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# Assessment of Physico-chemical Parameters of River Yamuna at Agra Region of Uttar Pradesh, India

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## Abstract

*To mankind rivers have been considered sacred from ancient times. At religious centers the water quality restoration of any river, especially of the Yamuna at Agra region, is a very complex and difficult task. In the present study water quality was assessed along the four different sampling locations of the river Yamuna for a period of six months (May 2014 to October 2014). Specific water quality parameters like EC, TDS, turbidity, chloride, and chemical oxygen demand in river Yamuna were analyzed. Correlation matrix analysis shows strong relationship between all the analysed water quality parameters. Higher values of physico-chemical parameters indicate that river water is not safe for drinking and domestic uses as prescribed by BIS.*

**Keywords:** Yamuna River, water quality, physico-chemical parameters, Agra, BIS, correlation.

## Introduction

For human being wholesome water is necessary for various purposes. Rapid urbanization, coupled with accelerated pace of population growth is the main cause for discharge of untreated sewage and industrial effluents into the surface water bodies. Excessive withdrawal and use of water from rivers for domestic, industrial and irrigation purposes and lack of awareness are also considered as major causes for deterioration of river water quality[1-4]. The pollution status of any river can be evaluated by analyzing the physico-chemical properties of the water bodies. Several research in relation to river water pollution like Krishna, Godavari and Tungbhdra[5], Sutlej[6], Ulhas[7], Cauvery[8], Jhelum[9], Kosi[10], Narmada[11,12], Brahamani[13], Goriganga[14,15], Ganga[16-20], Godavari [21], Yamuna[22-25], have attracted more attention during recent past years. Day by days the holy river Yamuna is continuously subjected to various uses, such as bathing, irrigation, disposal of industrial effluents and raw sewage, drinking water supply etc. Therefore an effort has been made to assess the pollution status of river Yamuna at Agra region.

## Material and Methods

**Description of the study sites:** Water samples were collected at following designated sampling locations identified on the basis of disposal of raw sewage and occurrence of industries which are responsible for point source of contamination for the river. The sampling locations are as follows: (S1) Runkata village; (S2) Kailash Mandir; (S3) Jiwani Mandi; and (S4) Taj Mahal.

**Collection and characterization of water samples:** Water samples from the River were collected on weekly basis from 4 selected locations in 1 liter airtight plastic bottles. Thereafter all the samples were transferred to the regional laboratory of Uttar Pradesh Pollution Control Board, Agra and preserved in refrigerator (4°C) prior to processing and analysis. All the samples were analyzed in the regional laboratory of Uttar Pradesh Pollution Control Board, Agra. All the water quality parameters were analyzed according to the standard methods[26]. The monitoring was made over a period of 6 months (May-October, 2014), comprising of two sessions i.e. pre-monsoon and post-monsoon. All measurements were done in triplicates. Distilled water was used for experimental purpose. A comparison of analysed physico-chemical parameters of river Yamuna as observed with drinking water quality standards (Indian) was given in table-1.

## Results and Discussion

**Electrical conductivity (EC):** The EC values of the river water samples of Agra region varied from minimum 1.052 mS/cm at sampling station 3 to maximum 1.29mS/cm at sampling station 4 during pre-monsoon session and minimum 1.0 mS/cm at sampling station 1 to maximum 1.19mS/cm at sampling station 4 during post-monsoon season (figure-1). The results shows that EC values of the river water collected from four different sampling stations were not within the maximum permissible limit (0.3mS/cm) of drinking water quality standards of BIS (table-1). Statistical summary for EC in river water samples is presented in figure-2. Analyzing the figure-2, it shows that the curve for electrical conductivity is positively skewed (1.85314) and mean>median >mode. It shows that the values of EC varies along the sampling stations and found unsymmetrical. The curve is flat topped which mean that the curve is leptokurtic and the fourth standardized moment ($\beta_2$) >3.

