Continental J. Applied Sciences 7 (2): 1 - 8, 2012 ISSN: 1597 – 9928

http://www.wiloludjournal.com
Printed in Nigeria doi:10.5707/cjapplsci.2012.7.2.1.8

TIME AND TREND PLOTS: APPLICATION TO AGGREGATE MEAN OF WATER POLLUTANTS DISCHARGED IN STREAMS AND RIVERS IN IBADAN SOUTHWEST NIGERIA

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ABSTRACT
This study examines time and trend plots: Application to aggregate mean of water pollutants discharged in streams and rivers in Ibadan environs. The data was collected from the Ministry of Environment and Water Resources, Secretariat, Ibadan, Nigeria. This study is therefore meant to study the impact of the regulatory measures by the government on the discharge of water pollutants in streams and rivers. It is supposed that with these regulatory measures, water pollutants discharge in streams and rivers should be on the decrease. Specifically, data were collected on alkalinity; total hardness; calcium hardness; magnesium hardness; total solids; total suspended solids; total dissolved solids; chloride; sodium chloride; dissolved oxygen; biochemical oxygen demand; chemical oxygen demand; oil and grease. The study reveals (1) Aggregate mean of water pollutants quarterly. (2) Gradual reduction of water pollutants discharge in streams and rivers from the fitted model (3) Gradual increase of water pollutants discharge in streams and rivers from the predicted values.

KEYWORDS: Pollution, Hardness, Government, Regulatory measures, Predicted.

INTRODUCTION
Pollution can be defined as the increase, or even decrease, of any atmospheric constituent from the value that would have existed without human activity Martin Crawford (1980). Anagani Srinivas (1998) also defined pollution as the presence of substances in the ambient atmosphere, resulting from the activity of man or from natural processes, causing adverse effects to man and environment. Pollutants, the elements of pollution, can be foreign substances or energies, or naturally occurring; when naturally occurring, they are considered contaminants when they exceed natural levels.

According to the World Health Organization in 1974, “the environment is considered polluted when it is altered in composition or condition directly or indirectly as a result of activities of man so that it becomes less suitable for some or all of the uses for which it would be suitable in its natural state”. The FEPA Act also defines pollution to mean: “man-made or man-aided alteration of chemical, physical or biological quality of the environment to the extent that is detrimental to that environment or beyond acceptable limits and ‘pollutants’ shall be construed accordingly”. Therefore any undesirable change in the natural characteristics of any state of matter is, therefore, pollution or damage.

Pollution is a special case of habitat destruction; it is the addition of any substance or form of energy (e.g., heat, sound, and radioactivity) to the environment at a rate faster than the environment can accommodate it by dispersion, breakdown, recycling, or storage in some harmless form. There are different types of pollution such as air, water and land. In this research work emphasis will be laid on water pollution because of the prevalent occurrence of the pollutants and the serious hazardous health implications it has on both plant and animals.

Although pollution had been known to exist for a very long time, it had seen the growth of truly global proportions only since the onset of the industrial revolution during the 19th century. The industrial revolution brought with it technological progress such as discovery of oil and its virtually universal use throughout different industries. Technological progress facilitated by super efficiency of capitalist business practices had probably become one of the main causes of serious deterioration of natural resources. At the same time, of course, development of natural sciences led to the better understanding of negative effects produced by pollution on the environment.

Environmental pollution is a problem both in developed and developing countries. Factors such as population growth and urbanization invariably place greater demands on the planet and stretch the use of natural resources to the maximum. It has been argued that the carrying capacity of earth is significantly smaller than the demands placed on it by large numbers of human populations. And overuse of natural resources often results in nature's degradation. Each year millions of naira is spent by various agencies to monitor the quality of water as the water pollution continues to be one of many environmental problems that mankind is facing today. The thousands of tons of organic pollutants and wastes discharged by industries and municipalities in streams, lakes and rivers greatly affect the quality of water and the various aquatic processes.

