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Physiochemical Analysis of River Ganges at Mirzapur In Uttar Pradesh, India

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Abstract: *The present investigation is an attempt to study the effect of sewage discharge into River Ganges and to record the qualitative change in water. Physiochemical properties of River Ganges at Mirzapur were studied at five different sites, viz., Site Ist-Shivpur (Up stream of Ganges river), Site IInd-Choubey ghat (Khandwa Nala), Site IIIrd-Baba ghat (After Khandwa Nala), Site IVth-Ghore Shaheed (After Badshahi Nala) and Site Vth-Bisunderpur (Mirzapur Downstream). The physio-chemical characteristics were studied and analyzed during February to May-2011. The range of observations are as under; temperature ranges from 22.10^{0}C to 30^{0}C, pH of river water ranges between 7.59 to 8.42, Electrical conductivity from 440 to 573 µS/cm, TDS from 272 to 382 mg/L, TSS from 30 to 65 mg/L, DO from 6 to 9.10 mg/L, BOD from 2.30 to 5.80 mg/L, COD from 10.20 to 28.30 mg/L, Alkalinity from 180 to 276 mg/L, Cl$^-$ from 28 to 66 mg/L and TC ranges from 2.7 x 10^3 to 1.5 x 10^4 MPN/100 m/L.*

Keywords: *River Ganges, Physico-chemical Parameter, Sewage.*

I. Introduction

The Ganges rises in the Garhwal Himalayas (30^{0}55N, 79^{0}7E) under the name of Bhagirathi. The total length of Ganges river is about 2525 Km. The River Ganges is a part and parcel of everyday life in the city and it is one of the most sacred river in India, yet it is being polluted by many sources. The main townships of Uttarakhand and Uttarpradesh falling at bank of Ganges river are Rishikesh, Haridwar, Garhmukteshwar, Narora, Kannauj, Kanpur, Dalmau, Allahabad, Mirzapur, Varanasi, Ghazipur, Ballia and goes up to the Bay of Bengal in the Indian Ocean [1]. Today, over 29 cities, 70 towns, and thousands of villages extend along the Ganga banks. Nearly all of their sewage - over 1.3 billion litres per day - goes directly into the river, along with thousands of animal carcasses, mainly cattle [2]. Due to rapid population growth, agricultural and industrial developments, the quality of water in rivers is being degraded continuously making it unsuitable for various uses. An accurate and rational assessment for river water quality is required for determining the extent of usefulness of water bodies for various uses. Untreated wastewater may contain different range of pathogens including bacteria, parasites, and viruses, toxic chemicals such as heavy metals and organic chemicals from agriculture, industrial and domestic sources [3, 4]. The present investigation is concerned in Nagar block of Mirzapur district of Uttar Pradesh. The study of different water parameter is very important for understanding of the metabolic events in aquatic system. The parameters influence each other, therefore it has become obligatory to analyze important water parameters time to time which can indicate the favourable or unfavourable changes occurring in the ecosystem.

II. Materials And Methods

The present study was conducted in Nagar block of Mirzapur district of Uttar Pradesh, India bounded by longitudes 82 ^{0}25' to 82 ^{0} 41'30"E and latitudes 25 ^{0}00' to 25 ^{0}14'N. The total geographical area is 255.7 sq.km surrounded by low lying hills. The Mirzapur city is located in the district by the same name in Uttar Pradesh. Water sample were collected in the pre monsoon season of year 2011. The downstream sites ranged 4.5 km, 6.0 km, 8.5 km and 12.0 km, respectively from upstream site Shivpur (0 km).

