conductivity, Turbidity, Biological Oxygen Demand (BOD), Dissolved Oxygen (DO) and 7 Heavy metals i.e. Arsenic, Mercury, Cadmium, Chromium, Copper, Nickel and Iron during different season (Summer, Monsoon and Winters) at 4 different sites (Bhimgodha, Prem- Nagar, Kankhal and Jwalapur) of city. The different parameters was compairedwith the standards provided by WHO, BIS, etc. It was observed that thephysico- chemical parameters were mostly within the standard limits during the different seasons, but the load of heavy metals varies seasonally, the monsoon season faces more load, followed by summer and least in winter season. The deterioration of water quality during monsoon season is due to poor sanitation condition, soil erosion, turbulent flow and high anthropogenic activities.

Keywords: Ganga, Physicochemical parameters, Heavy metals, ICP-MS, APHA

1. INTRODUCTION:

Ganga is one of the river which fulfill the requirement of vast area in India, it arises from Garhwal Himalayas as a Bhagirathi and have a approximately a run of 2525 km and finally fall in Indian Ocean at Bay of Bengal (Yadav and Srivastava, 2011). Increased in population and industrialization, demand of freshwater increases which was fulfilled by the rivers which provide water for various human activities (Gupta*et al*.,2017).Increased urbanization and industrialization the problem of river pollution is also mushrooming day by day and reaches to crisis and further deteriorate the water quality. The factors which basically deteriorate the water quality of river Ganga is disposal of dead bodies, Discharge of sewage and industrial waste, agriculture run off, disposal of various veneration items directly in river Ganga. For effective maintenance of water quality through appropriate control measures, continous monitoring of physico-chemical parameters are necessary (Bhandari and Nayal, 2008). DO and BOD are used to check the pollution level of aqueous system directly. Contaminated water may also contain the various heavy metals, it is a metals having a density of 5g/cm^3, these metals are highly toxic to the environment and in turn to humans, they are associated with deadly disease of humans such as cancer, The organic forms of heavy metals have been reported to be very toxic and adversely affects water quality. It is not necessary that low pH values of water shows the presence of heavy metals such as Zn, Cd, As, etc, shows their presence at neutral pH (Sharma and Singh, 2015). Thus a regular analysis of water quality start fading off the appropriate measure can be taken to prevent these valuable rivers for our future generations.

2. MATERIAL AND METHODS:

2.1. Site Description: Total 4 sites had been selected on the bank of river Ganga at Haridwar , which were Bhimgodha, Prem-Nagar, Kankhal and Jwalapur.

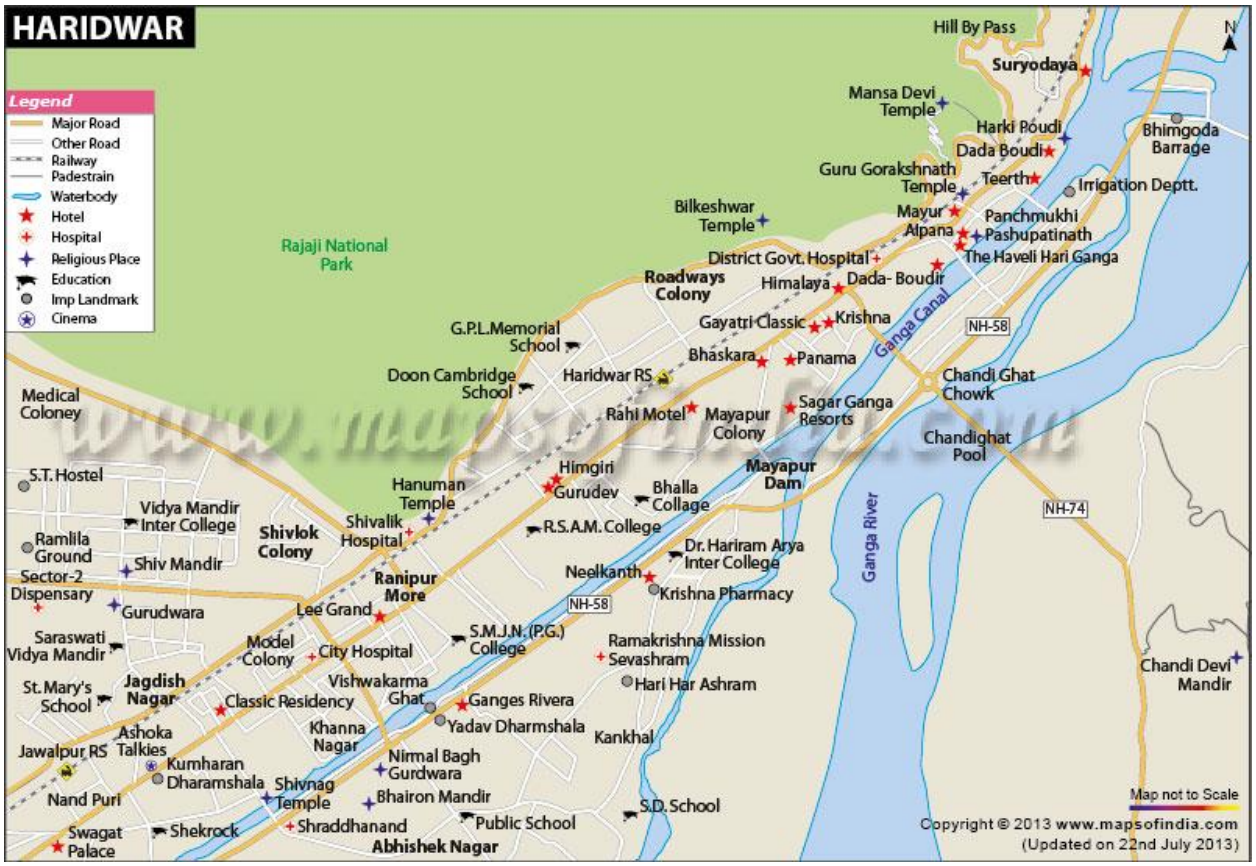

Fig 1: Map showing the sampling sites of Ganga river used in the study

Bhimgodha-(N 29°60' 25.9''/ E 078° 14'28.1'').It is at 500m from HarkiPauri, it is a barrage on the Ganges river, it is a site of high tourist interest as this sites have many mythological sites, here the Ganga meets the waste of most of the hotels, dharamshala and residential sewage.