Water pollution is caused by the release of waste products and contaminants into surface run-off into river drainage systems, leaching into groundwater, liquid spills, wastewater discharges, and littering. Water pollutants include insecticides and herbicides, food processing waste, pollutants from livestock operations, volatile organic compounds (VOCs), heavy metals, chemical waste and others. The special report of the study of infrastructure facilities in 2008 showed that water pollution causes approximately 14000 deaths per day, mostly due to contamination of drinking water by untreated sewage in developing countries. An estimated 700 million Indians have no access to a proper toilet, and 1000 Indian children die of diarrhoea sickness every day.
Countries all over the world, particularly the developing ones, face severe environmental degradation that appears to be threatening their long-term developments prospects. This is so because they rely upon the use of natural resources in their growth and development process. These natural resources are being used up in a manner that appears wasteful and, thereby, forecloses options for development in the future Oyeranti, (2001).
Most developing countries lack essential information for the effective planning, development and management of water resources. Many countries do not have well-articulated goals, objectives and policies to project a long-term resource development and management. Environmental objectives are not defined in required details to guide project planners. Hence, resource control in support of investment decisions cannot be formulated with relative clarity.

Development and use of statistical and other quantitative methods in the environmental sciences have been a major communication between environmental scientists and statisticians Hertzberg and Frew (2003). In recent years, many statistical analyses have been used to study air pollution as a common problem in urban areas Lee (2002). The common descriptive statistical approach used for air quality measurement and modeling is rather limited as a method to understand behavior and variability of air quality Voigt (2004). Many investigators have used probability models to explain temporal distribution of air pollutants (Bencala and Seinfeld, 1979, Yee and Chen, 1997). The main aim of time series analysis is to describe movement history of a particular variable in time. Many authors have tried to detect changing behavior of air pollution through time using different techniques (Salcedo *et a*l., 1999, Hies *et a*l., 2000, Kocak *et a*l., 2000, among others). Many others have tried to relate air pollution to human health through time series analysis (Gouveia and Fletcher, 2000, Roberts, 2003, Touloumi *et a*l., 2004). Time series analysis is a useful tool for better understanding of cause and effect relationship in environmental pollution (Schwartz and Marcus, 1990, Salcedo *et al*., 1999, Kyriakidis and Journel, 2001). In the light of the above we shall consider time trend plots: application to aggregate mean of water pollutants discharged in streams and rivers in Ibadan environs.

MATERIALS AND METHODS

Scope of the Study

We have considered majorly linear, quadratic and exponential trend models for this study. We have found out through the coefficient of determination which measures the goodness fit that quadratic trend model performed better than linear and exponential trend models. This is shown in table 3. As a result, we shall report quadratic trend model in this study.

The data for this study was secondary obtained from the Ministry of Environment and Water Resources, Secretariat, Ibadan. The report was based on the following components: Alkalinity; Total Hardness; Calcium Hardness; Magnesium Hardness; Total Solids; Total Suspended Solids; Total Dissolved Solids; Chloride; Sodium Chloride; Dissolved Oxygen; Biochemical Oxygen Demand; Chemical Oxygen Demand; Oil & Grease. All these components were measured in milligramme per litre (mg/l). The aggregate mean of all the components were obtained for the period of six years (2005 to 2010).

Time Plot

The first exploration of a time series data is the plot of the series over time and then a sample descriptive measure of the main properties of the series could be obtained (Sangodoyin and Ojo 2002). In this, we intend to look at outliers, troughs, presence of turning points that may be pronounced on the time plot.

Trend Models

Trend refers to the general direction in which the graph of a set of observation made successfully in time (usually at equal intervals) tends to be going over a long period of time. The term "long period of time" could be five, ten, fifteen or more year's period. The time period to be made use of, however, depends on the objectives of the study. Again, the nature of the study will dictate whether to observe the sets of observations monthly, quarterly or annually. For the purpose of this study, quarterly values have been used because it gives comprehensive view of water pollutants discharge into streams and rivers.