**Table-1**
**Comparison of water quality parameters of river Yamuna at Agra region with BIS**

| **Parameters** | **Observed Range of Samples** | | **Indian Standards (BIS)** | |
|---|---|---|---|---|
| | **Minimum** | **Maximum** | **Desirable limit** | **Maximum limit** |
| EC (mS/cm) | 1.05 | 1.29 | - | 0.3 |
| TDS (mg/l)) | 798.75 | 936.22 | 500 | 2000 |
| Turbidity (NTU) | 56.25 | 113.44 | 5 | 10 |
| $Cl^-$(mg/l) | 214.22 | 311 | 250 | 1000 |
| COD (mg/l) | 34.24 | 85.95 | - | - |

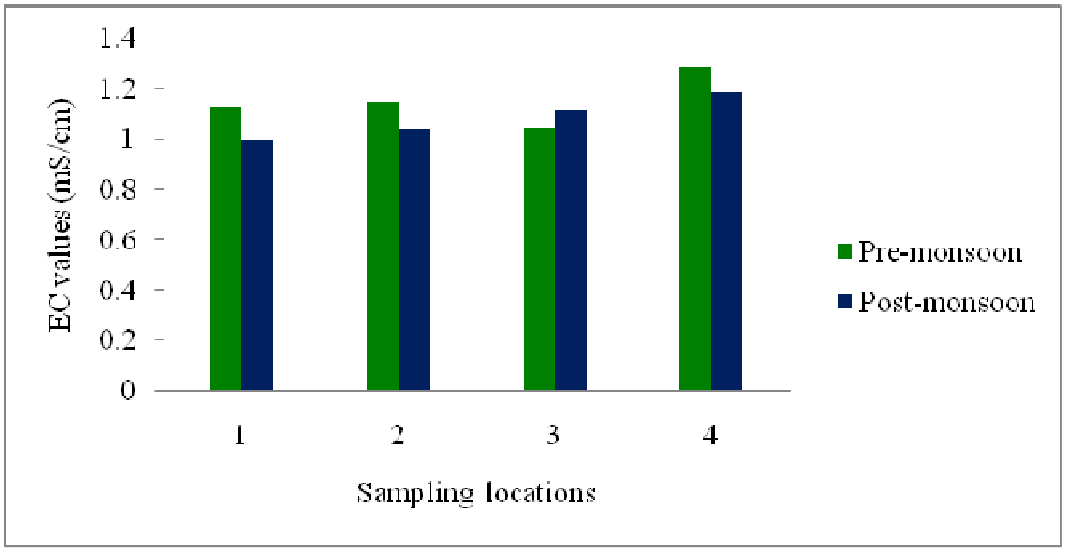


**Figure-1**
**Variation of electrical conductivity of river Yamuna at sampling locations**

**Total dissolved solids (TDS):** The TDS values of the collected river water samples at Agra region varied from minimum 798.75 mg/l at sampling station 2 to maximum 824.12 mg/l at sampling station 4 during pre-monsoon session and minimum 804.33 mg/l at sampling station 1 to maximum 936.22 mg/l at sampling station 4 during post-monsoon session (figure-3). The observed results indicate that during post-monsoon session the TDS content of river water was more than that of pre-monsoon session. The results shows that TDS content of river water collected from four different sampling stations were not satisfying the desire limit (500 mg/l) of drinking water quality standards of BIS (table 1). Statistical summary for TDS is shown in figure-4. Analyzing the figure 4, it shows that the curve for total dissolved solids is positively skewed (0.945297) and mean > median > mode. It shows that the values of total dissolved solids content varies along the sampling stations and found unsymmetrical. The curve is flat topped which mean that the curve is platykurtic and the fourth standardized moment ($\beta_2$) < 3.

**Turbidity:** The turbidity content of the river water samples varied from minimum 56.25 NTU at sampling station 1 to maximum 61 NTU at sampling station 4 during pre-monsoon and minimum 65.88 NTU at sampling station 1 to maximum 113.44 NTU at sampling station 4 during post-monsoon session (figure-5). The observed results indicate that during post-monsoon session the turbidity content of river water was more than that of pre-monsoon session. The results shows that turbidity content of river water collected from four different sampling stations were at least five times more than the maximum limit (10 NTU) as prescribed by Bureau of Indian Standards (table-1). Statistical summary for turbidity in river water samples is presented in figure-6. Analyzing the figure-6, it shows that the curve for turbidity is positively skewed (1.13304) and mean > median > mode. It shows that the values of turbidity varies along the sampling stations and found unsymmetrical. The curve is flat topped which mean that the curve is platykurtic and the fourth standardized moment ($\beta_2$) < 3.