III. Sampling And Analysis

Total 50 water samples were collected for physico-chemical analysis from the five different sampling site at 10 days interval, selected on the basis of discharge of two main nala's in river Ganges by Grab method viz. (S1) Shivpur (Vindhyachal) Mirzapur. (Upstream), (S2) Choubey ghat (Khandwa nala), (S3) Baba ghat (After Khandwa nala) i.e. mid of Mirzapur, (S4) Ghore shaheed ghat (out let of Mirzapur STP) and (S5) Bisunderpur (Mirzapur Downstream) respectively. As per the norms of the APHA, Wide mouth plastic bottles of one liter size, D.O bottle and sterilised 250 ml glass bottle were used for collecting the samples. These are analysed using standard methods for physiochemical examination of water (APHA) [5]. Samples were collected in ten days interval in a routine manner from the all sites of river Ganges at Mirzapur. Sample were analysed for

following physicochemical and biological parameters viz. Temperature, pH, EC, TSS, TDS, DO (wrinkle`s method), BOD (5 days at 20^0C), COD (by dichromate method), alkalinity, Chloride (Argentometric method) and Total coliform (by MPN method). All the experiment was done within 24 hours of sampling.

Fig: 1. Sampling site / Location at Mirzapur city.

IV. Result And Discussions

The present study evaluates the physico-chemical status of the Ganges River at Mirzapur district. The estimation of 11 parameters (Temp, pH, EC, TDS, TSS, DO, BOD, COD, Alk., Cl^- and Toal coliform) with respect to mean ± SD values for surface water quality and their comparison (by ANOVA) among five sites are summarized in **Table: 1**. The mean comparison of each parameter between sites are also done by Tukey's post hoc test and summarized in **Table: 2**. The physico-chemical status and their mean comparison among five sites are summarized and shown graphically.

1. Temperature

The mean Temperature of the Ganges River increase with distance but found similar among all sites ($F=0.17$, $p=0.951$). Temperature was recorded to ±0.1°C accuracy using a mercury thermometer, immediately after collecting the water samples from different sites. The fluctuation in river water temperature usually depends on the season, geographic location, sampling time and temperature of effluents entering the stream [6]. Water temperature is recorded lower (22.1^{o}C) on 01st Feb at Ghore Shaheed due to winter and higher (30.0^{o}C) on 30th April at Ghore Shaheed during summer. Higher temperature during summers was due to greater heating. In polluted water, temperature can have profound effect on Dissolved oxygen (DO) and Biological Oxygen Demand (BOD). Similar trends are also showed by Yadav & Srivastava (2011).

2. pH

In contrast, mean pH decrease with distance and differed significantly among the sites ($F=3.79$, $p=0.010$). The pH at Site 4 is lower as compared to Site 1. pH is an important parameter which plays an important role in the evaluation of acid-base balance of water. The pH of water mainly depends upon carbonic acid and interaction between carbonate and bicarbonates (V. Mathivanan, 2005). The maximum mean pH value 8.08 was recorded at Shivpur (Upstream), however the minimum mean pH value 7.83 was recorded at Ghore Shaheed. The maximum pH value (8.42) was recorded at Shivpur in the sixth sampling and minimum pH value (7.59) recorded at Ghore Shaheed in seventh sampling. The decreased in pH values of water recorded from upstream to downstream is indicates increasing of pollution load from upstream to downstream .The pH value of water at sewage discharge points were usually lower than that of the river water [8, 9].

3. Electrical Conductivity

Conversely, mean EC increase with distance but not differed significantly among the sites ($F=1.25$, $p=0.303$). The maximum mean EC value 507.70 µS/cm was recorded at Ghore Shaheed which carried about 15-20 % city raw sewage and treated sewage from Mirzapur STP, however minimum mean EC value 483.40 µS/cm was observed at Shivpur (Upstream). The maximum EC value (573.0µS/cm) was recorded at Ghore Shaheed and minimum EC value (440.0µS/cm) was recorded at Upstream. EC is significantly increasing at all sites to downstream, similar observation were also reported by Srivastava and Sinha at Allahabad [7]**.** The increased in EC values of water indicates that there is a source of dissolved ions in the vicinity. Higher the value of dissolved solids, greater the amount of ions in water [10]. Increasing levels of conductivity and cations are the products of decomposition and mineralization of organic materials [11].

