Statistical Analysis of the Quality of Water of River Ganga

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ABSTRACT   *River Ganga is considered as the mother of Indians. Crores of people lives with the water of this holy river. Hindus were worshiped it as Goddess. This is a great gift of God to the Indian people. The water of Ganga is used for many purpose. But now a days due to the explosion of population, deforestation, increase in urbanization and increase in industries makes Ganga water pollution. The purity level of water is decreasing day by day. Two main components of purity level is dissolved oxygen (DO) and bio-chemical oxygen demand(BOD). In this paper a Statistical analysis of DO and BOD of Ganga water is made by using a sample of water 16 locations. The results of 2012 are compared with the purity level in 1986[1]. The study shows that the dissolved oxygen level is having very high variation and is decreased significantly. The bio-chemical oxygen demand is also having high variation and decreased in a significant rate in 2012 as compared to 1986[2]. An exponential-power model for dissolved oxygen is constructed for both 1986 and 2012 for the purpose of estimation[3]. The model is tested by using chi-square test[4].*

INTRODUCTION:

The Ganga is India's most important river. It sprawling basin accounts for one-fourth of the country's water resources and is shelter for 35crores of Indians[5]. The rivers 2525Km journey from its glacial source in Himalya to its enormous fan-shaped delta in the Bay of Bengal traverses five Indian states along the mainstream, enriching huge swathes of agricultural plains and sustaining a long procession of towns and cities.As Indian's holiest river, the Ganga has a cultural and spiritual significance that far transcends the boundaries of its basin. It is worshipped as a living Goddess and since time immemorial people from across the country hence come to the many historic temple towns on its banks to prey and bathe in its water. Despite this iconic status and religious heritage, the Ganga today is facing formidable pollution pressures and associated threats to its biodiversity and environmental sustainability. An ever growing population, inadequately planned urbanization and industrialization have affected the water quality in the river. At present the water of Ganga is sullied by sewage as well as solid and industrial wastes generated by human and economic activity along its banks. The absence of adequate infrastructure to manage these extreme pollution pressure leads to the deterioration of water quality in recent decades. Today about one-third of the sewage generated by the towns and cities on the main stem of the river is treated. The untreated and poorly treated industrial waste is responsible for 20% of all waste water inflows in the river. In fact Ganga is severely polluted especially in its critical middle stretch, that its water not suitable for drinking and some locations even for bathing.

In this paper two important components of water dissolved oxygen (DO) and bio-chemical oxygen demand(BOD) of the water of Ganga water is analyzed Statistically using the sample of the year 1986 and 2012. These results were compared with normal level for drinking and bathing purpose. It shows that the water is totally unfit for drinking purpose and in some places even for bathing. A exponential –power model for DO is constructed for the purpose of estimation. The goodness of the model is tested by using chi-square test.

SALIENT FEATURE OF GANGA The river Ganga is stretched about 26.4% of the Indian water resource. The main features of the river is as under[6]

Total length	2525 kilometre
Uttarkhand and U.P	1450 km
Boundary of U.P and Bihar	110 km
Bihar	445 km
West Bengal	520 km
Geographical area of India	3.28 million sq.km
Reported area of Ganga basin	3.05 million sq.km
Catchment area of Ganga basin	861404 sq.km
Average annual discharge	493400 million cm

| Tributaries	Yamuna, Ramaganga, Gomati, Ghaghara, Gondak, Koshi and Kali
Main sub tributaries	Chambal,Sindh, Betwa, Ken, Tons, Sone, Damodar and Kangsabatihaldi

The total number of people residing in the Ganga basin and taking the benefit of this water is as follows

Basin	Total population	Urban population	Percentage
Uttarakhand	8489349	2179074	25.66
Uttar Pradesh	166197927	34539582	20.78
Bihar	82998509	8681800	10.46
West Bengal	80176197	22427251	27.97
Total	337861976	67827707	20.07

In the basin of Ganga river there are 36 class I cities and 14 class II towns which generate the sewage of 6087 million litre per day (MLD) and a total treatment capacity is 2722 MLD and discharge it to the river[7]. Status of water generation and treatment capacity, difference between actual and measured sewage generation in these urban centres along Ganga river is summarized in the following table.

