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CORRELATION AND REGRESSION ANALYSIS OF PHYSICOCHEMICAL PARAMETERS OF CHAMBAL RIVER WATER IN DCM INDUSTRIAL AREA OF KOTA (RAJASTHAN)

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Rivers are the soul of life on the Earth. They are the ultimate wellspring of all activities on the planet. But human's imprudent notion that water bodies are ceaseless asset to humanity has led to their substantial exploitation. Discharge of industrial, domestic and agricultural wastes and direct release of untreated sewage into water bodies are the prime cause of their deterioration. Physicochemical analysis of water is reliable means of assessing water quality. Present study deals with statistical analysis of physicochemical parameters affecting water quality of river Chambal running through Kota (Rajasthan).Correlation coefficient helps to determine degree of association between parameters while regression analysis aids to ascertain as to which factors affect each other significantly. Parameters were found both positively as well as negatively correlated with each other. Significant positive interaction was found between BOD and Temperature (R^2= 0.8076) while BOD-Dissolved Oxygen (R^2 = 0.965) and Dissolved Oxygen (DO) –Temperature (R^2= 0.786) showed remarkable negative interaction with each other.

Keywords Correlation, Interaction, Pollution, Physico-chemical analysis, Regression analysis.

Introduction

Water, 'The Blue Gold' is an essential element of life for all leaving beings[1]. River water is an important source to fulfill the daily requirement of the fresh water for drinking and other purposes[2,3].But unfortunately rivers are also the most exploited natural system by man since his advent. Population growth, agricultural activities industrialization and urbanization are the vital reasons of pollution and contamination of water resources[4]. Release of untreated domestic sewage, detergents and industrial wastes are major causes of pollution of water bodies in India. Contamination of water poses health hazards and is a great concern all over the world[5].

Analysis of biochemical parameters is the most practiced technique to assess water quality for determining the extent of pollution of a water source[6].The present study deals with the statistical analysis of various physicochemical parameters affecting water quality of river Chambal running through DCM industrial area of Kota city (Rajasthan). Kota, also known as educational and industrial city of Rajasthan, is located in its southern part. It is situated south east of Aravalli ranges on the eastern bank of river Chambal (25°11' N and 75°51' E) with elevation of 273 m above sea level[7].

Material and Methods

Water samples were collected in first quarter of 2020 from five sites spreading over a stretch of approx. 10 kms of canal of river Chambal running through DCM industrial area, Kota (Raj). Seven physico-chemical parameters were analysed according to the recommendations of APHA 2005[8]. Chemical used were of AR grade. Distilled water was used for all preparations.

Results and Discussion

Seven physicochemical parameters were analyzed viz. pH, Temperature, Total Dissolved Solids (TDS), Total Hardness (TH), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD). Minimum, maximum and mean values of each parameter were calculated of all water samples. The mean values were used for further analysis. The result of physico-chemical analysis is summarized in Table 1. Correlation and regression analysis was carried out for all the seven parameters. The outcomes of analysis are summarized in Tables 2 and 3.

Table 1. Comparative analysis of study sites of river Chambal with reference to physico-chemical parameters

