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Short Note

Correlation between Physicochemical Water Parameters Using Regression Analysis: A Case Study of River Ram Ganga at Moradabad, India

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Abstract: A study was carried out in river Ram Ganga (India) to assess the extent of pollution by different industrial and domestic activities. Water samples were collected from river Ram Ganga at six sites and analysed for acidity, alkalinity, total dissolved solids (TDS), biological oxygen demand (BOD), chemical oxygen demand (COD) and dissolved oxygen (DO) during summer, winter and rainy season. The collected data subjected to statistical analysis and some good correlation between parameters is established. Regression equations also established between above parameters to predict the level of contamination of river Ram Ganga. The present study gives us a tool to find the value of physicochemical parameters and extent of pollution theoretically, which is not only time saving but also cost effective.

Key words: Environmental assessment, water quality, river water, correlation coefficient, physicochemical parameters, regression equation, scatter diagram.

Introduction

Water existed on earth as early as 3000 million years ago. It is the most common fluid in nature. Water is also a vital resource for agriculture, manufacturing and other human activities. In urban areas, the careless disposal of industrial effluents and other wastes in rivers and lakes may contribute greatly to the poor quality of river water (Agarwal and Saxena, 2011; Chindah et al., 2004; Emongor et al., 2005; Furtado et al., 1998, Ugochukwu, 2004). Most of the rivers in the urban areas of the developing countries are the ends of effluents discharged from the industries. African countries and Asian countries are experiencing rapid industrial growth and this is making environmental conservation a difficult task (Kadongola, 1997). Moradabad is a major city in north India and is situated on the banks of river Ram Ganga. Its altitude from sea level is about 670 feet (28°20′, 29°15′ N and 78°4′, 79°E) with more than 3.7 million urban population and has witnessed rapid industrialization during last few decades. The city is full of brass, steel and glass cottage industries. A paper industry, some electroplating plants and other small-scale industries are situated in the heart of the city. The annual turn over of the city is nearly Rs 10,000 million. All these industries are in unorganized sector and thus have unplanned growth leading to high degree of air, water and soil pollution. Most of the industries are dumping their effluents in two major rivers of the city – Ram Ganga and Gagan (Figure 1).

A number of investigators attempted to check the quality of water and its physicochemical parameters.

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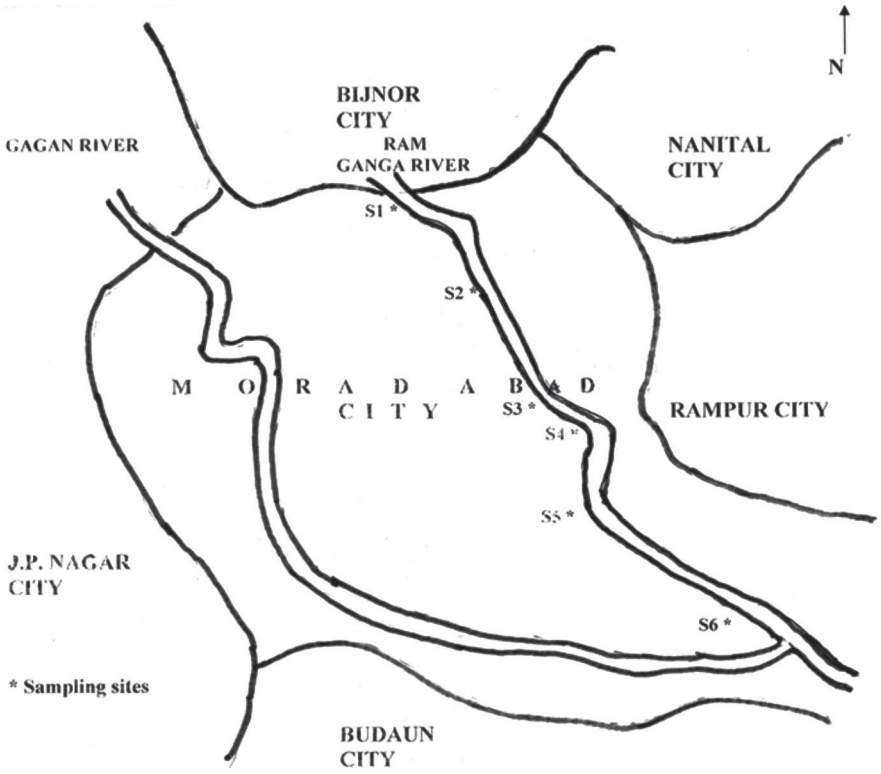

Figure 1: Map of sampling sites.