Prem- Nagar-(N 29°55'48.8''/E 078° 08'10.3'').It is the site where one of the oldest ashram is situated along with this include the basic residential area of Haridwar and hence contribute to anthropogenic and mythological wastes.

Kankhal-(N 29°63'92.6''/E 078°14'6.3'').Kankhal is a small colony in Haridwar, Kankhal is one of Panchtirth within Haridwar. It is a site where according to hindu religion ash of dead bodies made to dump in Ganga and various sewage opening dump direct sewage in river.

Jwalapur-(N 29°71'92.7''/E 078°10'8.0''). It is the site of Haridwar where a large number of sewage opening dump the human sewage directly in the river at Jatwara Bridge various human activities such as bathing, washing of clothes and disposal of industrial waste pollute Ganga River.

2.2 Sampling- Water sample were collected from the above mentioned sites in a clean sampling bottles around 10 am and carried to the laboratory in cold condition and were analyzed within 7 hours of collection.

2.3. Physicochemical Parameters and Heavy Metals Analysis- The physico- chemical parameters were determined by the standard method for the analysis of water APHA (2012). For heavy metal analysis the water samples were collected and are filtered with vaccum filter and then the water sample was analyzed for the presence of different heavy

metals by the ICP-MS technique (Malassa*et al*., 2013).

2.4. Statistical analysis- Observed data was statistically analyzed by determining the correlation between the different parameters. Correlation is a bivariate analysis that measure the strength of association between two variables and the direction of the relationship, the value of the correlation varies between +1 and -1and a value of ± 1 indicates a perfect association between the two variables. Pearson (r) correlation is the most widely used correlation it is the correlation to determine the strength of relationship, correlation coefficient between 0.10 and 0.29 represent a small association, 0.30 and 0.49 represent a medium association, and the coefficient of 0.5 represent a large association between two variables (Bhandari and Nayal, 2008).Further data was statistically analyzed by using Analysis of Variance (ANOVA) to determine the seasonal and spatial variations of mean concentrations of different heavy metals in the Ganga water (Elbag, 2006).

3. RESULTS AND DISCUSSION:

The various physicochemical parameters which were considered during summers, winters and Monsoon are pH, Total Dissolved Solids, Turbidity, Conductivity, Free CO_2, Biological Oxygen Demand, Dissolved Oxygen and the heavy metals such as Arsenic(As), Mercury(Hg), Cadmium (Cd), Chromium (Cr), Copper (Cu), Nickel (Ni) and Iron (Fe).Each analysis was done in triplicates and the mean value was taken.

Table 1: Standards for drinking water

Characteristics	ICMR	WHO	CPCB	BIS-IS:10500-2012
pH (pH units)	7.0-8.5	7.0-8.5	Class A- 6.5-8.5	Class A-6.5-8.5
			Class B- 6.5-8.5	Class B- 6.5-8.5
			Class C- 6.5-9.0	Class C- 6.5-8.5 and Permissible – no relaxation
TDS (mgL^{-1})	500	500	-	ClassA-500 mgL^{-1}
				ClassB-500 mgL^{-1}
				ClassC-1500 $mgL^{-1}$and permissible-2000 mgL^{-1}
Temperature (^0C)	-	-	-	-
Turbidity (NTU)	5	2.5	-	Desirable-05 NTU Permissible- 10NTU
BOD (mgL^{-1})	-	-	Class A- 2mgL^{-1} Class B- 3mgL^{-1} Class C- 3mgL^{-1}	Class A- 2mgL^{-1} Class B- 3mgL^{-1} Class C- 3mgL^{-1} and no relaxation (permissible)
DO (mgL^{-1})	-	-	Class A- 6mgL^{-1} Class B- 5mgL^{-1} Class C- 4mgL^{-1}	Class A- 6mgL^{-1} Class B- 5mgL^{-1} Class C- 4mgL^{-1} and No relaxation (permissible)
Free CO_2(mg/ml)	-	10	-	10
Conductivity (µs/cm)	-	-	-	750
Chromium (mg/L)		0.05		0.003-no relaxation

		(permissible)
Copper (mg/L)	0.05	0.05-1.50
Iron (mg/L)	0.3	0.3- no relaxation (permissible)
Mercury (mg/L)	0.001	
Cadmium (mg/L)	0.02	0.03-no relaxation (permissible)
Nickel (mg/L)	0.02	
Arsenic (mg/L)	0.01	

Table 2: Water Quality Data of river Ganga during different season at different sites (Average of triplicates ± SEM)

Parameters	Units	Jwalapur	Prem- Nagar	Kankhal	Bhimgodha
Winters					
pH		8.351 ± 0.57	7.674 ± 0.33	9.289 ± 0.88	10.265 ± 0.57
Conductivity	µs/cm	215.66 ± 0.66	202 ± 1	645 ± 35.16	279.66 ± 1.45
Temperature	^{0}C	10.76 ± 0.66	9.66 ± 0.33	10.46 ± 0.88	10.66 ± 1.20
TDS	ppm	75.33 ± 2.60	73 ± 4.35	96.33 ± 1.45	97.33 ± 0.66
Free CO_2	mg/ml	16.09 ± 1.20	20.08 ± 1.15	32 ± 3.05	22.33 ± 1.45
DO	mg/L	10.26 ± 1.54	11.92 ± 0.88	11.2 ± 1.33	11.06 ± 0.33
BOD	mg/L	1.13 ± 0.33	3.2 ± 0.57	1.533 ± 0.57	1.16 ± 0.33
Turbidity	NTU	0.025 ± 0	0.024 ± 0	0.02 ± 0.33	0.009 ± 0
Summers					
pH		7.833 ± 0.38	7.73 ± 0.33	7.366 ± 1.15	7.29 ± 0.24
Conductivity	µs/cm	1002 ± 25.54	557 ± 20.79	1010 ± 2.88	847.3 ± 14.49
Temperature	^{0}C	25 ± 1.93	20.3 ± 0.35	21.84 ± 1.35	28.33 ± 1.85
TDS	ppm	76 ± 3.21	70.56 ± 4.70	171.3 ± 70.6	97.66 ± 8.19
Free CO_2	mg/ml	97.42 ± 0.66	119.33±10.11	78.48 ± 4.16	25.23 ± 0.66
DO	mg/L	10.14 ± 1.15	8.8 ± 0.33	7.53 ± 1	8.5 ± 0
BOD	mg/L	4.48 ± 0	3.8 ± 0.33	1.73 ± 0.30	1.46 ± 0.33
Turbidity	NTU	0.18 ± 0	0.22 ± 0	0.28 ± 0	0.26 ± 0
Monsoon					
pH		8.088 ± 0.31	7.425 ± 0.82	7.811 ± 0.18	7.36 ± 0.57
Conductivity	µs/cm	1900 ± 17.32	983 ± 2.08	1085 ± 2.88	1050 ± 0.5
Temperature	^{0}C	17.66 ± 1.45	19.86 ± 0.88	18.9 ± 0.66	18.4 ± 1.15
TDS	ppm	94 ± 3.05	90 ± 1.15	301 ± 15.60	267 ± 21.85
Free CO_2	mg/ml	49.79 ± 1.85	28.08 ± 1.20	68 ± 1.15	25.23 ± 0.66
DO	mg/ L	10 ± 1.15	10.62 ± 1.45	8.66 ± 0.66	8.5 ± 0
BOD	mg/ L	0.933 ± 0.33	1.76 ± 0.33	0.6 ± 0.33	0.8 ± 0.23
Turbidity	NTU	0.30 ± 0	0.83 ± 0	1.73 ± 0.30	0.76 ± 0