S. No.	Parameters	SITE 1			SITE 2			SITE 3			SITE 4			SITE 5		
		Min	Max	Mean & SD	Min	Max	Mean & SD	*Min*	Max	Mean & SD	Min	Max	Mean & SD	Min	Max	Mean & SD
1	pH	8.1	8.4	8.25 ±0.21	8.2	8.3	8.25 ±0.07	*8.2*	8.4	8.3 ±0.14	8	9	8.5 ±0.71	9	9.2	9.1 ±.0.14
2	Temperature (˚C)	21	25	23 ±2.83	21	25	23 ±2.83	*20*	25	22.5 ±3.54	20	24	22 ±2.83	20	25	22.5 ±3.54
3	TDS (mg/L)	136	145	140.5 ±6.36	154	162	158 ±5.66	*137*	142	139.5 ±3.54	135	143	139 ±5.66	128	134	131 ±4.24
4	Total Hardness (mg/L)	100	125	112.5 ±17.68	95	150	122.5 ±38.89	*150*	175	162.5 ±17.68	150	200	175 ±35.56	175	200	187.5 ±17.68
5	COD (mg/L)	29	39	34 ±7.07	23	34	28.5 ±7.78	*26*	35	30.5 ±6.36	22	36	29 ±9.9	31	33	32 ±1.41
6	Dissolved Oxygen (mg/L)	9	15	12 ±4.24	10	12	11 ±1.41	*14*	17	15.5 ±4.24	14	23	18.5 ±6.36	10	14	12 ±2.83
7	BOD (mg/L)	5	6	5.5 ±2.83	4	8	6 ±2.83	*4*	5	4.5 ±0.71	2	3	2.5 ±0.71	5	6	5.5 ±0.71

Table 2. Correlation coefficient matrix of water quality parameters.

Parameters	pH	Temperature	TDS	Total Hardness	COD	Dissolved Oxygen	BOD
pH	1						
Temperature	-0.39665	1					
TDS	-0.68052	0.53913	1				
Total Hardness	0.76595	-0.83554	-0.68816	1			
COD	0.17033	0.35813	-0.54419	-0.20406	1		
Dissolved Oxygen	-0.05955	-0.88656	-0.32680	0.52301	-0.36997	1	
BOD	0.00248	0.89872	0.32662	-0.51285	0.36159	-0.98239	1

Table 3. Type of correlation between various physicochemical parameters of water samples.

S.No.	Parameter	Correlation type	Interacting parameters
1	pH	negative	Temperature, TDS, DO
		positive	Total hardness COD, , BOD
2	Temperature	negative	pH, Total hardness, DO
		positive	TDS, , COD, , BOD
3	TDS	negative	pH, Total hardness, COD, DO
		positive	Temperature, , BOD
4	Total hardness	negative	Temperature, TDS ,pH, COD,
		positive	BOD
5	COD	negative	TDS, Total hardness, DO
		positive	pH, Temperature, BOD
6	DO	negative	TDS, pH, Temperature, COD,
		positive	Total hardness
7	BOD	negative	Total hardness, DO,
		Positive	pH Temperature, TDS, COD

Regression and correlation analysis are used to study the relationships between variables. Correlation analysis refers to the, degree of relationship between variables[9]. But through it we cannot determine which of the variable is cause and which one is the effect.

Let x and y be only two variables and (x_i, y_i) be n pairs of observed value of these variables. (i = 1, 2, 3…, n). Then the correlation coefficient equation for these variables will be as following

$$r = \frac{\sum x y - \bar{x}\sum y}{\sqrt{[\sum x^2 - \bar{x}\sum x][\sum y^2 - \bar{y}\sum y]}}$$

Where the summations are taken over 1 to n. (n= Number of observations) and r represents the correlation coefficient[10].

Regression is used to predict the value of a dependent variable based on the value of independent variable. Regression analysis helps us to establish a relationship between variables by the equation called the regression line[11]. Through Least Square Method parameters of regression equation is estimated by minimizing the error sum of square of dependent[12]. Equation of Simple egression is as following

If Y is a dependent variable and X is an independent variable then regression equation of Y is-

