Int. J. Chem. Sci.: 8(1), 2010, 573-581

ASSESSMENT AND MANAGEMENT OF RIVER WATER QUALITY THROUGH STATISTICAL TECHNIQUE : AN APPROACH

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ABSTRACT

Fresh and clean water is the substance most essential to human life. Water is a prime natural resource, a basic human need and a precious national asset. The present study is aimed to suggest some effective measures for the river water quality management with correlation studies with the help of statistical regression analysis of thirteen data points of Gagan river water in and around Moradabad. The statistical regression analysis has been found to be a highly useful tool for correlating different parameters. Correlation analysis measures the closeness of the relationship between chosen independent and dependent variables. To find an approach to water quality management through correlation studies between various water quality parameters, the statistical regression analysis for thirteen data points of Gagan river water of different sites in and around Moradabad was performed. The comparison of estimated values with W.H.O. standards revealed that water of study area is polluted with reference to a number of physico-chemical parameters studied. Regression analysis suggests that conductivity of river water is an important water quality parameter and it is found to be significantly correlated with ten parameters out of sixteen water quality parameters studied and it is moderately correlated with other five parameters. It may be suggested that Gagan river water quality in and around Moradabad can be checked effectively by controlling the conductivity of river water.

Kew words: Water quality parameters, Regression equations, Correlation, Water quality management

INTRODUCTION

The human cultures evolved along the river courses and man had used this resource for disposal of his wastes, irrigation of his crops, and more recently, for industrial development. All these activities make them a subject of detailed scientific investigation. Life is supposed to have originated in water and water is the most essential requirement of all lives. Water pollution is a serious problem in the global context and pose worldwide

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disturbance. Polluted water like chemicals in drinking water causes problems to health and leads to water-borne diseases, which can be prevented by taking proper measures.

The statistical regression analysis has been found to be a highly useful tool for correlating different parameters. Correlation analysis measures the closeness of the relationship between chosen independent and dependent variables[1-3]. The analysis attempts to establish the nature of the relationship between the variables and thereby; provides a mechanism for prediction or forecasting[4,5]. If the correlation coefficient is nearer to +1 or – 1, it shows the probability of linear relationship between the variables x and y. In this way, this analysis attempts to establish the nature of the relationship between the variables and thereby provides a mechanism for prediction or forecasting[6-10].

Moradabad is a B class city of western Uttar Pradesh having urban population more than 38 lacs. Moradabad is situated at the bank of Ram Ganga river and its altitude from the sea level is about 670 feet. It is extended from Himalaya in north to Chambal river in south. It is at 28°20', 29°15' and 78°4', 79°E. District Bijnor and Nainital are in the north, Rampur in the east, Ganga river in the west and district Budaun is in the north of district Moradabad. Moradabad has seen rapid industrialization and population growth during the last few decades. The major industries are brassware, steelware, paper mills, sugar mills, crushers, dye factories and a number of associated ancillaries. Most of these industries and different kinds of human activities are playing their roles in multiplying the level of water pollution.

Gagan river is originated from a pond at Harganpur of Nazibabad, which is in district Bijnor. It travers through J.P.Nagar and Moradabad covering the total length of about 150 km. In South-East of Moradabad, it mixes up with Ram Ganga river at Seekanderpur-Patti. Two small rivers, Bann and Karula-I originating from district Bijnor are also mixing at the right bank of Gagan river at Moradabad city. A number of densely populated villages are situated on both side of river Gagan. Thousands of people are dependent on river water for their daily routine. The Gagan river water seems to be highly polluted and unfit for human and animal consumption.

EXPERIMENTAL

Sixteen different water quality physico-chemical parameters including conductivity at thirteen different Gagan river water sites at Moradabad were estimated following standard methods and procedures of sampling and estimation[11,12]. All chemicals of Anal R grade were used for quantitative analysis. For the determination of conductivity, phosphate and

ammoniacal nitrogen, RI 215 R conductivity meter and Hach spectrophotometer 2010 were used, respectively. A brief description of sampling sites for quantitative estimation of water quality parameters is presented in Table 1.

Table 1: A brief description of sampling sites

No. and name of site		Location of site	Apparent water quality	Noticed activities
I.	**U/S River at Sirsa Manihar**	25 km West to Moradabad city	Objectionable odour, colour 450 units	Nil
II.	**Bann river at Sirsa Manihar**	50 meter West to site No.I	Odourless, colourless, flora and fauna in good quantity	Occasional bathing and fishing
III.	**D/S River at Sirsa Manihar**	50 meter East to site No.II	Objectionable odour and colour	Nil
IV.	**River at Taiya-Moda**	6 km. North- east to site No. I	Odourless, colour 250 units	Nil
V.	**River at Chaudharpur**	6 km. from Taiya-Moda, site No. IV	Odourless, colour 400 units	Very occasional funeral activities
VI.	**River at Malgadda**	8 km. West to Moradabad city	Odourless, colour 150 units	Receives agricultural run off
VII.	**U/S River at Mbd-Dlh bridge**	About 4.5 km. east to site No. VI	Appears contaminated	Sand digging, cattle bathing and launder- ing of clothes
VIII.	**Mixed discharge at Mbd-Dlh bridge**	50 meter East to site no. VII	Pungent smell of H_2S, colour 420 units	Nil
IX.	**D/S River at Mbd-Dlh bridge**	50 Meter to mixing up of effluent of site No. VIII	Appears contaminated with objectionable odour	Sand digging, occasional funeral activities
X.	**U/S River at Mbd-Sambhal bridge**	3.5 km. East to site No. IX	Not good	Occasional human and cattle activity