TDS= Total Dissolved Solids, DO= Dissolved Oxygen, BOD= Bio-chemical Oxygen Demand,

Table 3: Assessment of Heavy metals during different season and at different sites of Ganga River by ICP-MS

Heavy Metals	**Units**	**Jwalapur**	**Prem-Nagar**	**Kankhal**	**Bhimgodha**
Winters					
Arsenic	mg/ml	**0.0249± 0.007**	0.00349± 0.005	**0.03296± 0.001**	**0.05172±0.005**
Mercury	mg/ml	**0.0177 ± 0.01**	0.00045± 0.002	0.00128± 1	**0.0096± 0.8**
Cadmium	mg/ml	0.0000806± 0.001	0.0045 ± 0.1	0.000104±0.5	0.0008± 0.18

Chromium	mg/ml	0.0109± 0.23	0.00396 ±05	**0.1899± 0.001**	0.02549 ± 0.8
Copper	mg/ml	0.0315± 0.006	0.0032 ±0.001	**0.3347± 0.08**	**0.21111 ± 0.007**
Nickel	mg/ml	0.00125 ± 0.01	0.00146 ± 0.003	0.00286 ± 0.06	0.00145± 0.006
Iron	mg/ml	**1.5725± 0.001**	**0.8531± 0.003**	**0.99635± 0.007**	**1.6522± 0.5**
Summer					
Arsenic	mg/ml	0.00428± 0.65	0.000362±0.11	0.00823± 1.4	0.0022± 0.01
Mercury	mg/ml	**0.0347 ± 0.02**	0.00036 ± 0.1	**0.0062± 0.5**	**0.0772± 0.003**
Cadmium	mg/ml	0.00017± 0.001	0.0002± 0.002	0.00017± 0.5	0.0023± 1
Chromium	mg/ml	0.0213± 0.05	0.03± 2	**0.0721± 1.2**	**0.0687± 0.9**
Copper	mg/ml	0.0078± 0.62	0.0024± 0.9	**0.1005± 0.01**	0.0205 ± 0.5
Nickel	mg/ml	0.0015± 0.3	**0.0667± 0.08**	0.0041± 0.01	0.0065± 0.5
Iron	mg/ml	**1.121± 0.01**	**1.203± 0.18**	**2.958± 0.2**	**1.582±0.03**
Monsoon					
Arsenic	mg/ml	**0.0344± 0.005**	**0.0245±0.01**	**0.066± 0.006**	**0.069± 0.01**
Mercury	mg/ml	**0.02007± 1.9**	**0.01399 ± 2.5**	0.00135± 1	**0.00815± 0.9**
Cadmium	mg/ml	**0.1485± 0.002**	0.0143± 1.1	0.00821± 0.007	0.0004± 1
Chromium	mg/ml	**0.3233± 0.02**	**1.349± 0.02**	**0.7083± 0.04**	**0.4373± 0.03**
Copper	mg/ml	**0.1478± 0.11**	**0.2006± 0.003**	**0.4007± 0.12**	**0.7816± 0.01**
Nickel	mg/ml	0.01922± 0.003	0.01525± 0.1	0.01609± 1	0.0088± 2.1
Iron	mg/ml	**1.304± 0.05**	**1.588± 0.9**	**2.278± 1.2**	**0.0088± 0.01**

Table 4: Pearson correlation coefficient between physico-chemical properties of 4 sites during different seasons of river Ganga Haridwar, India.

Parameters	**Parameters**	**Pearson correlation (r)**	**Pearson correlation (r)**	**Pearson correlation (r)**
		Winters	**Summers**	**Monsoon**
pH	Conductivity	0.40622	0.629896	0.465787
	Temperature	0.71816	-0.3888	-0.75459
	TDS	0.91723	-0.6557	-0.56086
	Free CO_2	0.42265	0.823481	0.232982
	DO	-0.33891	-0.64094	0.358354
	BOD	-0.77125	0.998706	-0.11803
	Turbidity	-0.86933	-0.93029	-0.46742
	Arsenic	-0.99980	-0.90645	-0.0775
	Mercury	-0.03399	-0.59359	0.94055
	Cadmium	-0.73271	-0.66591	0.927757
	Chromium	0.97501	-0.97206	-0.52583
	Copper	0.35961	-0.62782	-0.52646
	Nickel	0.48689	-0.97109	0.61158
	Iron	-0.36545	-0.70957	-0.42413
Conductivity	Temperature	0.190726	0.244793	-0.79331
	TDS	0.67771	-0.23004	0.455017
	Free CO_2	0.952971	0.230484	0.741412
	DO	0.05712	-0.29341	-0.58395
	BOD	-0.24972	0.652076	-0.9161
	Turbidity	-0.11293	-0.7678	0.151312
	Arsenic	0.370459	-0.30063	0.750969
	Mercury	-0.43065	-0.15617	0.231137
	Cadmium	-0.43065	-0.27385	0.270892
	Chromium	0.555984	-0.44158	-0.84956
	Copper	0.992518	-0.31753	0.151575