State	Estimated(MLD)	No. of drains	Actual(MLD)	Diff(Untreated) waste
Uttarkhand	61	14	440	379(86%)
Uttar Pradesh	937	45	3289	2352(71%)
Bihar	407	25	579	172(30%)
West Bengal	1317	54	1779	462(26%)
Total	2722	138	6087	3315(55%)

The bar chart representing the above information is as given below.
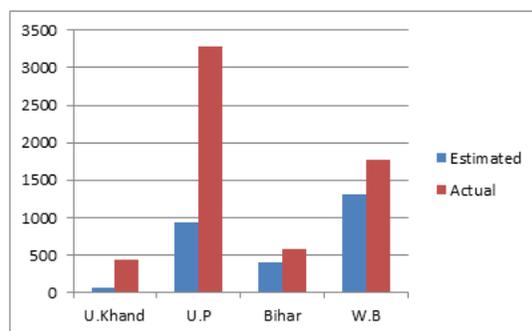
The proportion of drain sewage water directly released the river is more than 50 percentage.

WATER ANALYSIS:

To study the water quality of river Ganga, the Central Pollution Control Board (CPCB) has set up 39 water quality monitoring stations on the main river and 102 stations on its various tributaries[8]. Details of monitoring station locations are presented in the following table.

States	Uttarakhand	U.P	Bihar	West Bengal
No. of locations	09	13	09	08

The core water quality parameters studied are temperature, pH, conductivity, dissolved oxygen(DO), bio-chemical oxygen demand(BOD), nitrate, total coli forms, faecal coli forms. Besides several other location specific parameters are also studied. DO and BOD are normally indicate the biological health of water. The minimum level of DO for drinking water without treatment is 6.0mg/lt, and for bathing purpose is more than 5.0 mg/lt. The BOD level for drinking water should be less than or equal to 2.0 mg/lt and for bathing water is 3.0mg/lt. The water temperature is about 20°C. Therefore the two important parameters DO and BOD were selected to study the water quality trend in the river Ganga.

A sample of 16 locations are considered for our analysis. The DO level and BOD level is observed during the March-June of 1986 and 2012. These 16 locations are from Rishikesh(1km) of Uttarakhand to Uleberia(2500km) of West Bengal This information is given the following table[9].

Sl.No	Name of the place	Km	DO(1986)	DO (2012)	BOD (1986)	BOD (2012)
1	Rishikesh	01	8.1	7.5	1.7	1.2
2	Hardwar(U/S)	30	8.1	7.4	1.8	1.6
3	Garhmukteshwa	175	7.8	7.4	2.2	1.7
4	Kannenj(U/S)	430	7.2	6.8	5.5	3.9
5	Kannenj(D/S)	433	7.1	7.0	5.1	4.4
6	Kanpur(U/S)	530	7.2	7.2	7.2	3.9
7	Kanpur(D/S)	548	6.7	6.1	86	4.5
8	Allahabad(U/S)	733	6.4	7.8	11.4	6.4
9	Allahabad(D/S)	743	6.6	7.4	15.5	3.6
10	Varanashi(U/S)	908	5.6	8.2	10.1	2.6
11	Varanashi(D/S)	916	5.9	7.5	10.6	3.4
12	Patna(U/S)	1188	8.4	7.1	2.0	1.8
13	Patna(D/S)	1198	8.1	6.9	2.2	2.2
14	Rajmahal	1580	7.8	6.8	1.8	1.4
15	Palta	2050	7.4	7.4	2.5	2.2
16	Uleberia	2500	7.1	6.3	3.1	3.2

The graph representing these observed level of DO and BOD is as follows
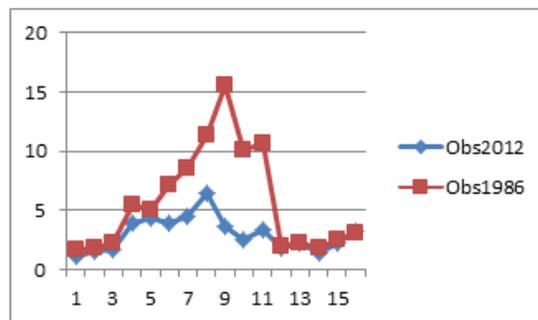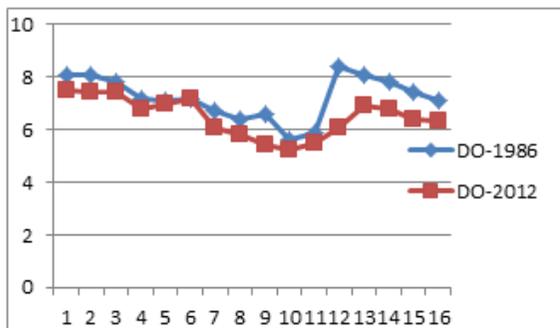
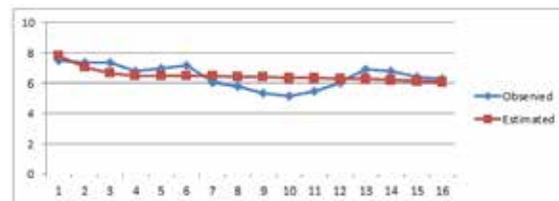**STATISTICAL ANALYSIS OF DISSOLVED OXYGEN:**