4. Total Dissolved Solid

Similarly, mean TDS also increase with distance and also not differed significantly among the sites ($F=1.22$, $p=0.314$). The maximum mean TDS value 348.60 was recorded at Ghore Shaheed which carried about 15-20 % city raw sewage and treated sewage from Mirzapur STP, however the minimum TDS mean value 324.30 observed at Shivpur (Upstream). The maximum TDS value (382.0) in fifth sample was recorded at Ghore Shaheed and minimum TDS value (272.0) in sixth sample was recorded at Shivpur. The trend shows that as we move towards downstream the value is also increasing. Most of studies show that TDS value increases after post winter and decreases on monsoon season. The largest amount of total solids adds to the highest turbidity and electrical conductivity [12, 13].

5. Total Suspended Solid

The mean TSS also increase with distance but differed significantly among the sites ($F=10.58$, $p<0.001$). The TSS is higher in both Site 4 and Site 5 as compared to Site 1 and Site 2. Further, the mean TSS at Site 4 was also found to be significantly ($p<0.05$) different and higher as compared to Site 3. The maximum mean TSS value 54.00 was recorded at Ghore Shaheed, however the minimum TSS mean value 37.90 observed at Shivpur (Upstream). The maximum TSS value (65.0) in fifth sample was recorded at Ghore Shaheed and minimum TSS value (30.0) in third and sixth sample were recorded at Shivpur (upstream). The trends show that as we move towards downstream the values are also increasing. It might be due to running off from many bathing Ghats, drain water discharge and garbage dump sites at river bank [14].

6. Dissolved Oxygen (DO)

Conversely, mean DO decrease with distance and also differed significantly among the sites ($F=8.31$, $p<0.001$). The DO was lower in Site 4 as compared to Site 1, Site 2 and Site 3. Further, the mean DO at Site 5 also lowered significantly ($p<0.01$) as compared to Site 1. The maximum mean DO value 8.25 recorded at Shivpur (Upstream), however the minimum mean DO value 6.81 observed at Ghore Shaheed. The maximum DO value (9.10) recorded in second sample at shivpur and minimum DO value (6.00) was recorded in eighth sample at Ghore Shaheed due to entrance of Mirzapur city's sewage which is rich in bacteria. So the bacteria utilize the dissolved oxygen in the process of decomposition and DO have reached the lowest level. Decreasing of DO value from upstream to downstream is indication of organic pollution load in river or it may be also due to increasing of temperature [15, 16].

7. Biochemical Oxygen Demand (BOD)

In contrast, mean BOD increase with distance and differed significantly among the sites ($F=11.98$, $p<0.001$). BOD increases due to biodegradation of organic materials which exerts oxygen tension in water body [11]. The BOD was higher at both Site 4 and Site 5 as compared to Site 1 and Site 2. Further, the mean BOD was also higher significantly ($p<0.01$) at Site 4 as compared to Site 3. The maximum mean value of BOD_5 was 4.61 observed at Ghore Shaheed, however the minimum mean value of BOD_5 was 3.00 observed at Shivpur (upstream). The maximum BOD value is 5.80 in eighth sample which was recorded at Ghore Shaheed. The increasing in BOD values of water may be due to increasing of organic pollution including untreated domestic sewage, agricultural runoff, and containing residual fertilizers, which is maximum on Ghore Shaheed. Minimum BOD value in February (winter) may be due to suspended solids settle in the bottom [17, 18].

8. Chemical Oxygen Demand (COD)

Similarly, mean COD also increase with distance and also differed significantly among the sites ($F=7.13$, $p<0.001$). The measure of COD determines the quality of organic matter found in water. The COD was higher at Site 4 as compared to Site 1, Site 2 and Site 3. The maximum mean COD value 21.9 recorded at Ghore Shaheed, however the minimum mean COD value 15.2 was observed at Shivpur (Upstream). The maximum COD value (28.3) recorded on eighth sample at Ghore Shaheed and minimum COD value (10.2) was recorded on second sample at Shivpur. Graph shows about increasing trends on all sites as we go towards downstream, except Bisunderpur site due to low activity of human and industry, it show less COD than Ghore Shaheed. The highest values of COD indicate that most of the pollution in study zone in caused by industrial units like carpet industry, metal industry and automobile industries etc [19, 20].