	Nickel	0.995957	-0.428	0.073427
	Iron	0.085604	-0.2864	0.214899
Temperature	TDS	0.47384	-0.19713	-0.055
	Free CO_2	0.00163	-0.84244	-0.25236
	DO	-0.89595	0.84551	0.31903
	BOD	-0.99628	-0.34185	-0.86587
	Turbidity	0.36918	0.024382	-0.28095
	Arsenic	0.71313	0.412204	0.411875
	Mercury	0.63703	0.914189	0.186872
	Cadmium	-0.95921	0.863829	0.178737
	Chromium	0.77561	0.461216	0.775619
	Copper		-0.21121	0.231078
	Nickel	0,26374	0.49056	-0.4158
	Iron	0.32256	-0.04633	0.004231
TDS	Free CO_2	0.73727	-0.24856	0.333611
	DO	-0.04095	-0.13411	-0.95554
	BOD	-0.54795	-0.66834	-0.75587
	Turbidity	-0.80008	0.802594	0.46411
	Arsenic	0.90666	0.080258	0.685048
	Mercury	-0.37524	-0.15358	-0.68157
	Cadmium	-0.58684	-0.0796	-0.70317
	Chromium	0.92314	0.71733	-0.34627
	Copper	0.61363	0.99923	0.78389
	Nickel	0.73313	0.68995	-0.66763
	Iron	-0.44386	0.98795	0.898216
Free CO_2	DO	0.31526	0.320894	-0.26686
	BOD	-0.07539	0.793683	-0.59325
	Turbidity	-0.26655	-0.55801	0.702993
	Arsenic	0.391912	-0.77335	0.914885
	Mercury	-0.67196	-0.91662	0.214142
	Cadmium	-0.25849	-0.93563	0.305911
	Chromium	0.519243	-0.84671	-0.2774
	Copper	0.91043	-0.22367	-0.27791
	Nickel	0.94718	-0.86753	0.46858
	Iron	-0.20389	-0.37194	0.411812
DO	BOD	0.855349	0.860401	0.860401
	Turbidity	-0.03076	-0.2179	-0.2179
	Arsenic	-0.33393	-0.98377	-0.60714
	Mercury	-0.90094	-0.60691	0.631397
	Cadmium	0.81473	-0.65081	0.614829
	Chromium	-0.41854	-0.98341	0.588577
	Copper	-0.02595	-0.67988	-0.85037
	Nickel	0.006065	-0.98616	0.672031
	Iron	-0.64154	-0.77539	-0.72916
BOD	Turbidity	0.427171	-0.9477	-0.19658
	Arsenic	-0.76528	-0.90443	-0.76737
	Mercury	-0.56825	-0.55356	0.165273
	Cadmium	0.969337	-0.6281	0.067774
	Chromium	-0.82704	-0.96771	0.827125
	Copper	-0.28199	-0.65612	-0.51701
	Nickel	-0.32436	-0.96428	0.309431
	Iron	-0.26503	-0.7304	-0.49109
Turbidity	Arsenic	-0.88548	0.82854	0.758251

	Mercury	0.278488	0.02738	-0.34518
	Cadmium	0.317501	0.36515	-0.24804
	Chromium	0.74531	-0.81314	0.35571
	Copper	0.118849	0.777489	-0.12997
	Nickel	-0.32436	0.860429	0.202405
	Iron	-0.26503	0.801964	0.768797
Arsenic	Mercury	-0.02743	0.575203	-0.16998
	Cadmium	-0.71585	0.468325	-0.65242
	Chromium	0.965464	0.97892	0.589926
	Copper	0.32012	0.779653	0.976252
	Nickel	0.45057	0.975028	0.079801
	Iron	-0.38776	0.869205	0.712687
Mercury	Cadmium	-0.48244	-0.39739	0.994685
	Chromium	0.009929	0.445379	-0.21
	Copper	-0.33593	0.947638	-0.32103
	Nickel	-0.39976	0.412927	0.816878
	Iron	0.69042	0.900517	-0.8013
Cadmium	Chromium	-0.83456	0.63558	-0.19409
	Copper	-0.49603	-0.11187	-0.80904
	Nickel	-0.518	0.66498	0.860552
	Iron	-0.36581	0.03597	-0.73888
Chromium	Copper	-0.18809	0.695622	-0.39548
	Nickel	-0.518	0.999179	0.223758
	Iron	-0.18907	0.790643	0.058801
Copper	Nickel	0.986078	0.667767	-0.97393
	Iron	0.206522	0.986075	0.534036
Nickel	Iron	0.062178	1.00000	-0.45806

Table 5: Analysis of Variance (ANOVA) for seasonal and spatial variations in different heavy metals in Ganga river at Haridwar.

Parameters	ANOVA Seasonal Variation P-value	ANOVA Spatial Variation P-value
Arsenic	0.017	0.441
Mercury	0.326	0.308
Cadmium	0.295	0.495
Chromium	0.015	0.784
Copper	0.063	0.366
Nickel	0.396	0.449
Iron	0.667	0.380

Values are statistically significant at $P \leq 0.05$.

The present study shows the considerable variation between different physico-chemical parameters during different seasons as compared with the standards provided by WHO, ICMR, CPCB and BIS in table1, From table 2, it was clear that the range of pH lies between 7.29 in summers to 10.265 in winters (Singh *et al*., 2012). This variation in pH value was observed due to annual variation in free CO_2 (Kumari *et al*., 2013) and (Sharma *et al*., 2008). The pH was toward acidic in summer was due to high Free CO_2(Santosh *et al*., 2008). pH shows positive relationship between Electrical Conductivity (0.406), Free CO_2 (0.422), TDS (0.917), Temperature (0.718) (Tripathi *et al*., 2014).