$$Y = a + b X$$

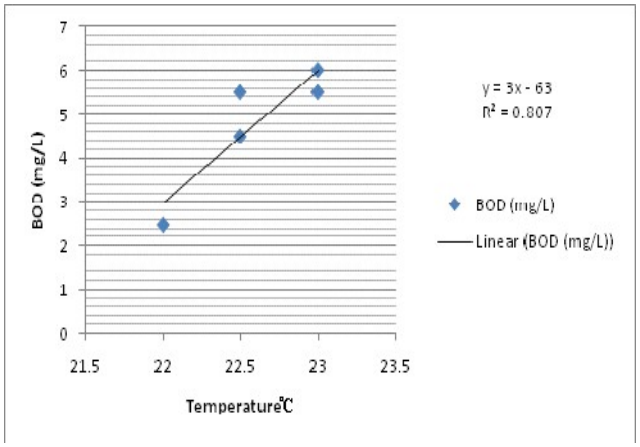
Where,

a = y intercept = constant = value of Y when X =0

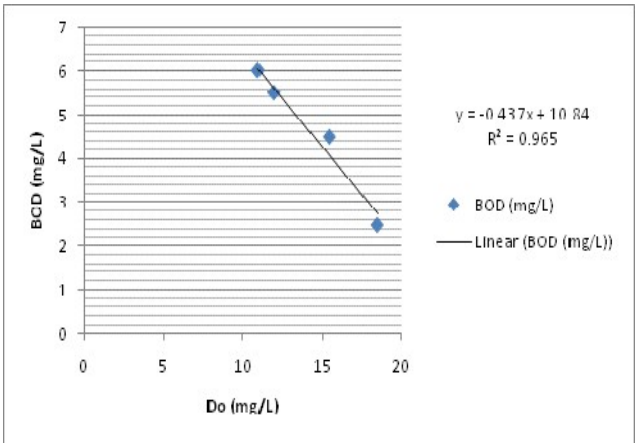
b= regression coefficient = slope coefficient = change in the value of Y per unit change in the valueof X.

According to the matrix (Table 2), for the seven physicochemical parameters studied,21 correlation coefficient are possible. These coefficients indicate both positive and negative relationship between the parameters. Negative correlation was observed between twelve pairs viz. temperature-pH, TDS-pH, Dissolved Oxygen-pH, Total hardness-temperature, Dissolved Oxygen-temperature, Total hardness-TDS, COD-TDS, Dissolved Oxygen-TDS, COD-Total hardness, BOD- Total hardness, Dissolved Oxygen-COD and Dissolved Oxygen–BOD (Table 2).Out of 28 interactions 9 showed positive correlation. Highly positive correlation was found between the BOD and temperature (r = 0.89872), Total hardness and pH (r = 0.76595) while highly negative correlation was observed between BOD-DO

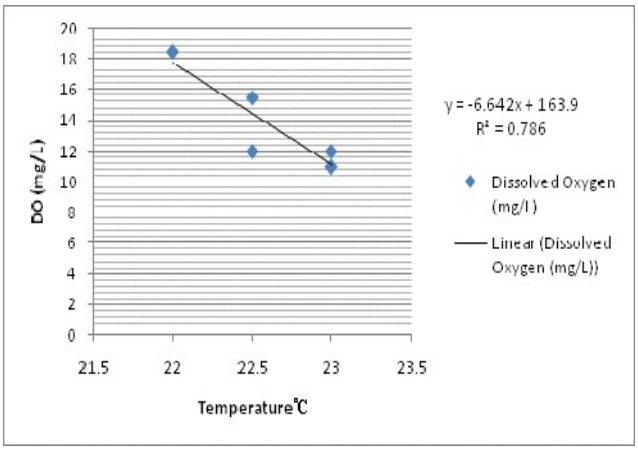
Regression analysis graphs of physico-chemical parameters of water samples of river Chambal