9. Alkalinity

Conversely, though mean Alkalinity increase with distance but not differed significantly among the sites ($F=0.26$, $p=0.903$). The maximum mean Alkalinity value 228.5 recorded at Ghore Shaheed, however the minimum mean Alkalinity value 217.5 was observed at Shivpur (Upstream). The maximum Alkalinity value (276.0) recorded on fourth sample at Ghore Shaheed and minimum Alkalinity value (180.0) was recorded on fifth sample at Choubey ghat. Graph shows about increasing trends on all sites as we go towards downstream,

except Bisunderpur site. The high value of alkalinity indicates the presence of weak and strong base as carbonates, Bicarbonates and hydroxides in the water body (Abassi et al., 1999; Jain et al., 1997). The high values of alkalinity may also be due to increase in free carbon dioxide in the River Ganges which ultimately results in the increase in alkalinity at site 3 & site 4 [21, 22].

10. Chloride (Cl^-)

However, mean Cl^- increase with distance and also differed significantly among the sites ($F=7.68$, $p<0.001$). The Cl^- was higher at Site 4 as compared to Site 1, Site 2 and Site 3. Further, the mean Cl^- at Site 5 was also found significantly ($p<0.05$) different and higher as compared to Site 1. The maximum mean Cl^- value 55.3 recorded at Ghore Shaheed, however the minimum mean Cl^- value 40.5 was observed at Shivpur (Upstream). The maximum Cl^- value (66.0) recorded on fourth sample at Ghore Shaheed and minimum Cl^- value (28.0) was recorded on second sample at Shivpur. Graph shows about increasing trends on all sites as we go towards downstream, except Bisunderpur site. Chlorides in River Ganges waters can be attributed to discharge of local effluents or domestic sewage disposal at different points which may result in moderate increase in levels of chlorides [23].

11. Total Coliform (TC)

Similarly, mean Total coliform increase comparatively with distance and also differed significantly among the sites ($F=55.69$, $p<0.001$). The Total colifom was higher at Site 3, Site 4 and Site 5 as compared to Site 1. Further, the mean Total coliform at both Site 4 and Site 5 was also found significantly ($p<0.01$ or $p<0.001$) different and higher as compared to both Site 2 and Site 3. Moreover, it was also significantly ($p<0.001$) higher at Site 4 as compared to Site 5. The maximum mean TC value 12080 MPN/100mL was recorded at Ghore Shaheed, however the minimum mean TC value 3520 MPN/100mL was observed at Shivpur (Upstream). The maximum TC value 15000 MPN/100mL recorded on fifth and ninth sample at Ghore Shaheed and minimum TC value 2700 MPN/100mL was recorded on third sample at Shivpur. On moving from Upstream to Downstream graph shows increasing trends on all sites, except Bisunderpur site. Maximum mean value of Total coliform at Ghore Shaheed site is due to discharge of city sewage disposal points which may result in moderate increase in levels of Coliforms. The high value in the present study may be attributed to the presence of bacterial load from the nearby surrounding areas (Fecal matter) and due to this reason the River Ganges is absolutely unfit for drinking and unhealthy for bathing. Such higher value of MPN is also supported from the studies of other researchers [24, 25].