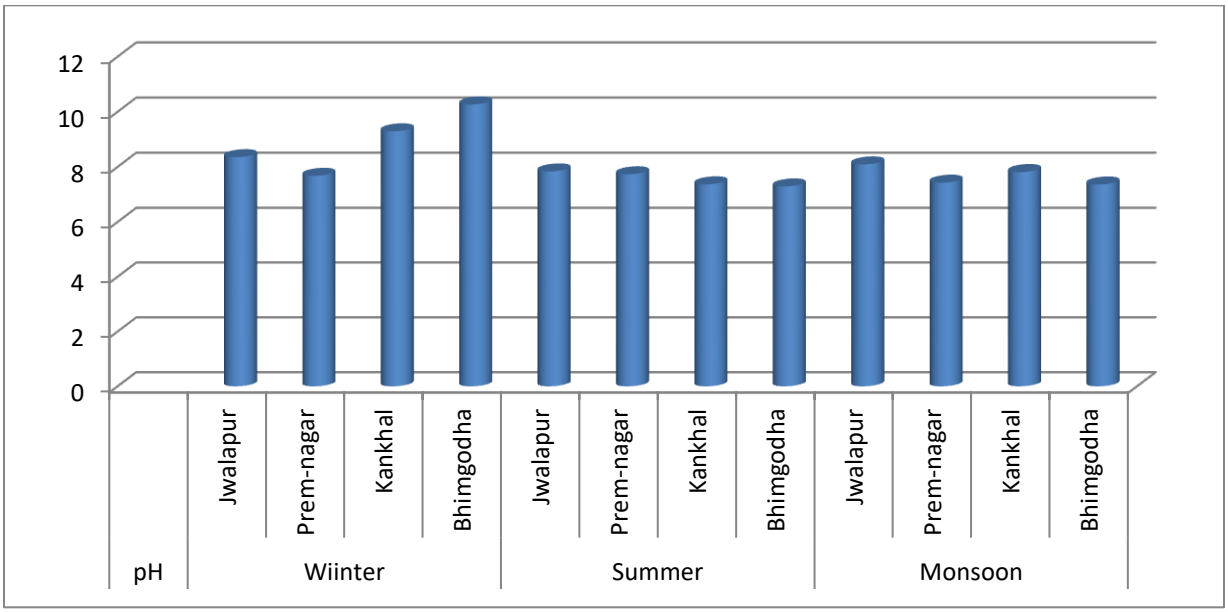

Fig2: pH variation for different season

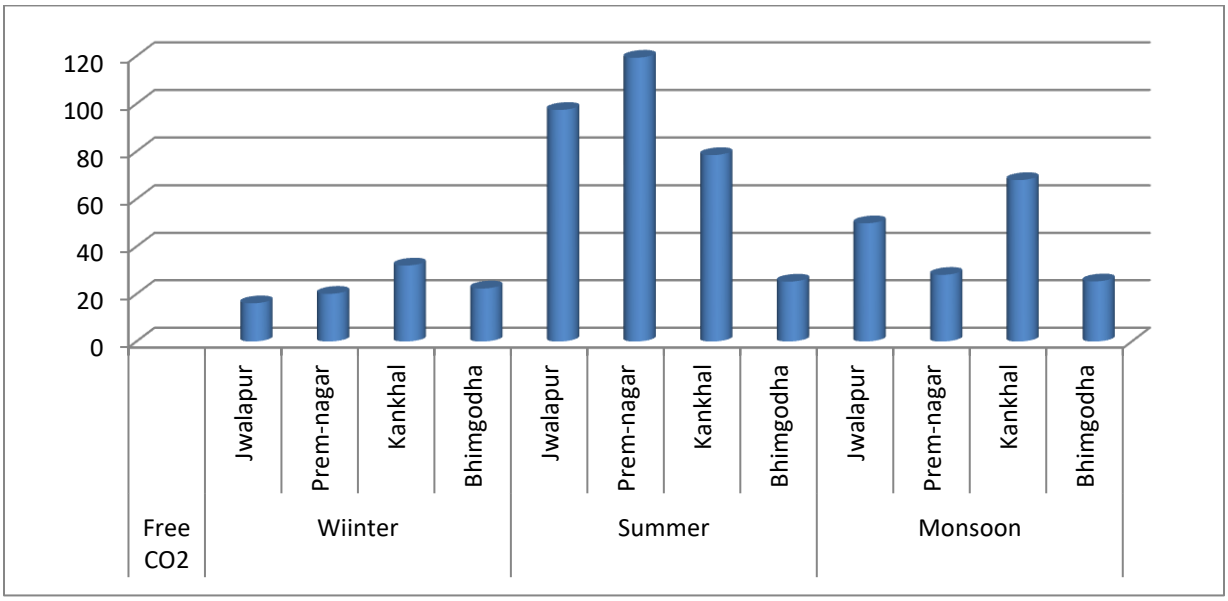

Fig3: Free CO_2 variation for different season

Total dissolved solid was in the range of 301-73 mgL^{-1} which lies within the prescribed limit of 500 mgL^{-1} by WHO, ICMR and BIS, similar results was obtained by (Yadav and Srivastava, 2011) and (Tripathi *et al*., 2014). during study of river Ganga at Ghazipur. TDS shows positive correlation with Free CO_2 (0.737), pH (0.917), Conductivity (0.677), Temperature (0.473). Turbidity values of different seasons falls in the range of 1.73 NTU- 0.009 NTU highest value was found to be at site kankhal. The high value of turbidity is in monsoon is due to turbulent flow which stirred silt and sand which was present at the bottom

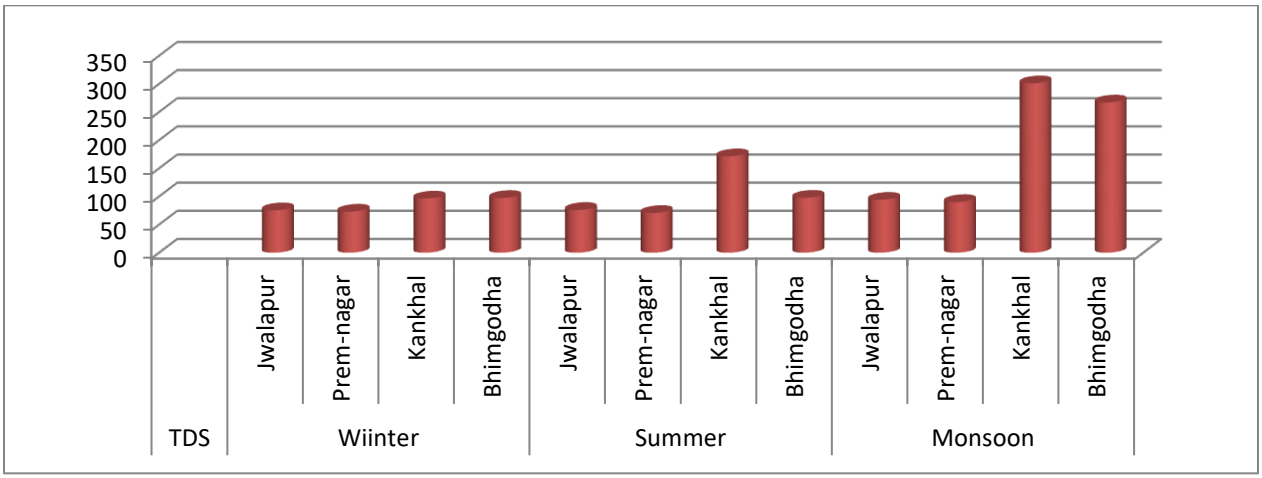

Fig 4: TDS parameters during different season

stirred silt and sand which was present at the bottom of river, similar pattern was observed in other rivers during monsoon season (Narayan and Chauhan, 2000) and (Almeida *et al*., 2012). It shows positive correlation with BOD(0.427) and Temperature (0.369).