Most of the trend curves in all human endeavours have the tendency to either grow increasingly or decreasingly in absolute terms or fluctuate over the period of time so considered. Such trend series can be described using appropriate mathematical models called trend models.

Quadratic Trend Model

The quadratic trend curve is used to estimate the trend curve of a set of observations measured over time, when the trend fails to exhibit a straight line pattern. It is represented by $T_t = b_0 + b_1 t + b_2 t^2$ where, T_t = trend value, t = time index/ period, t^2 = the square of the i^{th} time /period. The parameters of the above are estimated using the method of least squares.

Model Estimation

There are three parameters in the quadratic trend model and estimation of these parameters is done through the least squares method. Conventionally, using least squares method, three normal equations are required. These are obtained as follows:

$$\sum_{t=1}^{n} T_t = nb_0 + b_1 \sum_{t=1}^{n} t + b_2 \sum_{t=1}^{n} t^2$$

$$\sum_{t=1}^{n} tT_t = b_0 \sum_{t=1}^{n} t + b_1 \sum_{t=1}^{n} t^2 + b_2 \sum_{t=1}^{n} t^3$$

$$\sum_{t=1}^{n} t^2 T_t = b_0 \sum_{t=1}^{n} t^2 + b_1 \sum_{t=1}^{n} t^3 + b_2 \sum_{t=1}^{n} t^4$$

Simplifying the normal equations into matrix form we have,

$$\begin{pmatrix} b_0 \\ b_1 \\ b_2 \end{pmatrix} = \begin{pmatrix} n & \sum_{t=1}^{n} t & \sum_{t=1}^{n} t^2 \\ \sum_{t=1}^{n} t & \sum_{t=1}^{n} t^2 & \sum_{t=1}^{n} t^3 \\ \sum_{t=1}^{n} t^2 & \sum_{t=1}^{n} t^3 & \sum_{t=1}^{n} t^4 \end{pmatrix}^{-1} \begin{pmatrix} \sum_{t=1}^{n} T_t \\ \sum_{t=1}^{n} tT_t \\ \sum_{t=1}^{n} t^2 T_t \end{pmatrix}$$

RESULTS AND DISCUSSION

Table 1: Aggregate Mean of Water Pollutants Discharged in Streams and Rivers

Serial Number	Year	Quarter	Water Pollutants (mg/l^3)
1	2005	q1	4423.965
2		q2	5117.325
3		q3	5284.355
4		q4	4905.655
5	2006	q1	6195.800
6		q2	6012.420
7		q3	5489.750
8		q4	4619.330
9	2007	q1	3709.280
10		q2	3410.010
11		q3	3326.570
12		q4	3469.280
13	2008	q1	3254.508
14		q2	3182.838
15		q3	3117.778
16		q4	3061.228
17	2009	q1	2642.595
18		q2	2719.465
19		q3	2931.645
20		q4	3284.645
21	2010	q1	4867.550
22		q2	4500.790
23		q3	3567.980
24		q4	2053.030

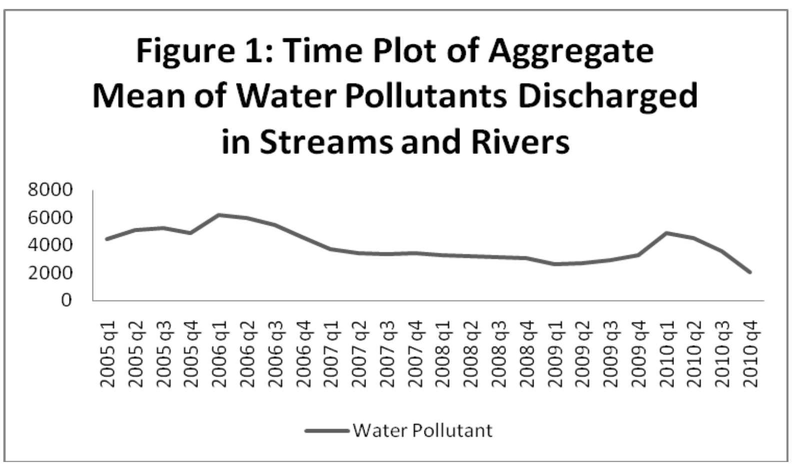


Table 1 and Figure 1 revealed a sharp rise in water pollutants but later decreased until 2009. It increased again because of introduction of new product. This new challenge was gradually checked and the magnitude of the water pollutants was barely minimum as at the end of 2010.