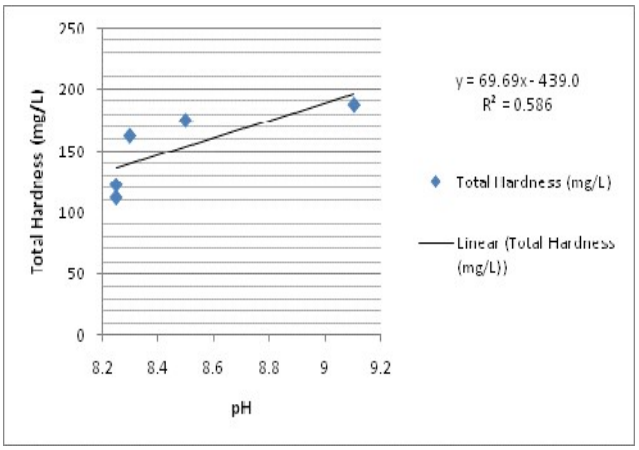
(Fig. 1) BOD-Temperature



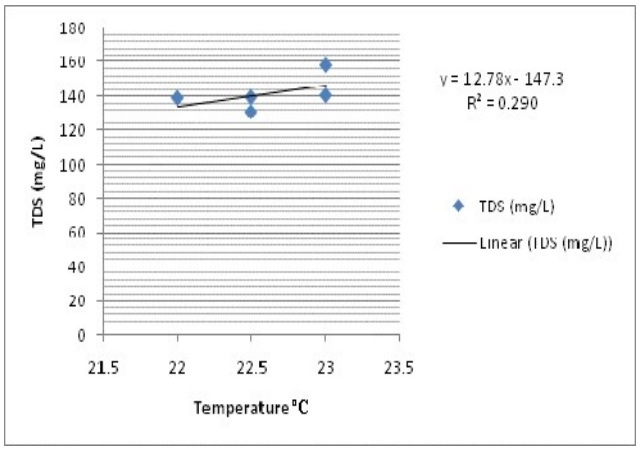
(Fig. 2) BOD-DO



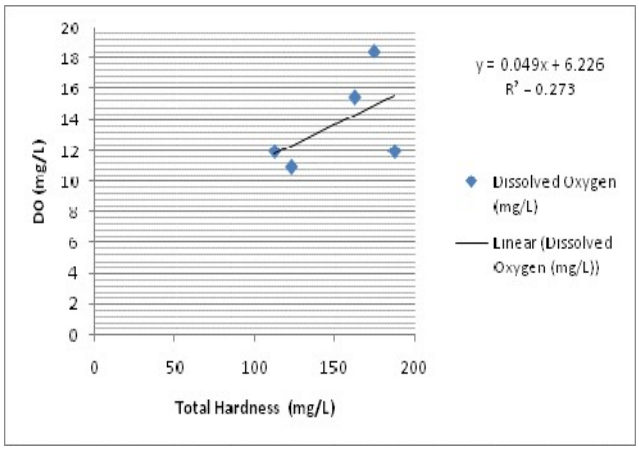
(Fig. 3) DO-Temperature



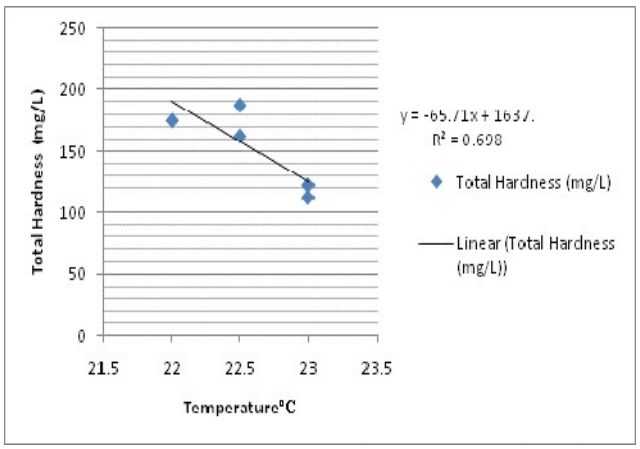
(Fig. 4) Total Hardness-pH



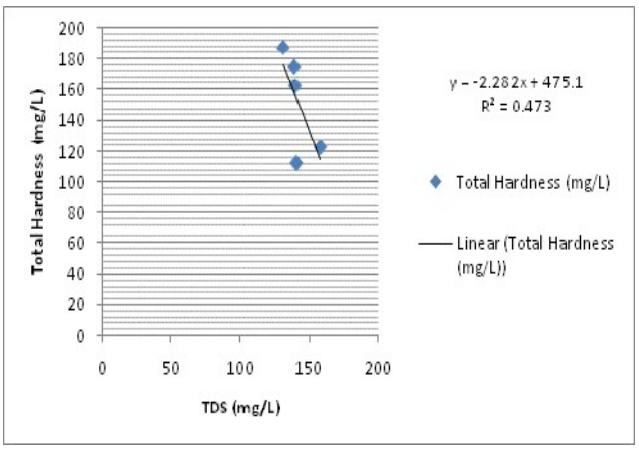
(Fig. 5) TDS-Temperature