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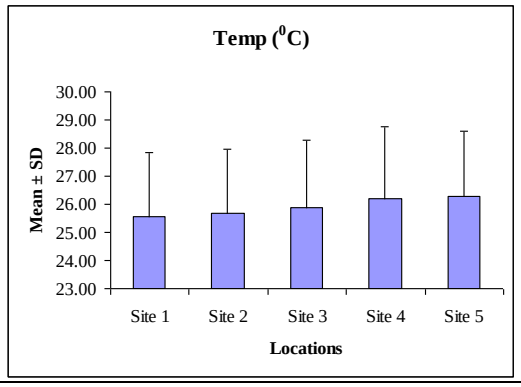
Table 1: Physico-chemical parameter levels (Mean ± SD, n=10) at different sites of the Ganga River at Mirzapur city

Parameter	Site 1	Site 2	Site 3	Site 4	Site 5	F value (4, 45 DF)	p value
Temp (^{0}C)	25.57 ± 2.28	25.69 ± 2.26	25.90 ± 2.39	26.21 ± 2.56	26.28 ± 2.34	0.17	0.951
pH	8.08 ± 0.16	8.03 ± 0.13	7.98 ± 0.13	7.83 ± 0.17	7.91 ± 0.18	3.79	0.010
EC (µS/cm)	483.40 ± 25.53	488.70 ± 26.52	491.80 ± 27.37	507.70 ± 28.89	499.60 ± 26.33	1.25	0.303
TDS (mg/L)	324.30 ± 28.28	328.50 ± 28.60	335.60 ± 28.49	348.60 ± 29.53	342.70 ± 27.48	1.22	0.314
TSS (mg/L)	37.90 ± 5.63	40.60 ± 6.80	45.20 ± 6.20	54.00 ± 7.41	49.30 ± 5.27	10.58	<0.001
DO (mg/L)	8.25 ± 0.59	7.99 ± 0.61	7.83 ± 0.74	6.81 ± 0.62	7.21 ± 0.67	8.31	<0.001
BOD (mg/L)	3.00 ± 0.45	3.31 ± 0.52	3.39 ± 0.52	4.61 ± 0.69	4.11 ± 0.77	11.98	<0.001
COD (mg/L)	15.18 ± 2.73	15.88 ± 3.02	16.43 ± 3.06	21.94 ± 4.06	19.36 ± 3.69	7.13	<0.001
Alk (mg/L)	217.50 ± 30.56	218.20 ± 30.99	223.50 ± 31.20	228.50 ± 31.48	226.90 ± 30.29	0.26	0.903
Cl^- (mg/L)	40.50 ± 6.57	42.90 ± 6.52	45.50 ± 6.35	55.30 ± 7.33	49.10 ± 6.19	7.68	<0.001
T. Coliform MPN/100ml	3520.00 ± 875.34	4310.00 ± 952.72	5760.00 ± 877.12	12080.00 ± 2444.40	8110.00 ± 1507.33	55.69	<0.001

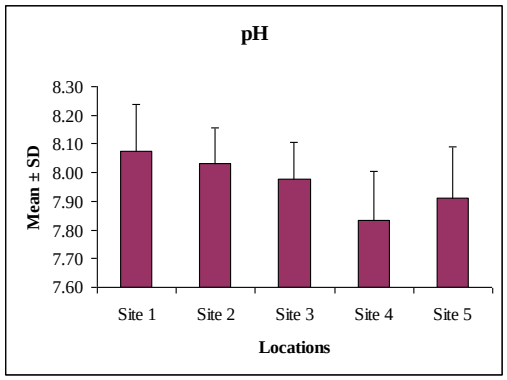
Table 2: Significance (p value) of mean difference in physico-chemical parameters between sites by Tukey test