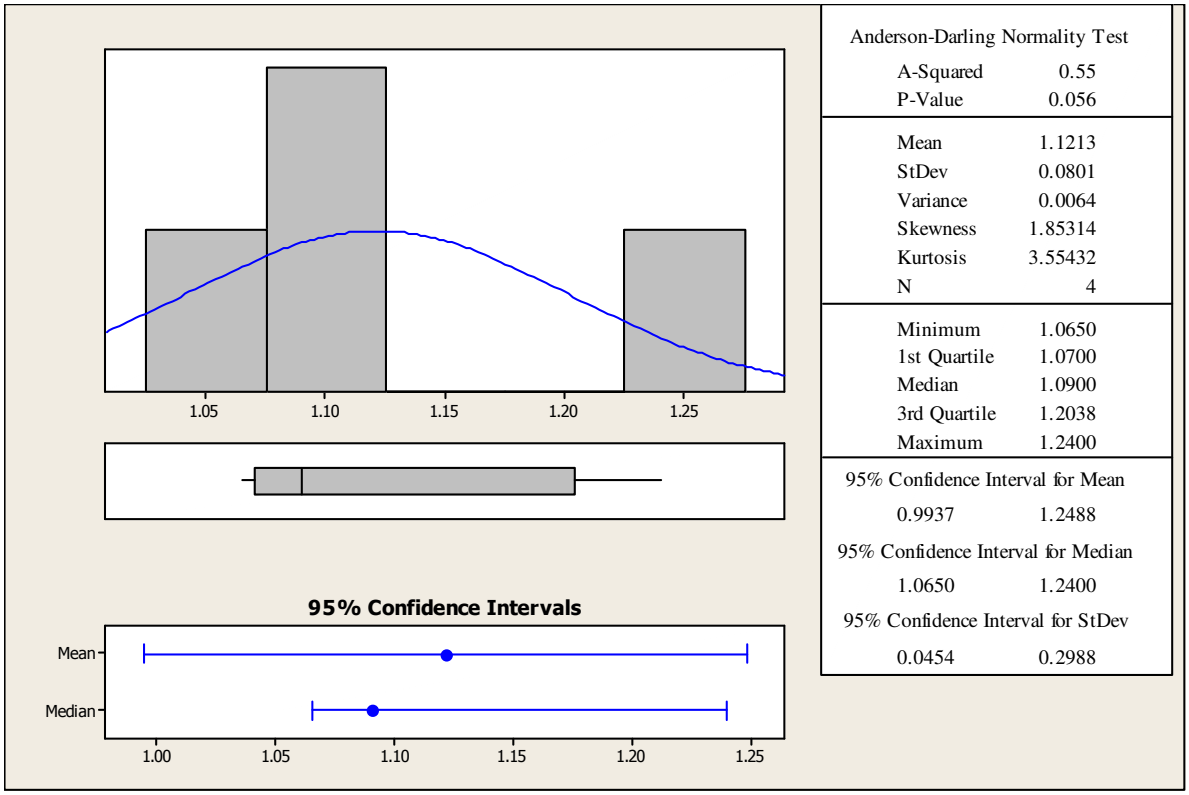


**Figure-2**
**Statistical summary for EC of river Yamuna at Agra region**

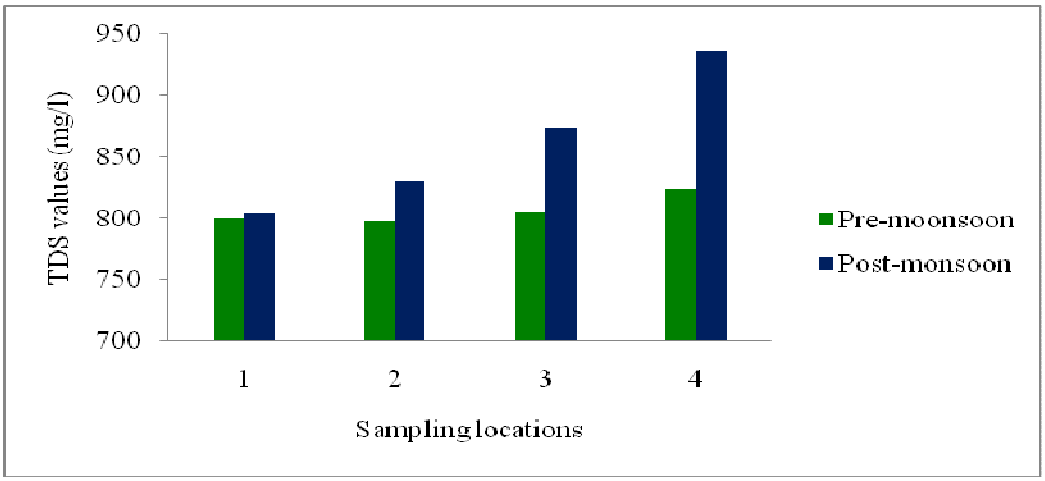


**Figure-3**
**Variation of total dissolved solids of river Yamuna at sampling locations**

**Chloride ($Cl^-$):** The chloride content of the collected river water samples varied from minimum 272.25 mg/l at sampling station 1 to maximum 311 mg/l at sampling station 4 during pre-monsoon session and minimum 214.22 mg/l at sampling station 1 to maximum 281.5 mg/l at sampling station 4 during post-monsoon session (figure-7). The observed results showed that during pre-monsoon session the chloride content of river water was more than that of post-monsoon session. The results shows that chloride content of river water collected from four different sampling stations were within the maximum limit (1000 mg/l) of drinking water quality standards of BIS (table-1). Statistical summary for $Cl^-$ in river water samples is presented in figure-8. Analyzing the figure-8, it shows that the curve for chloride is positively skewed (0.68023) and mean > median > mode. It shows that the values of chloride varies along the sampling stations and found unsymmetrical. The curve is flat topped which mean that the curve is platykurtic and the fourth standardized moment ($\beta_2$) < 3.