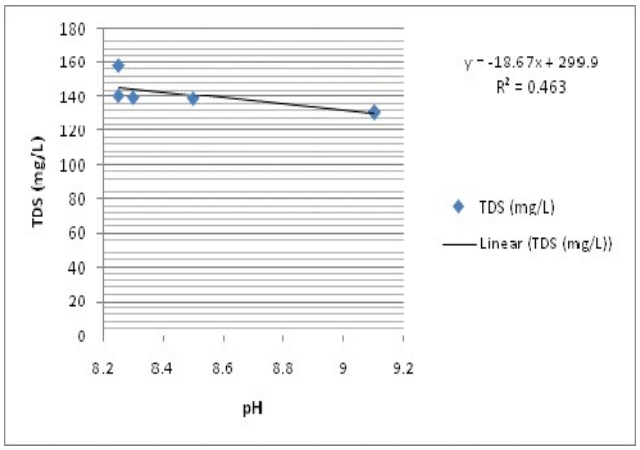
(Fig. 6) DO-Total Hardness



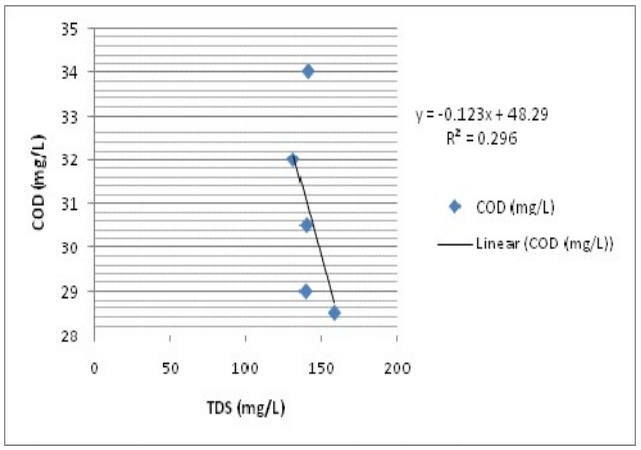
(Fig. 7) Total Hardness-Temperature



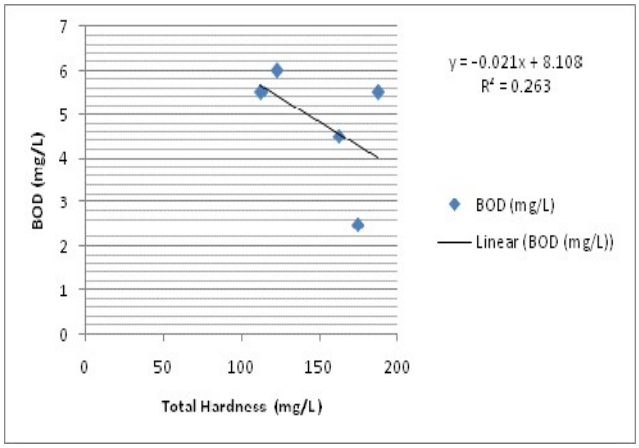
(Fig. 8) Total Hardness-TDS



(Fig. 9) TDS-pH



(Fig. 10) COD-TDS



(Fig. 11) BOD-Total Hardness

(r= -0.98239), Temperature-DO (r= -0.88656), Temperature-pH (r= -0.83554).