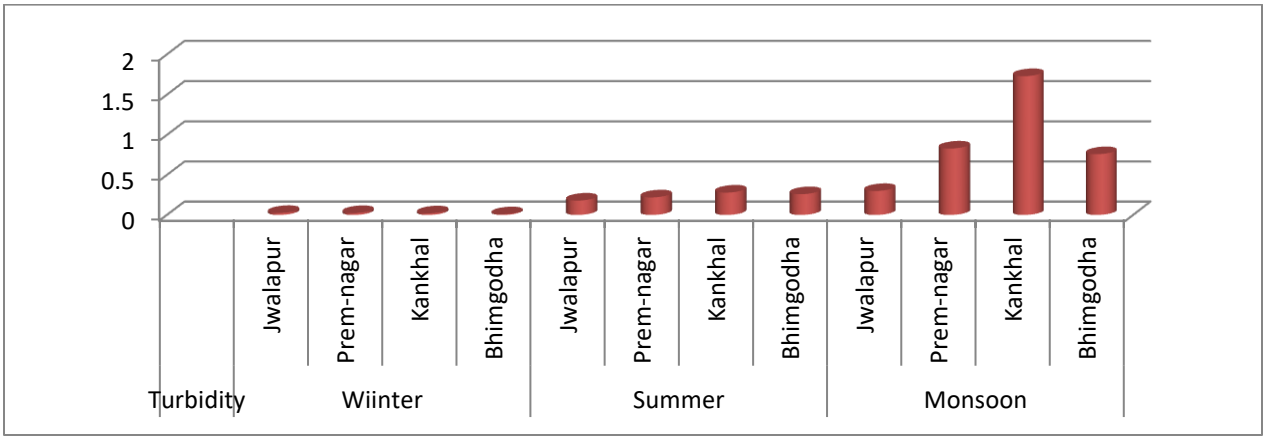

Fig 5: variation in turbidity values during different season

Dissolved Oxygen of Ganga water is highest during winter 11.92 mgL^{-1} this was probably due to low temperature, low turbidity, which increase photosynthesis activity of the algae found on submerged stones (Joshi *et al*., 2009). Lowest in summers 7.53 mgL^{-1}. DO have positive correlation with BOD (0.855), Free CO_2 (0.315).

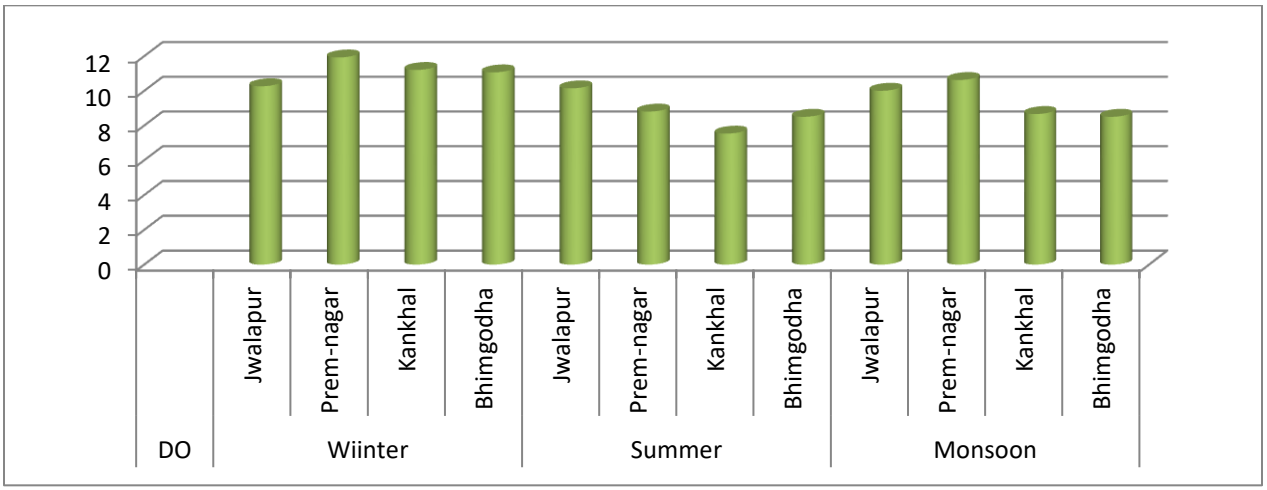

Fig 6: DO Parameters during different season

BOD value ranges from maximum 4.48 mgL^{-1} in summer to 0.6 mgL^{-1} in monsoon; this was due to higher rate of decomposition of organic matter (Kumari *et al*., 2013). Water temperature plays an important role which influence both chemical and biological factors of water resources, temperature was found to be minimum 9.66 ^{o}C in winter and maximum 28.33 ^{o}C in summer.

