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Quantitative Study for Exchange of Gases from Open Sewer Channel to Atmosphere

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Abstract**—**In this communication a quantitative modeling approach is applied to construct model for the exchange of gases from open sewer channel to the atmosphere. The data for the exchange of gases of the open sewer channel for the year January 1979 to December 2006 is utilized for the construction of the model. The study reveals that stream flow of the open sewer channel exchanges the toxic gases continuously with time varying scale. We find that the quantitative modeling approach is more parsimonious model for these exchanges. The usual diagnostic tests are applied for the model adequacy. This model is beneficial for planner and managerial bodies for the improvement of implemented policies to overcome future environmental problems.

Keywords**—**Open sewer channel, Industrial waste, Municipal waste, Gases exchange, Atmosphere, Stochastic models, Diagnostics checks.

I. INTRODUCTION

KARACHI, the provisional capital of Sindh is located at the extreme west end of the Indus delta between north latitude $24^{o}51^{/}$ and east longitude $67^{o}4^{/}$.

The river Lyari is one of the three rivers along with Malir and Hub river through the greater metropolitan area of Karachi. The river Lyari is primarily a seasonal river and now becomes a drainage system for the adjoining industries and localities. There are about six thousands registered and unregistered industrial units in the city. These industrial units include textile, paints, leather, pharmaceuticals, oil, paper and food products. Three fourth of these units are discharging there effluents through Lyari river which empties into coastal water. The polluted water discharged by the river remains stagnant during low tide. This process keeps polluting the south-eastern creeks. Further more, since the currents move clockwise, the outgoing channel water contaminates the outer region and emits significant quantities of polluted gases (i.e. CO, SO_2, NO, NO_x, Org Vapours) in atmosphere, causing serious environmental and health impact. It is the most serious and rapidly going problem in the metropolitan city Karachi. [1-8]

In this communication long-term record of pollutant gases exchanges by the Lyari river waste water is fitted using stochastic approach, because some gases exchanges problem are of such complex nature that statistical models provides the only real means for predicting the source of impact and

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gases exchanges by the Lyari river waste water is fitted using stochastic approach, because some gases exchanges problem are of such complex nature that statistical models provides the only real means for predicting the source of impact and possible management alternative to correct the problem. It is concerned with modeling of multivariate time series data, which consists of simultaneous observation on several related variable for the construction of gases exchange model. This air quality models will help the managerial authority in providing information for better and more efficient air quality management planning.

II. MATERIAL AND METHODS

GOYEN PGA3000 and Endee Model MX 51 microprocessor based portable gas analyzer are used to measure the exchange of gases from polluted water with the help of probe of 6mm diameter and length of one meter just above the surface of the waste flow where as CEL Scientific Tedlar gas sampling bags were also used for collection of gases sample and concentration of pollutant gases were obtained by using gas chromatographer model CP3800 in the Pakistan Navy environmental laboratory. [9]

A. Modeling Approach

(i) A multivariate modeling techniques has been adopted for predicting gases exchanges from the waste flow of Lyari river. [10-12]

(ii) Analysis of residuals is carried to assess normality of the data set. [13].

III. GASES EXCHANGE MODEL

The inhale particulate in suspension i.e. (PM_{10}), $SOx(SO+SO_2)$, $COx(CO+CO_2)$, NO, $NOx(NO+NO_2)$ and Methane gases exchange by the waste flow measured in ppb (i.e. parts per billion) are considered as independent variable and flow (measured in m^3/sec) as a depended variable for the construction of gases exchange model. The basic summary statistics for the long term pollutant gases data set are given in Table I indicating non-stationarity of the parameters.

TABLE I
BASICS STATISTICS FOR POLLUTANT GASES DATA SET

Parameters	Basics Statistics	
	Mean	Std Dev
SO_2	2.35	4.78
CO	0.29	0.25
NO	3.99	7.50
NOx	12.19	13.84
PM10	129.27	39.93
Methane	4.97	1.92
Flow	5.90	0.57

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Examination of correlation matrix in Table II indicates that there is perfect linear positive and negative relationship (i.e. parameters are correlated positively and negatively) among the dependent and independent variables which can cause the problem of multicolinearity in the construction of model.

TABLE II
CORRELATION MATRIX OF GASES EXCHANGE DATA SET

Para-meter	SO_2	CO	NO	NO_X	PM10	Meth	Flow
SO2	1.00	0.78	0.24	0.55	0.34	0.31	-0.38
CO		1.00	0.55	0.82	0.59	0.45	-0.31
NO			1.00	0.91	0.70	0.16	0.03
NOX				1.00	0.71	0.32	-0.17
PM10					1.00	-0.01	-0.12
Meth						1.00	-0.14
Flow							1.00

The best regression equation that accurately describes the sampled data set into a smooth continuous function (i.e. gases exchange model equation) is given by (1) with additional information in the parenthesis.

$$
\begin{array}{llll}
\text{FLOW} = & -0.011[SO_2]_{-1} & -\ 0.58[CO]_{-3} & -\ 0.04[NO]_{-3} \\
\text{Std. Error} & (0.0105) & (0.039) & (0.020) \\
\text{t-Statistic} & (-1.055) & (-1.466) & (-1.779) \\
\text{Prob} & (0.04) & (0.01) & (0.04)
\end{array}
$$

$$
\begin{array}{lll}
+\ 0.20[NOx]_{-3} & +\ 0.0034[PM_{10}]_{-3} & +\ 0.043[Meth]_{-3} \\
(0.014) & (0.0011) & (0.018) \\
(1.413) & (2.909) & (2.29) \\
(0.01) & (0.00) & (0.02)
\end{array}
$$

$$
\begin{array}{ll}
+\ 0.91[Flow]_{-1} & -\ 0.23@Seas(1) \\
(0.027) & (0.119) \\
(33.31) & (-2.003) \\
(0.00) & (0.04)
\end{array}
\qquad (1)
$$

where @Seas denotes season.
Summary statistics for the model equation given by (1) is given in Table III.