A positive correlation indicates affirmative interdependency among parameters while negative correlation suggests that parameters affect each other inversely[13]. Higher the value of correlation coefficient 'r', the larger is the extent to which a linear relationship of the type holds between two variables x and y.

Regression analysis was done for those eleven interactions of parameters in which correlation coefficient was above ±0.5. Regression equations were derived and graphs were plotted (Fig 1 -11). R^2 values were calculated. The higher the values of R^2 the more significant is relationship between the variables. It also indicates that the values of dependent variable can be predicted though independent variables by means of regression equation[14].

The outcomes of regression analysis are as following-.

The parameters showed positive as well as negative interactions. Out of eleven interactions studied, four were positive viz. BOD-Temperature, Total Hardness-pH, TDS-Temperature, DO- Total Hardness while in seven interactions parameters were negatively correlated viz. BOD-DO, DO-Temperature, Total Hardness-Temperature, Total Hardness-TDS, pH-TDS, COD-TDS and BOD- Total Hardness. Only three interactions, out of eleven had p-value less than 0.05 and a high R^2 value which showed significant interaction among them. They are BOD-Temperature (p-value= 0.038; R^2= 0.8076), BOD-DO (p-value=0.002; R^2 = 0.965) and DO-Temperature (p-value= 0.045; R^2= 0.786). In rest seven interactions p-value was higher than 0.05 and R^2 value was very low which shows that these parameters do not influence each other significantly. They are Total hardness-pH (p-value= 0.131; R^2= 0.5866) , TDS-Temperature (p-value= 0.348; R^2= 0.2906), DO-Total hardness (p-value= 0.365;R^2=0.2735), Total hardness-Temperature (p-value= 0.078; R^2= 0.6981), Total hardness-TDS (p-value=0.199; R^2= 0.4375), pH-TDS (p-value= 0.206; R^2= 0.4631), COD-TDS (p-value= 0.343; R^2= 0.2961), BOD-Total hardness (p-value= 0.346; R^2= 0.2630). The results of regression analysis are summarized in Table 4.

Table 4. Correlation and regression analysis of physico-chemical parameters of river Chambal

S.No.	Regression equation	Correlation coefficient	R^2	p value
1	BOD= 3 Temperature-63	+0.8987	0.8076	0.038**
2	Total Hardness= 69.69 pH-439	+0.7659	0.5866	0.131*
3	TDS= 12.78 Temperature-147.3	+0.5391	0.2906	0.348*
4	DO= 0.049 Total hardness+6.226	+0.5230	0.2735	0.365*
5	BOD= -0.437 DO+10.84	-0.9823	0.965	0.002**
6	DO= -6.642 Temperature+163.9	-0.8865	0.786	0.045**
7	Total Hardness= -65.71 Temperature+1637.143	-0.8355	0.6981	0.078*
8	Total Hardness= -2.282 TDS+475.1	-0.6881	0.4375	0.199*
9	pH= -8.67 TDS+299.9	+0.6805	0.4631	0.206*
10	COD= -0.123TDS+48.29	+0.5442	0.2961	0.343*
11	BOD= -0.021Total Hardness+8.108	+0.5128	0.2630	0.346*

** $p<0.05$, * $p>0.05$

Conclusion

The correlation and regression study of physico-chemical parameters of river water of Chambal shows that all the parameters are either positively or negatively correlated with each other. In the present study BOD and temperature are highly positively correlated with each other which shows that with the rise in temperature we can observe rise in BOD too and vice versa. Significant negative interaction between BOD and DO shows that both the parameters are inversely related to each other so that the rise in the quantity of one parameter is associated with the fall in other's quantity. Same phenomenon is shown by DO and temperature as these two parameters also have significant negative interaction. The regression linear equations help us to determine the water quality such that by determining the value one parameter we can predict the quantity of other correlated parameter from the equations.

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