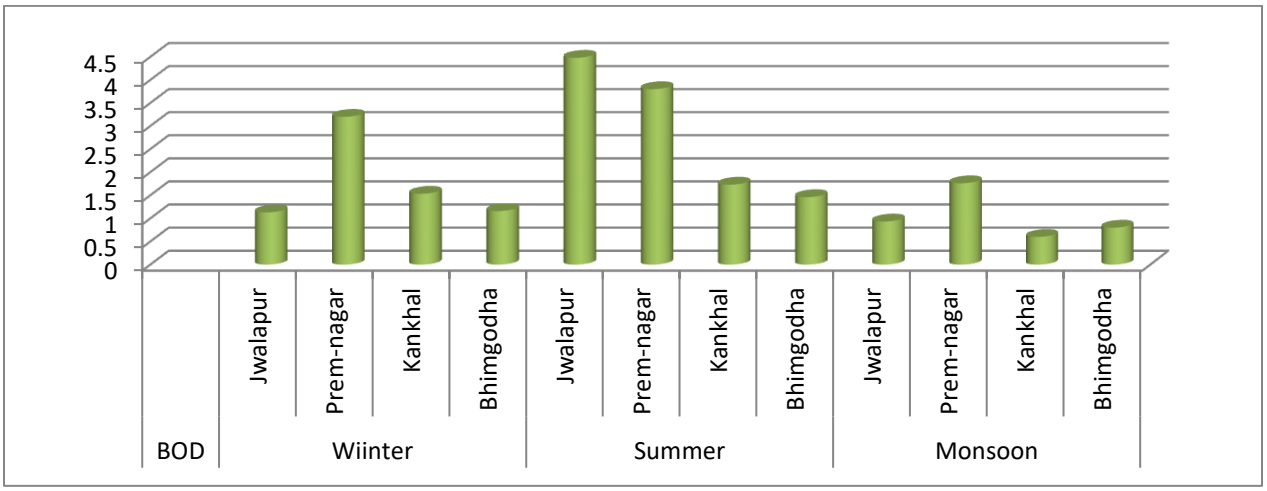

Fig 7: BOD Parameters during different seasons

Electrical Conductivity of water depends upon the ions in water and also affected by the suspended impurities and thus Electrical Conductivity was maximum in monsoon and minimum in winter. It was positively correlated with Temperature (0.190), TDS (0.677) (Joshi *et al*., 2009).

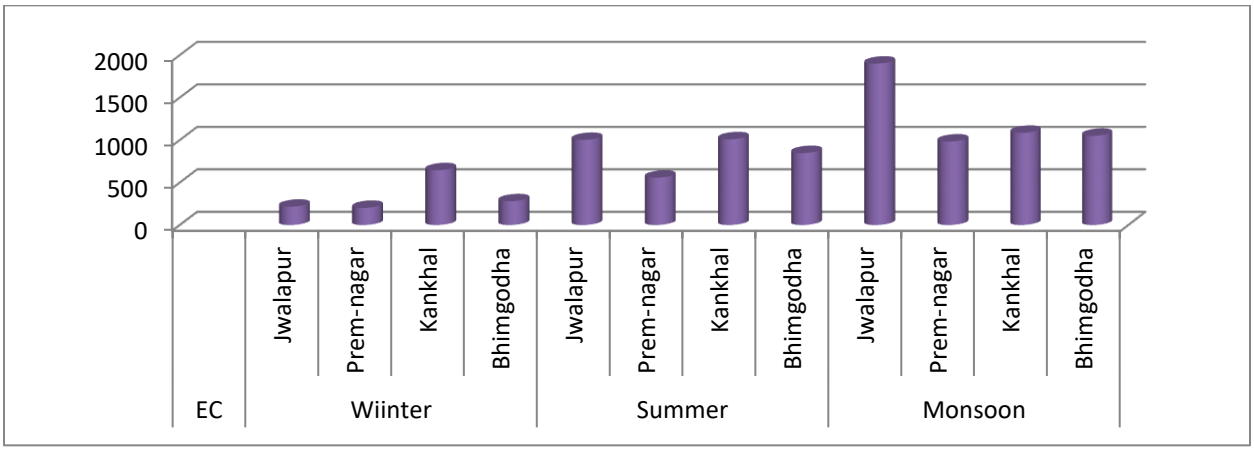

Fig 8: EC Parameters at during different seasons

The values of seven heavy metals in Ganga canal water at 4 different sites namely Bhimgodha, Premnagar, Kankhal and Jwalapur were presented in Table 3. Out of 3 seasons the maximum amount of heavy metals in monsoon season are above prescribed limit, this is due to high soil sediments comes in water in which metals are present along with festival season such as shivratri and many more which further increase load on city and further contribute to pollution, during monsoon season the range of different heavy metals varies as As (0.069-0.0245 mgL^{-1}), Hg(0.01-0.008 mgL^{-1}), Cd (0.0004-0.1485 mgL^{-1}), Cr (0.32- 1.34 mgL^{-1}), Cu (0.2006-0.7816 mgL^{-1}), Ni (0.008- 0.0019 mgL^{-1}), Fe (0.008-2.278 mgL^{-1}).

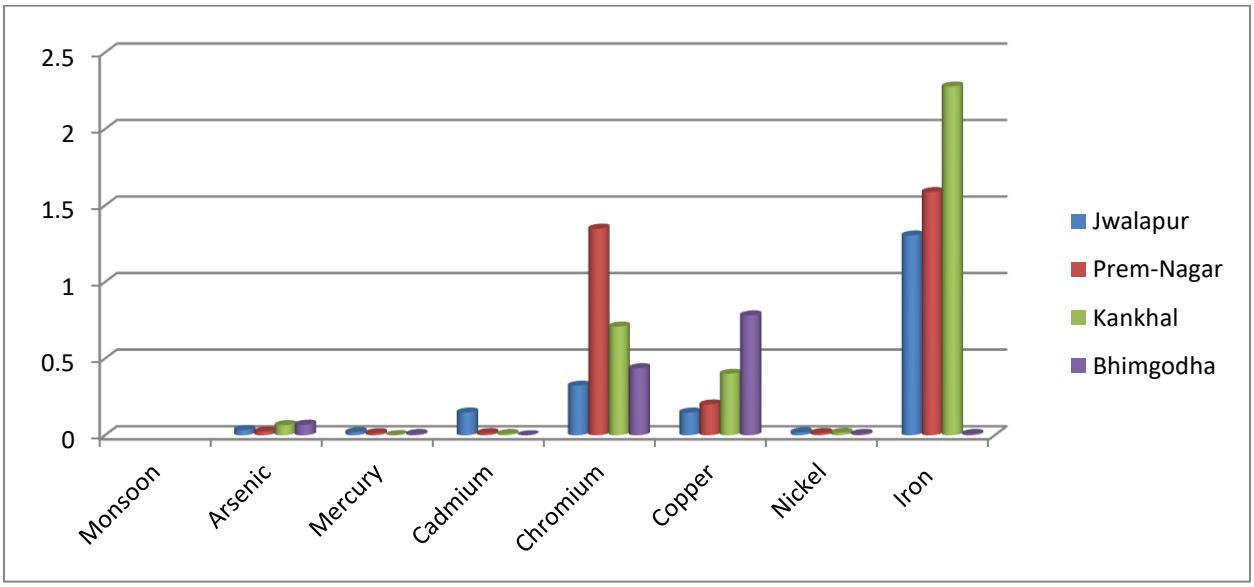

Fig 9: Concentration of different heavy metals during monsoon at different sites

Monsoon season was followed by summers in which the different metals concentration was asfollows, As (0.0003- 0.00823 mgL^{-1}), Hg (0.0003- 0.0772 mgL^{-1}), Cd (0.00017-0.0023 mgL^{-1}), Cr (0.02-0.072 mgL^{-1}),

Cu (0.002- 0.1005 mgL^{-1}), Ni (0.001- 0.066 mgL^{-1}), Fe (1.121-2.958 mgL^{-1}) and least in winters As (0.05-0.003 mgL^{-1}), Hg (0.0004- 0.017 mgL^{-1}), Cd (0.00008- 0.0045 mgL^{-1}), Cr (0.003- 0.189 mgL^{-1}), Cu (0.0032- 0.33 mgL^{-1}), Ni (0.0012- 0.0028 mgL^{-1}), Fe (0.85- 1.65 mgL^{-1}).