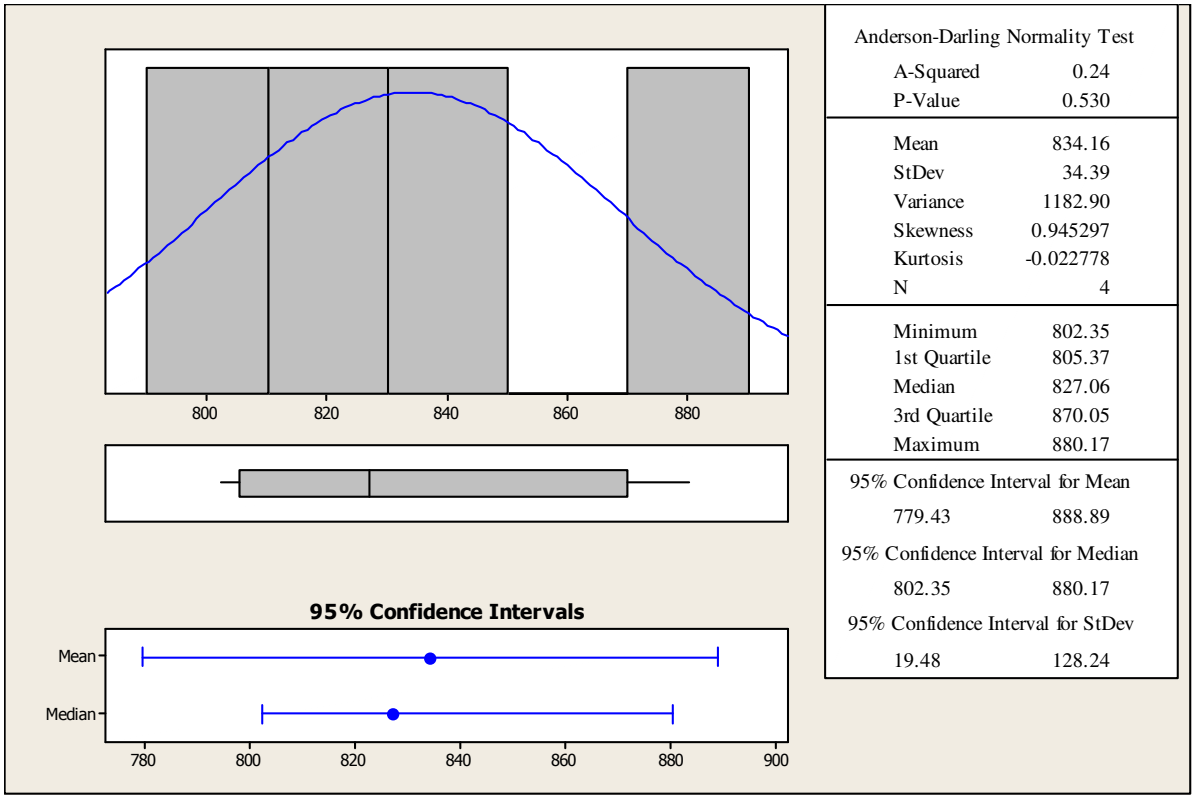


**Figure-4**
**Statistical summary for TDS of river Yamuna at Agra region**

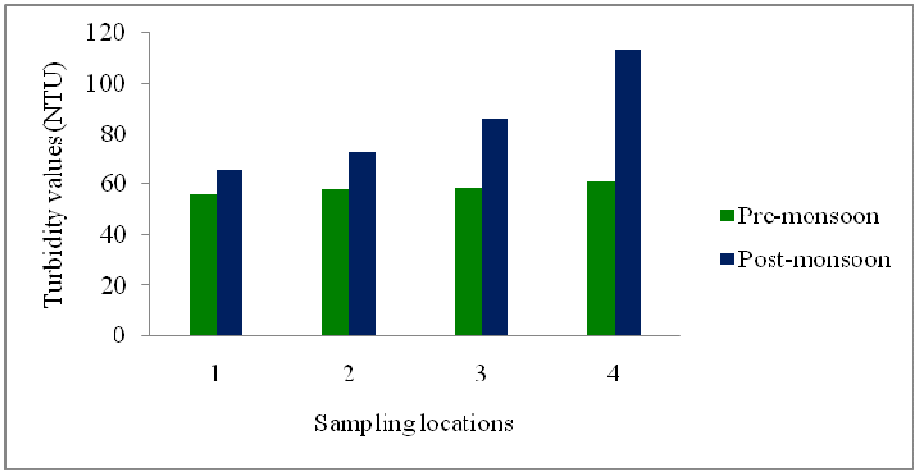


**Figure-5**
**Variation of turbidity of river Yamuna at sampling locations**

**Chemical oxygen demand (COD):** The COD of the collected water samples of river varied from minimum 56.75 mg/l at sampling station 1 to maximum 85.95 mg/l at sampling station 4 during pre-monsoon session and minimum 34.24 mg/l at sampling station 1 to maximum 68.06 mg/l at sampling station-4 during post-monsoon session (figure-9). The observed results shows that during pre-monsoon session the COD content of river water was more than that of post-monsoon session. The results shows that COD content of river water collected from four different sampling stations were exceeding the maximum limit (20 mg/l) of drinking water quality standards of WHO. Statistical summary for COD in river water samples is presented in figure-10. Analyzing the figure 10, it shows that the curve for chemical oxygen demand is positively skewed (0.708869) and mean > median > mode. It shows that the values of chemical oxygen demand varies along the sampling stations and found unsymmetrical. The curve is flat topped which mean that the curve is platykurtic and the fourth standardized moment ($\beta_2$)<3.