TABLE III
SUMMARY STATISTICS FOR THE MODEL EQUATION

R-squared	0.703	Mean dependent var	5.922
Adjusted R-squared	0.681	S.D. dependent var	0.570
S.E. of regression	0.322	Akaike info criterion	0.645
Sum squared resid	9.955	Schwarz criterion	0.849
Log likelihood	-25.562	Durbin-Watson stat	1.938

IV. ADEQUACY OF MODEL

In this section we do some diagnostic in order to show the adequacy of the model. The diagnostic checking is performed using current available software. All test performed on residual give the affirmative results for fitted model whose detail is given below.

(i) As we see the Table III it is evident that coefficient of determination is greater than 50%. Durban Watson statistics shows that there is no linear association between adjacent residuals of a regression model. The value of Akaike and Schwarz criteria also gives indication of model accuracy.

(ii) We have used Kolmogorove-Smirnov goodness-of-fit test for comparing the data computed as above to a theoretical distribution as given under Fig. 1, which shows satisfactoriness of model.

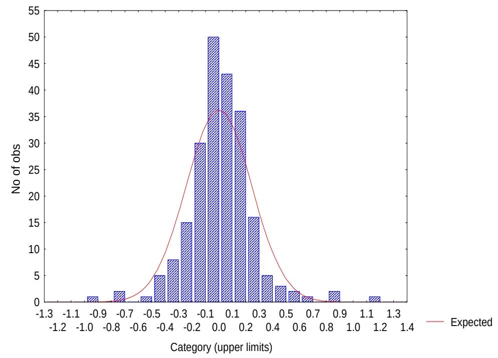

Fig. 1 Kolmogorove-Smirnov good-ness-of-fit test for gases exchange model

(iii) Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) plots depicted in Fig. 2 upper and lower respectively confirms the white noise assumption on residuals.

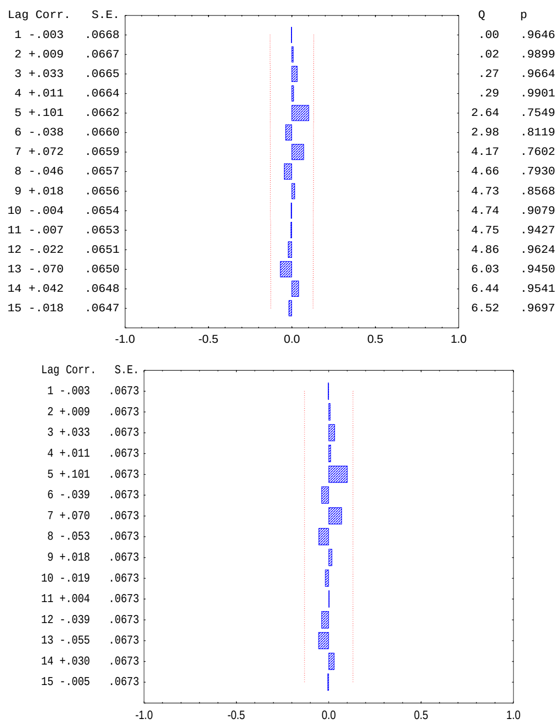

Fig. 2 The sample ACF (upper) and PACF (lower) for model residual, showing the bonds ± 1.96 / $\sqrt{N}$ indicate no serial dependence

(iv) Normal distribution plot and normal probability plot of model residuals arranged under Fig. 3 and 4 gives an acceptable overall fit of model.

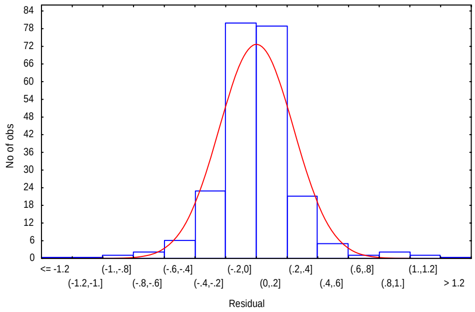

Fig. 3 Histogram of model residuals

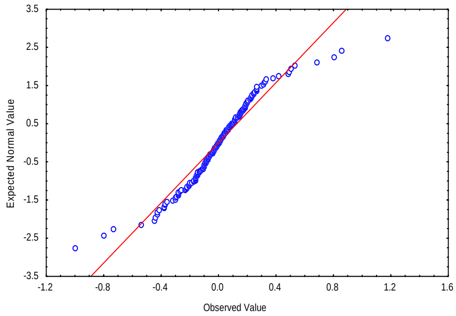

Fig. 4 Normal probability plot of model residuals

V. Conclusion

In this communication current gases exchanges by the Lyari river waste flow has been analyzed and model has been constructed for the pollutant gases contributed by the river to the costal atmosphere. The adequacy of the model has also been discussed. This model will help the planning personal and managerial authorities to control the environmental condition of the polluted river and coastal area of the metropolitan city Karachi.

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