Cont…

No. and name of site		Location of site	Apparent water quality	Noticed activities
XI.	**Mixed discharge at Mbd-Sambhal bridge**	50 Meter East to site No. X	Objectional pungent smell, colour 450 units	Nil
XII.	**D/S River at Mbd-Sambhal bridge**	50 Meter to mixing up of effluent of site No. XI	Objectionable odour	Nil
XIII.	**River at Seekand-arpur-Patti**	16 km. East to site No. X	Water quality appears better	Receives agricultural run off

To find the relationship between two parameters x and y, the Karl Pearson's correlation coefficient, r is used and it is determined as follows –

$$r = \frac{n \sum x y - \sum x \sum y}{\sqrt{[n \sum x^2 - (\sum x)^2] [n \sum y^2 - (\sum y)^2]}} \quad \ldots(1)$$

here, n = Number of data points ; x = Values of x–variable ; y = Values of y–variable

To evaluate the straight–line by linear regression, following equation of straight line can be used –

$$y = a x + b \quad \ldots(2)$$

here, y = Dependent variable; x = Independent variable; a = Slope of line; b = Intercept on y–axis

$$a = \frac{n \sum x y - \sum x \sum y}{\sum x^2 - (\sum x)^2} \quad \ldots(3)$$

and

$$b = \bar{y} - a \bar{x} \quad \ldots(4)$$

here, $\bar{x}$ = Mean of all values of x ; $\bar{y}$ = Mean of all values of y

To study the correlation between various water quality parameters, the regression analysis was carried out using computer software SPSS, version–7.5.

RESULTS AND DISCUSSION

Site-wise estimated values of sixteen Gagan river water quality physico-chemical parameters with their prescribed W.H.O. standards are presented in Table 2[13]. The comparison of estimated values of different parameters with W.H.O. standards indicated that river water is polluted with reference to all the parameters studied and water quality management is urgently needed in the study area.

Table 2 (a): Site-wise estimated values of water quality physico-chemical parameters with their W.H.O. Standards

Parameters	Site No. I	Site No. II	Site No. III	Site No. IV	Site No. V	Site No. VI	Site No. VII
Conductivity (μS/cm)	0.360	0.340	0.370	0.372	0.363	0.365	0.366
Acidity (ppm)	22	30	24	34	26	40	36
Alkalinity (ppm)	212	212	196	248	208	200	204
Total hardness (ppm)	155	134	162	165	153	167	170
Calcium (ppm)	132	118	141	145	138	146	152
Magnesium (ppm)	23	26	21	20	15	21	18
Dissolved oxygen (ppm)	1.1	2.3	1.3	1.3	1.3	1.6	1.5
Biological oxygen demand (ppm)	18.0	9.6	18.5	18.0	17.0	19.0	21.0
Chemical oxygen demand (ppm)	380	320	412	410	376	398	409
Total solids (ppm)	1211	970	1270	1262	1205	1270	1267
Total dissolved solids (ppm)	890	690	918	924	897	930	932
Total suspended solids (ppm)	321	280	352	338	308	340	335
Free CO_2 (ppm)	17.6	26.4	26.4	30.8	33.0	28.6	35.2
Chloride (ppm)	23	13	22	15	22	19	19
Phosphate (ppm)	2.60	1.62	2.40	2.25	2.45	2.35	2.40
Ammoniacal nitrogen (ppm)	8.50	6.40	9.20	9.30	8.40	9.25	9.55

Table 2 (b): Site-wise estimated values of water quality physico-chemical parameters with their W.H.O. Standards