The mean and standard deviation of the DO level in 1986 and 2012 are represented in the following table

Year	Mean	Standard deviation	Coefficient of variation(C.V)
1986	7.21875	0.7963	11.0304
2012	6.4875	0.7271	11.2069

The C.V(86) < C.V(12), this shows that there is a high variation of DO in 2012 as compared to DO level at 1986.

Test for difference between DO level: The mean difference between the DO of 16 locations in2012 and 1986 is X_d =0.73124 with a standard deviation of 0.5288. The t-test for the significance of on an average difference gives t-value t_0 = 5.3555 (p-value= 0.00004).This shows that there is a significant decrease in the DO level from 1986 to 2012.

For the purpose of estimation of DO of any location an exponential-power model is constructed from the observed values of 2012. The equation of the model is $\exp(y) = (2431.321) x^{-1.240668}$. The linearized form of this model is $y = 7.79619 - 0.21565(\ln x)$. The model is tested for its goodness by using chi-square statistic. The tabulated value is $\chi^2 = 0.915252$ (p-value=0.99). This shows that the model gives best estimate of DO at the given distance from Rishikesh. The estimated values corresponding to above observed values are: Estimated Values: 7.796, 7.063, 6.682, 6.488 ,6.487, 6.444, 6.436, 6.374, 6.371, 6.327, 6.325, 6.269, 6.208, 6.153, 6.109. The graph of the observed and estimated value of DO level is given below.

STATISTICAL ANALYSIS OF BIO-CHEMICAL DEMAND:

The mean and standard deviation of the BOD level in 1986 and 2012 are represented in the following table

Year	mean	Standard deviation	Coefficient of variation(C.V)
1986	5.706253	4.217296	73.9066
2012	3.0	1.3346	44.4869

The C.V(86) > C.V(12), this shows that there is a high variation of BOD in 1986 as compared to BOD level at 2012.

Test for difference between BOD level: The mean difference between the BOD of 16 locations in2012 and 1986 is X_d = - 2.70625 with a standard deviation of 3.437926. The t-test for the signifi-

cance of on an average difference gives t-value t_0 = - 3.04872 (p-value= 0.00001).This shows that there is a significant decrease in the BOD level from 1986 to 2012.

For the purpose of estimation of BOD of any location an exponential-power model is constructed from the observed values of 2012. The equation of the model is y = .0317922 + 2.36639 (ln X) – 0.22257(ln X)^2 . The model is tested for its goodness by using chi-square statistic. The tabulated value is χ^2 = 4.915252 (p-value=0.9944). This shows that the model gives best estimate of BOD at the given distance from Rishikesh. The estimated values corresponding to above observed values are: Estimated Values: 0.32, 5.79, 6.6, 6.48, 6.46, 6.4, 6.38, 6.24, 6.23, 6.11, 6.10, 5.91, 590, 567, 5.42, 5.21. The graph of the observed and estimated value of DO level is given below.
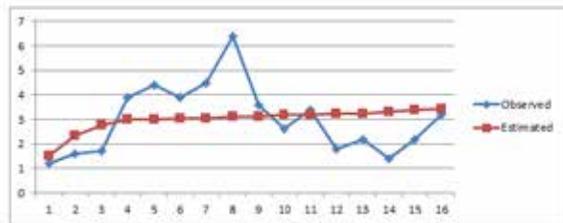
CONCLUSIONS:
Only 45% of the sewage water is treated before releasing it to the river. This shows present treatment capacity is insufficient.

The average dissolved level of oxygen is having very high variation and is decreased significantly by an average of 1.0 mg/lt.

The average level of DO is still about 6.5mg/lt. but some locations it is below 6.0mg/lt.

The average BOD is decreased significantly with decrease in variation.

The BOD of more than 50% of the locations are above the maximum level for bathing purpose.

SUGGESTIONS:
There are 138 drains releasing sewage to the river, so there should be at least 138 treatment stations.

Deforestation should be stopped in the source of Ganga river.

All possible steps should be taken to decrease the BOD level as well as to increase DO of the water in the river

The DO and BOD level of water should be estimated in the convolution of drain to the river.

The save Ganga activities should be taken seriously by the Government and the people.

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