Some give empirical relationship (Mohammad Alam and Pathak, 2010; Kumar and Shukla, 2010; Tiwari and Mishra, 1985; Pradhan et al., 2001; Sawyer et al., 1994) to measure the quality of water but nobody established a correlation between physicochemical parameters as it pollutes water. Analytical techniques are used to produce reliable results but generally the laboratory methods are time consuming and very costly. However, some models can be developed which will provide easy, reliable and cost effective methods to collect data and provide information of the level of pollution by different parameters. In the present work, an attempt has been made to analyse quantitatively the physicochemical parameters and to establish a mathematical relation between them. For that, correlation coefficient was calculated to understand the nature of correlation among physicochemical parameters and establish a regression equation to understand the extent of pollution by parameters.

Experimental Details

Sampling Sites

Six different sampling sites (S1, S2, S3, S4, S5, and S6) were chosen to study the physicochemical parameters of river Ram Ganga. Map of the sampling sites is given in Figure 1 and following were the six sampling sites.

(i) Ashiana Colony (S1): The river Ram Ganga enters the city from this site. A small-scale colour producing industry situated in this area discharges a lot of untreated industrial waste.

(ii) Jigar Colony (S2): It is about 2.5 km away from site (S1) and animal activity at this site is very high.

(iii) Bangla Gaon (S3): It is about one km from site (S2). Here cattle bathing and cloth washing are the main activities.

(iv) Lal Bagh Area (S4): It is about 1.5 km away from site (S3). At this site industrial waste, human excreta, animal waste, few small drainage lines, domestic waste flow into the river.

(v) Moradabad–Rampur Railway Bridge (S5): It is about 2 km far from site (S4) where sewage and animal waste mix into the river.

(vi) Moradabad–Delhi Bypass Bridge (S6): This site is 2 km from site (S5) and river leaves the city at this site.

Samples collected from each site for six times in a year according to three main seasons. In India, individual seasons are defined as summer (May–June), rainy (August–September) and winter (November–December). The present study is conducted from May 2010 to December 2010.

Chemical Analysis

Water sample for physicochemical analysis collected in pre-cleaned plastic containers from six sites twice in a month at regular intervals of 15 days. For one parameter, twelve values are obtained at each site and the average values of parameters are illustrated in Table 1. The samples were analysed for acidity, alkalinity, TDS, DO, BOD, and COD by following standard analytical technique [APHA, AWWA, WPCF 1995].

Statistical Analysis

All the data obtained is subjected to statistical analysis. In statistical analysis, a correlation developed between parameters by using Karl Pearson's Coefficient of correlation and a regression equation is established.

Calculation of Karl Pearson's Coefficient of Correlation

Correlation coefficient between two parameters X and Y calculated as

$$r = \frac{\sum xy}{\sqrt{\sum x^2 \sum y^2}}$$

where $x = X - \overline{X}$, $y = Y - \overline{Y}$, $\overline{X} = \frac{\sum X}{n}$, $\overline{Y} = \frac{\sum Y}{n}$ and n is the number of sites.

For good correlation value of r should be $-1 < r < 1$.

Calculation of Regression Equation

The term regression stands for some sort of functional relationship between two or more related variables. It measures the nature and extent of correlation and predicts the unknown values of one variable from known values of another variable. Following regression equation is used to establish correlation between parameters

$$Y - \overline{Y} = b_{yx}\left(X - \overline{X}\right)$$

The above equation is called regression line equation of Y on X and b_{yx} is called regression coefficient of Y on X and calculated as

$$b_{yx} = \frac{\sum XY}{\sum X^2}$$

Results and Discussion

The average values of physicochemical parameters are illustrated in Table 1. The relationships between parameters in the form of scatter diagrams is shown in Figures 2, 3, 4, and 5. The relationship between DO with BOD, DO with COD, TDS with Alkalinity, and TDS with acidity is established which gives correlation coefficient $r = -0.7$, $r = -0.8$, $r = 0.7$ and $r = 0.9$, respectively, showing a very good correlation as the values of r lies between –1 and +1.

Table 1: Average value (mg/lit) of physicochemical parameters of Ram Ganga river

Sites	*DO*	*BOD*	*COD*	*TDS*	*Alkalinity*	*Acidity*
S1	4.226	38.221	55.075	40.63	150.71	34.69
S2	5.19	37.798	37.619	51.69	180.59	85.05
S3	5.259	37.791	40.125	111.06	259.74	261.32
S4	5.437	37.545	30.276	66.77	172.34	160.7
S5	5.355	37.672	25.46	72.48	222.00	124.51
S6	5.557	36.695	21.73	84.65	209.85	201.09

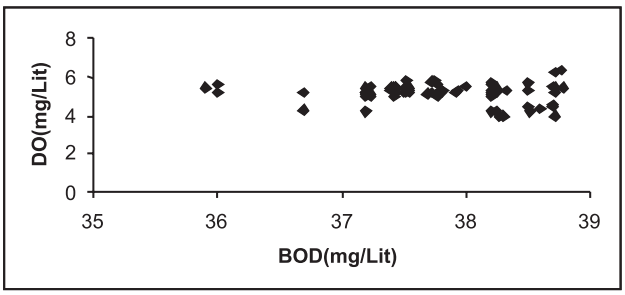

Figure 2: Scatter diagram between BOD and DO.