Comparisons	Temp	pH	EC	TDS	TSS	DO	BOD	COD	Alk	Cl^-	Total coliform
Site 1 vs. Site 2	1.000	0.967	0.992	0.997	0.873	0.897	0.778	0.990	1.000	0.925	0.747
Site 1 vs. Site 3	0.998	0.621	0.956	0.900	0.090	0.602	0.599	0.918	0.992	0.449	0.011
Site 1 vs. Site 4	0.974	0.010	0.275	0.328	p<0.001	p<0.001	p<0.001	0.001	0.931	p<0.001	p<0.001
Site 1 vs. Site 5	0.962	0.150	0.666	0.603	0.002	0.007	0.002	0.057	0.960	0.042	p<0.001
Site 2 vs. Site 3	1.000	0.937	0.999	0.980	0.486	0.981	0.998	0.996	0.995	0.903	0.192
Site 2 vs. Site 4	0.988	0.051	0.520	0.519	p<0.001	0.002	p<0.001	0.002	0.945	0.001	p<0.001
Site 2 vs. Site 5	0.980	0.443	0.894	0.798	0.027	0.072	0.036	0.156	0.970	0.238	p<0.001
Site 3 vs. Site 4	0.998	0.255	0.681	0.845	0.025	0.009	0.001	0.005	0.996	0.015	p<0.001
Site 3 vs. Site 5	0.996	0.884	0.966	0.980	0.597	0.224	0.074	0.304	0.999	0.741	0.007
Site 4 vs. Site 5	1.000	0.790	0.961	0.990	0.465	0.645	0.354	0.431	1.000	0.238	p<0.001

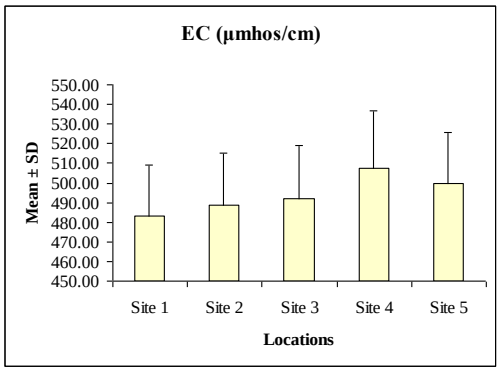
Temp of the Ganges River at Mirzapur city



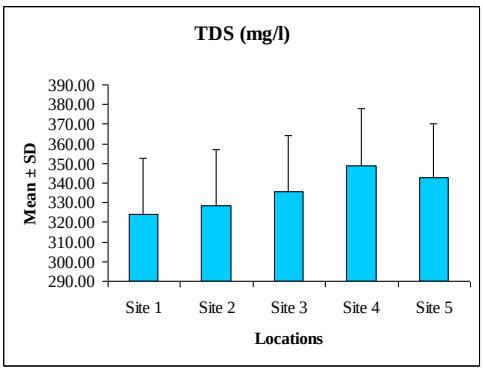
pH of the Ganges River at Mirzapur city



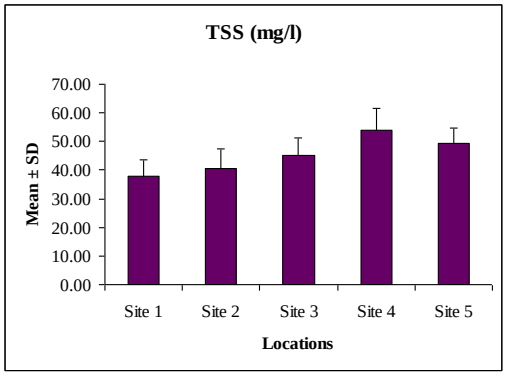
EC of the Ganges River at Mirzapur city



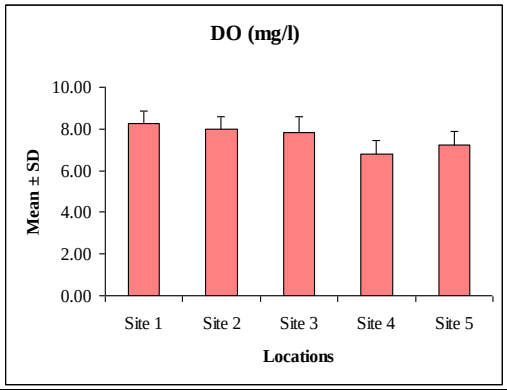
TDS of the Ganges River at Mirzapur city