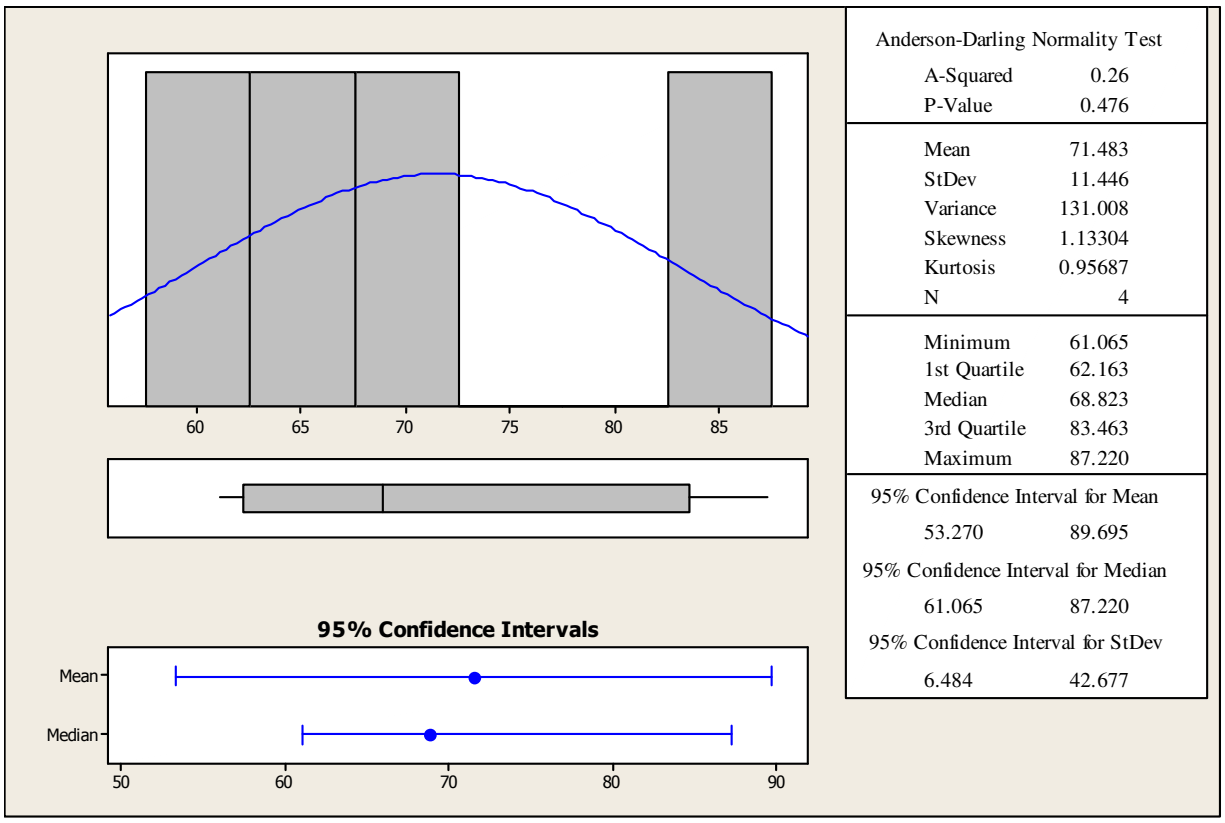


**Figure-6**
**Statistical summary for turbidity of river Yamuna at Agra region**

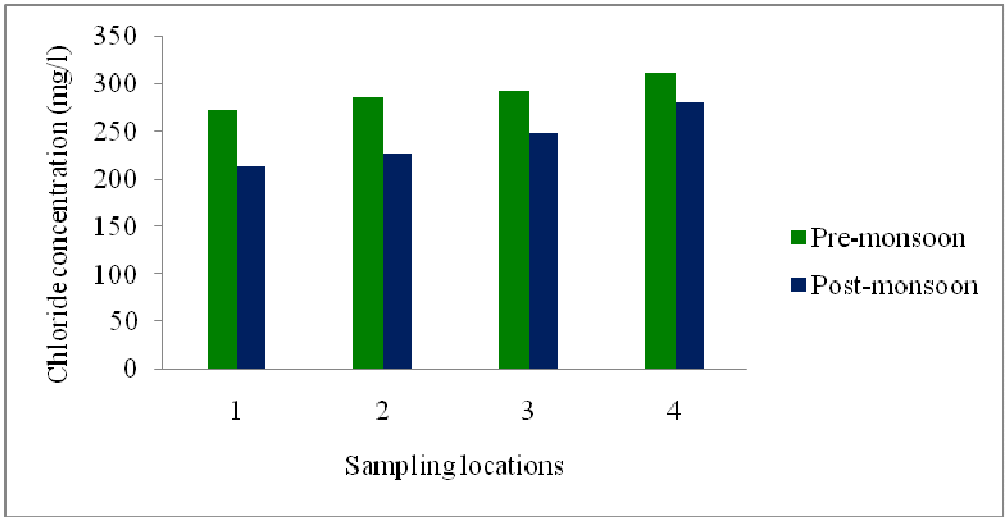


**Figure-7**
**Variation of chloride content of river Yamuna at sampling locations**

**Correlation matrix analysis:** The correlation coefficient ($r^2$) values vary within -1 to 1. Positive sign represents variables have similar trend whereas negative value represents variables do not have similar trend. More will be the accuracy of fitness if the value correlation coefficient is more close to 1 and 0 values means there is no relationship between the variables and both are independent to each other[27]. Correlation matrix analysis was prepared to know the type of relationship exist between the five different physico-chemical parameters and is presented in table-2. The highest positive correlation was observed between COD and TDS ($r^2$=0.998). There is also strong positive correlation exists between other physico-chemical parameters and shown in table-2.