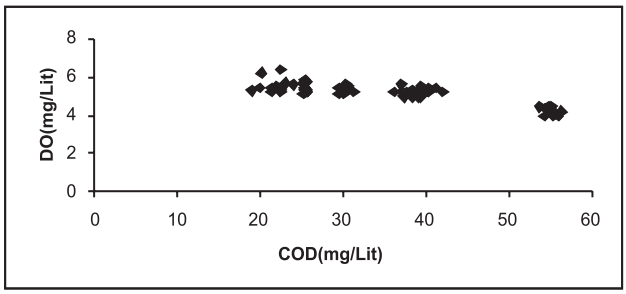

Figure 3: Scatter diagram between COD and DO.

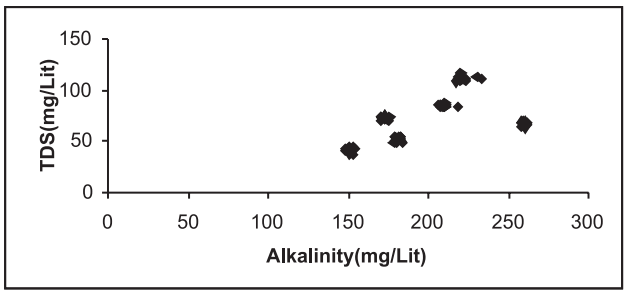

Figure 4: Scatter diagram between Alkalinity and TDS.

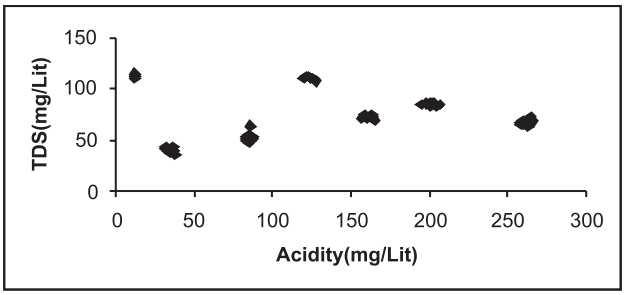

Figure 5: Scatter diagram between Acidity and TDS.

Organic and inorganic wastes decrease the DO as the higher amount of organic waste increases the rate of decomposition and oxygen consumption while BOD test measures the oxygen required by aerobic decomposers for the biochemical degradation of organic matter (biodegradable and non-biodegradable). High BOD level indicates decrease in DO as the oxygen present in the water is consumed by aerobic bacterias which lead to fish, plankton, mollusks and other aquatic organisms finding it difficult to survive.

Since DO regression equations $Y = 7.218\ X + 0.2982$ and $Y = 6.565\ X + 1.1018$ can be used to estimate the values of BOD and COD respectively. It can also be made easy to find the value of BOD/COD ratio to analyse the extent of pollution and the biodegradability of water as COD is the measure of requirement of oxygen by organic and inorganic compounds. The low DO value in river Ram Ganga suggests that the waste mixing from site (S1) has a small-scale colour producing industry discharging many organic substances, generally the dyes that are high oxygen demanding.

The alkalinity of water is due to the salt of carbonates, bicarbonates, borates, silicates and phosphates along with hydroxyl ions in the free state. The high value of alkalinity could be due to cattle bathing and cloth washing activity. Since most of the soaps have water softening agents such as washing soda and sodium carbonate, the use of these soaps might have increased the concentration of carbonates and hence alkalinity. Water with high dissolved solids generally is of inferior pot ability and may induce an unfavourable physiological reaction in the transient consumer. Since there is a good correlation between TDS and alkalinity and TDS and acidity, so the regression equations $Y = 2.673\ X + 8.789$ and $Y = 2.1352\ X - 7.499$ can be used to estimate alkalinity and acidity.

Conclusions

Some good correlations established between physico-chemical parameters using regression equation and these equations can be used to predict the level of contamination of river Ram Ganga water by different parameters. The above analysis is also cost effective and time saving because statistical equations can be used for calculating the value of physicochemical parameters and to measure the extent of pollution.

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