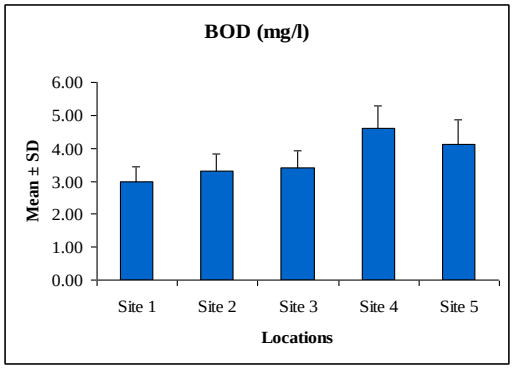
TSS of the Ganges River at Mirzapur city



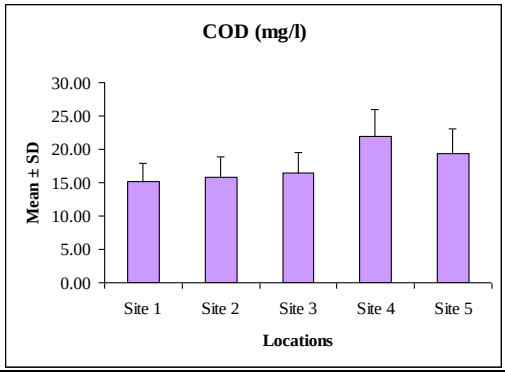
DO of the Ganges River at Mirzapur city



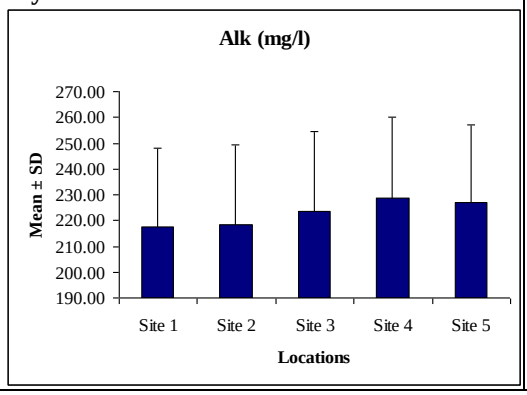
BOD of the Ganges River at Mirzapur city.



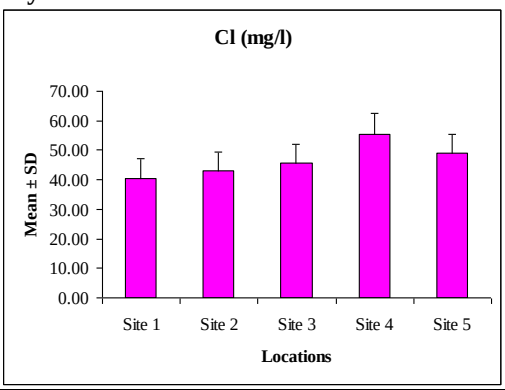
COD of the Ganges River at Mirzapur city.



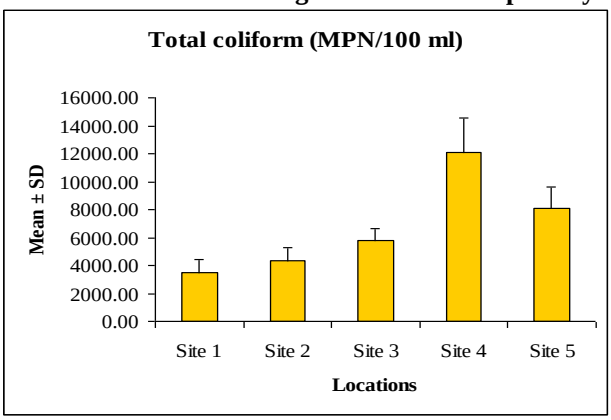
Alkalinity of the Ganges River at Mirzapur city.



Chloride of the Ganges River at Mirzapur city.



Total coliform of the Ganges River at Mirzapur city.



Graph showing Mean and SD of five sites of different parameters