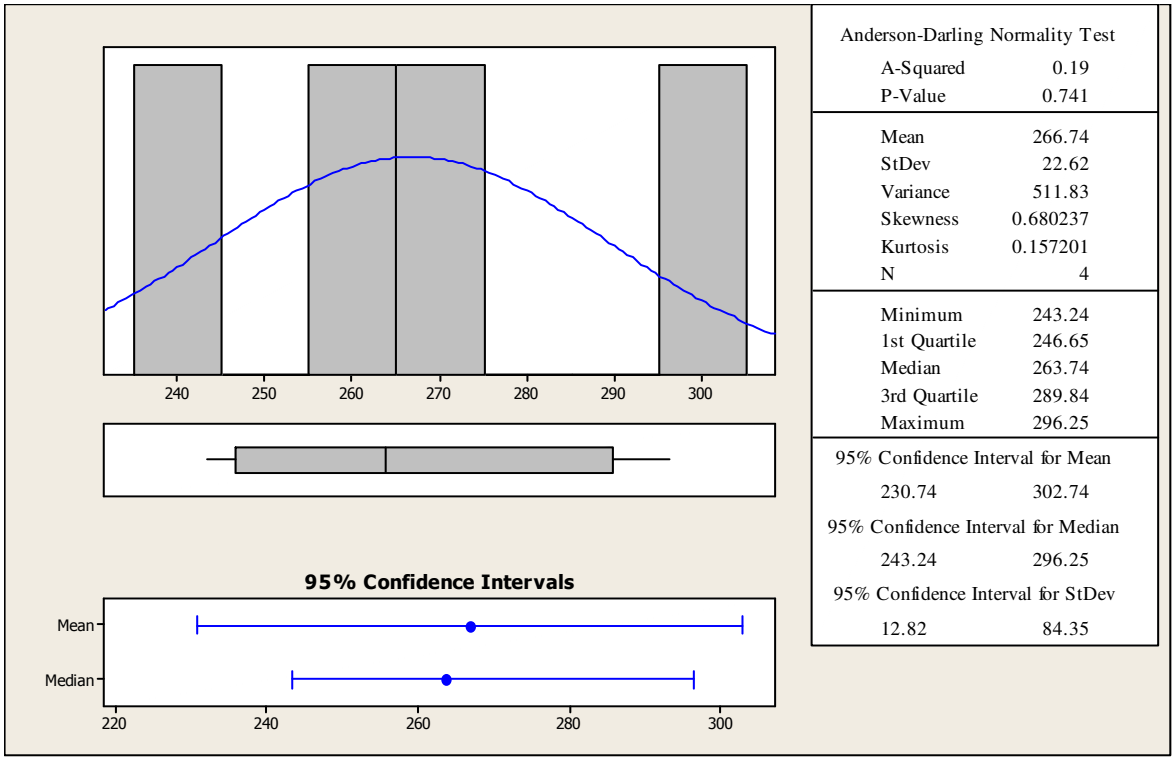


**Figure-8**
**Statistical summary for chloride of river Yamuna at Agra region**

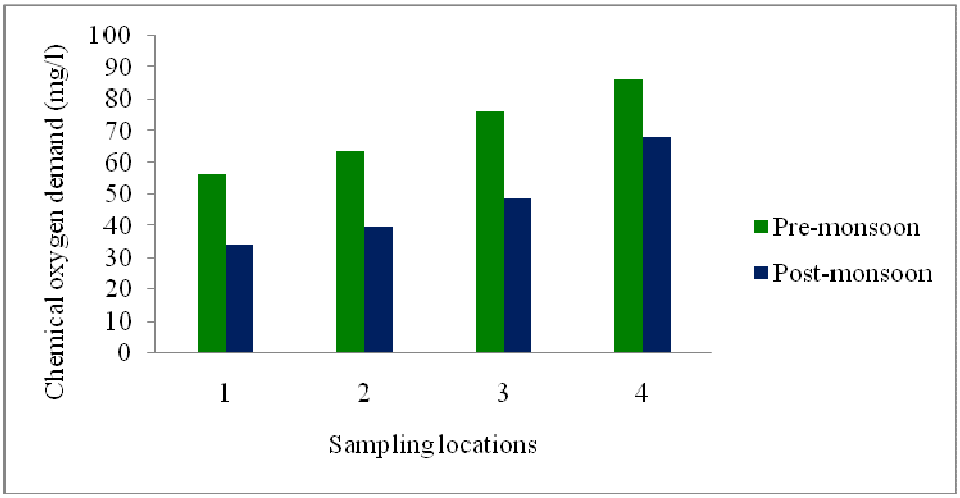


**Figure-9**
**Variation of chemical oxygen demand of river Yamuna at sampling locations**

**Table-2**
**Correlation matrixes among the physico-chemical characteristics of river water**

| | EC | TDS | Turbidity | Cl | COD |
|---|---|---|---|---|---|
| EC | 1 | - | - | - | - |
| TDS | 0.915** | 1 | - | - | - |
| Turbidity | 0.94** | 0.997** | 1 | - | - |
| Cl | 0.909** | 0.994** | 0.993** | 1 | - |
| COD | 0.893** | 0.998** | 0.993** | 0.996** | 1 |