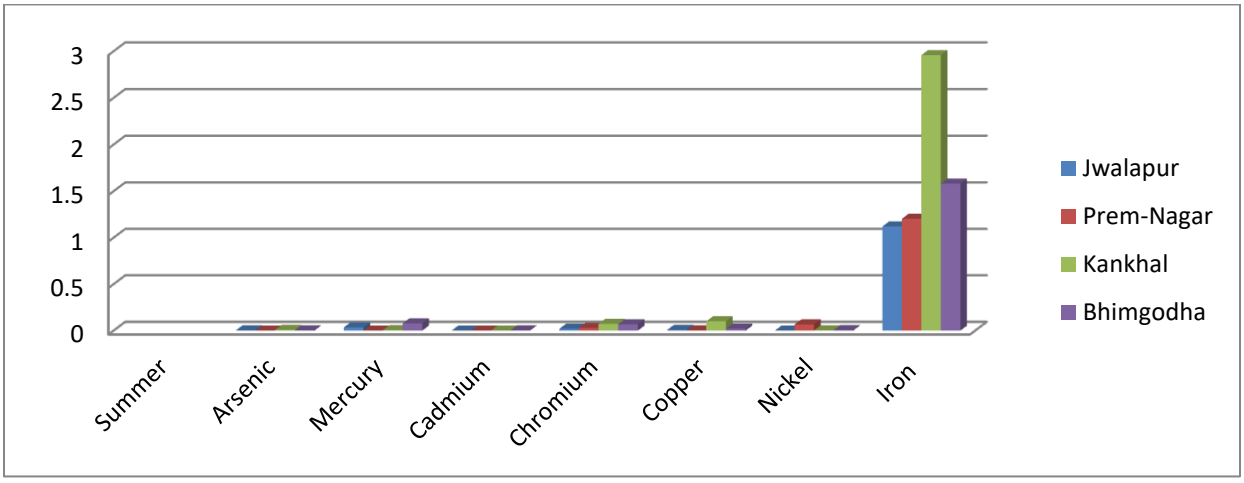

Fig 10: Concentration of different heavy metals during summer at different sites

The pattern which is obtained in the study of Heavy Metals in Ganga River was same as it was obtained in the study of (Singh *et al*., 2012) and (Kar *et al*., 2008). In terms of correlation Arsenic shows a significant correlation with Chromium (0.96), Mercury with Iron (0.69) and Copper with Nickel (0.98).

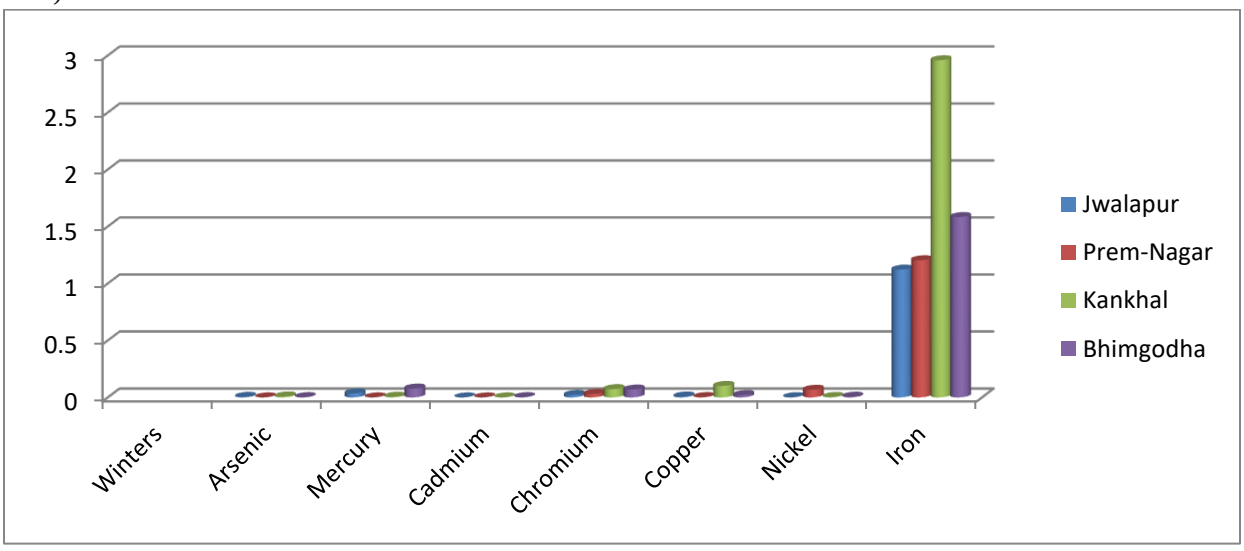

Fig 11: Concentration of different heavy metals during winters at different sites

Seasonal variation was determined by analyzing seven metals, according to seasonal variation, computed P- values by ANOVA which were depicted in Table 5. Arsenic and Chromium was found to be significant as P-value were found to be statistically significant (Seth *et al*., 2016). On the other hand

according to the spatial variation among four sampling sites none of the parameters was found to be statistically significant (Kansal*et al*., 2013).

CONCLUSION: The present study show detailed physicochemical characteristic of river Ganga in Haridwar at different sites during different seasons. The winters, summer and monsoon shows a considerable variation in physicochemical values and heavy metals like Arsenic, Mercury, Cadmium, Iron, etc. was found to be slightly above the permissible limit and hence degrade the quality of river water which is used for various purpose such as drinking and bathing, the values of different parameters shows that there is a considerable need to increase the awareness about the importance of river for our society and to maintain the quality of river along with this number of programs should be activated to check the quality of river water time to time. So that our resources get preserved.

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