Parameters	Site No. VIII	Site No. IX	Site No. X	Site No. XI	Site No. XII	Site No. VIII	W.H.O. Stds
Conductivity (μS/cm)	1.410	0.368	0.350	0.710	0.368	0.320	0.300
Acidity (ppm)	164	42	36	96	46	38	-
Alkalinity (ppm)	596	204	180	104	184	188	100
Total hardness (ppm)	322	168	142	230	171	130	100
Calcium (ppm)	280	155	132	198	154	112	100
Magnesium (ppm)	42	13	10	32	17	18	30
Dissolved oxygen (ppm)	0.0	1.9	1.9	0.0	1.5	1.7	5.0
Biological oxygen demand (ppm)	67.0	23.0	20.0	58.0	22.0	18.0	6.0
Chemical oxygen demand (ppm)	610	405	330	490	412	280	10
Total solids (ppm)	2400	1263	1012	1624	1250	906	500
Total dissolved solids (ppm)	1700	950	810	1210	936	810	500
Total suspended solids (ppm)	500	313	202	414	314	96	-
Free CO_2 (ppm)	121.0	37.4	33.0	125.4	42.8	28.6	10.0
Chloride (ppm)	115	19	17	55	19	16	200
Phosphate (ppm)	8.80	2.45	2.10	2.85	2.60	2.18	-
Ammoniacal nitrogen (ppm)	15.80	9.30	7.80	13.50	9.15	5.30	0.5

Following regression equations were obtained through statistical regression analysis of data presented in Table 2, taking conductivity as dependent variable for all the thirteen data points of river water in and around Moradabad, India.

$$\text{Conductivity} = + 0.016 \times \text{Biological oxygen demand} + 0.057 \quad \ldots(5)$$

$n = 13$, $r = 0.913$, $F = 55.124$, $S = 0.12$

Conductivity = + 0.010 × Chloride + 0.159 …(6)
n = 13, r = 0.995, F = 1134, S = 0.03

Conductivity = + 0.007 × CO_2 + 0.138 …(7)
n = 13, r = 0.854, F = 29.836, S = 0.16

Conductivity = + 0.003 × Chemical oxygen demand - 0.833 …(8)
n = 13, r = 0.905, F = 38.158, S = 0.13

Conductivity = -0.349 × Dissolved oxygen + 0.934 …(9)
n = 13, r = 0.824, F = 19.597, S = 0.17

Conductivity = + 7.648 × Total solids - 0.527 …(10)
n = 13, r = 0.956, F = 117.784, S = 0.09

Conductivity = + 0.001 × Total dissolved solids - 0.661 …(11)
n = 13, r = 0.965, F = 149.689, S = 0.08

Conductivity = + 0.002 × Total suspended solids - 0.225 …(12)
n = 13, r = 0.825, F = 15.321, S = 0.18

Conductivity = + 0.030 × Magnesium - 0.174 …(13)
n = 13, r = 0.845, F = 27.567, S = 0.16

Conductivity = + 0.007 × Acidity + 0.103 …(14)
n = 13, r = 0.974, F = 211.267, S = 0.06

Conductivity = +0.002×Alkalinity-0.020 …(15)
n = 13, r = 0.833, F = 24.948, S = 0.17

Conductivity = + 0.159 × Phosphate + 0.012 …(16)
n=13, r = 0.963, F = 141.571, S = 0.08

Conductivity = + 0.096 × Ammoniacal nitrogen - 0.431 …(17)
n = 13, r = 0.918, F = 35.829, S = 0.13

Conductivity = + 0.006 × Calcium - 0.563 …(18)
n = 13, r = 0.963, F = 144.003, S = 0.08

Conductivity = +0.005 × Total hardness - 0.536 …(19)
n = 13, r = 0.970, F = 177.719, S = 0.07

Here, n = Number of data points ; r = Correlation coefficient ;
F = Variance ratio; S = Standard error of estimate

Conductivity shows significant correlation with ten water quality parameters namely biological oxygen demand, chloride, chemical oxygen demand, phosphate, acidity, total hardness, calcium, total dissolved solids, total solids and ammoniacal nitrogen concentration of water with value of regression coefficient, r more than 0.90 or near to 0.90 i.e. there is more than 90% association in data. This correlation coefficient measures the degree of association or correlation that exists between two variables, one taken as dependent variable. The greater is the value of regression coefficient, the better is the fit and more useful are the regression variables. The values of variance ratio, F are high and standard error of estimate, S is low and these are also necessary requirements for significant correlation. Moderately significant correlation of conductivity with other five parameters namely dissolved oxygen, free CO_2, alkalinity, magnesium and total suspended solids of water is also noticed during the regression analysis.

On the basis of above discussion, it may be concluded that conductivity is an important physico-chemical water quality parameter. Conductivity shows highly significant correlation with ten parameters out of sixteen parameters studied for all the thirteen data points. The parameters are: biological oxygen demand, chloride, chemical oxygen demand, phosphate, acidity, total hardness, calcium, total dissolved solids, total solids and ammoniacal nitrogen concentration of water. The conductivity is also moderately correlated with other five parameters studied namely dissolved oxygen, free CO_2, alkalinity, magnesium and total suspended solids of water. Since other parameters and their functions can be explained by using these conditions, utilization of such methodology will thus greatly facilitate the task of rapid monitoring of the status of pollution of water economically and this is the most important part of any pollution study to suggest some effective and economic way for water quality management. On the basis of present study, it may be suggested confidently that the Gagan river water quality in and around Moradabad of study area can be checked effectively by controlling conductivity of water and this may also be applied to water quality management of other study areas.

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Accepted : 03.10.2009