**Significant at 0.01 level

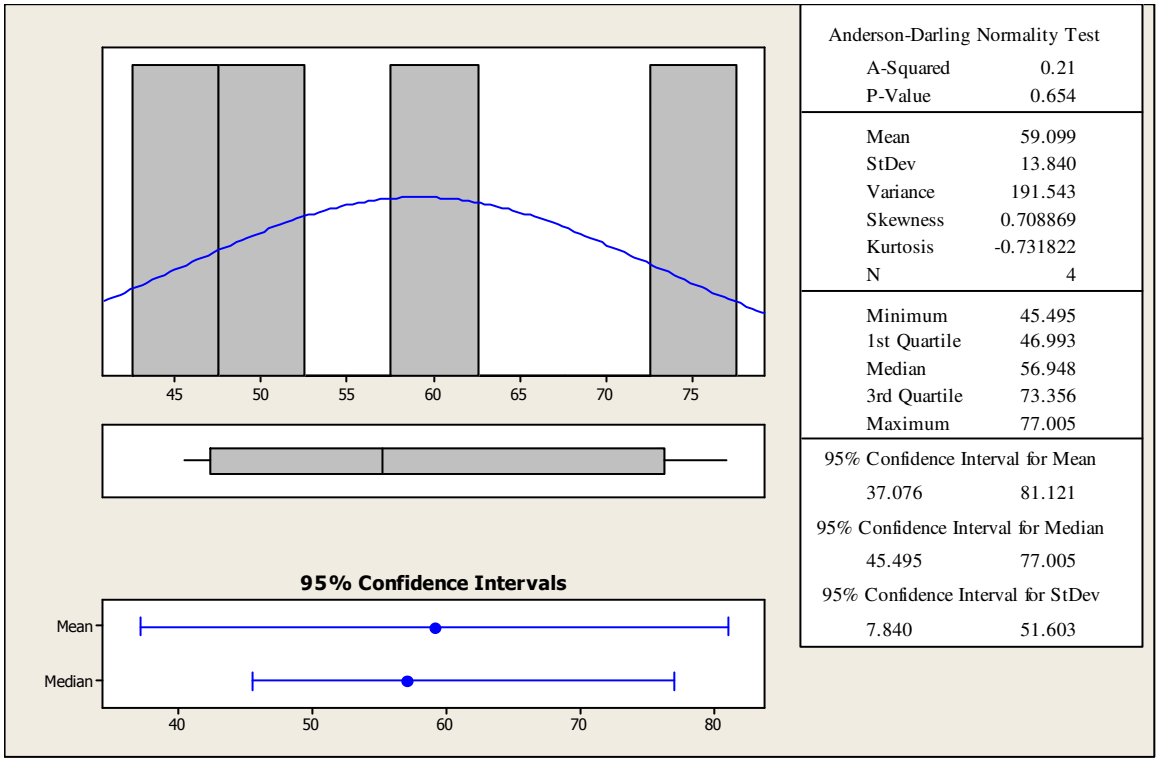


**Figure-10**
**Statistical summary for chemical oxygen demand of river Yamuna at Agra region**

## Conclusion

This study assessed some physico-chemical parameters of the Yamuna River collected from four different stations of Agra city, during the months of May to October 2014. Water quality parameters like EC, TDS, turbidity, chloride and chemical oxygen demand was analysed. The results revealed that parameters like EC and turbidity exceeding the level of pollution and TDS is exceeding the desire limit as prescribed by BIS at all the sampling stations. Therefore it is concluded that the Yamuna River in Agra city is highly polluted and is not safe for human consumption. The contamination of river water may be due to disposal of untreated sewage. Small to large scale industries and agriculture sectors are also playing role in contamination of the river water so further studies should be done to evaluate the role of industries and agricultural sectors.

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