Quadratic Trend Equation of water pollutants discharge in streams and rivers

Water pollutants: $T_t = 5994 – 270.66t + 6.63t^2$

Table 2: Trend Values of Aggregate Mean of Water Pollutants Discharged in Streams and Rivers

Serial Number	Year	Quarter	Water Pollutants (mg/l^3)
1	2005	q1	5729.97
2		q2	5479.2
3		q3	5241.69
4		q4	5017.44
5	2006	q1	4806.45
6		q2	4608.72
7		q3	4424.25
8		q4	4253.04
9	2007	q1	4095.09
10		q2	3950.4
11		q3	3818.97
12		q4	3700.8
13	2008	q1	3595.89
14		q2	3504.24
15		q3	3425.85
16		q4	3360.72
17	2009	q1	3308.85
18		q2	3270.24
19		q3	3244.89
20		q4	3232.8
21	2010	q1	3233.97
22		q2	3248.4
23		q3	3276.09
24		q4	3317.04

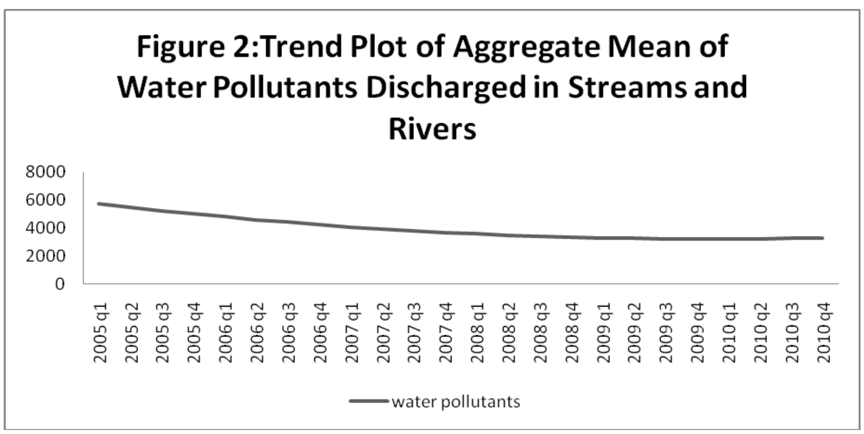
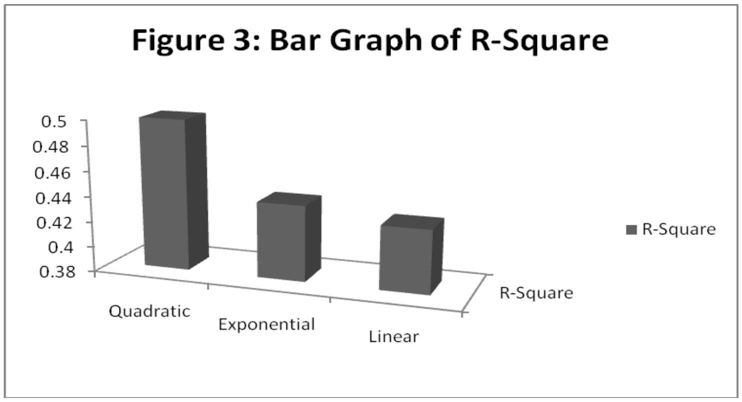


Table 2 and figure 2 revealed the actual direction of water pollutants discharge. There was a gradual decrease till the end of 2009. In 2010 we have gradual increase.

Goodness of Fit

Table 3: Values of Co-efficient of Determination (R^2) of Water Pollutants

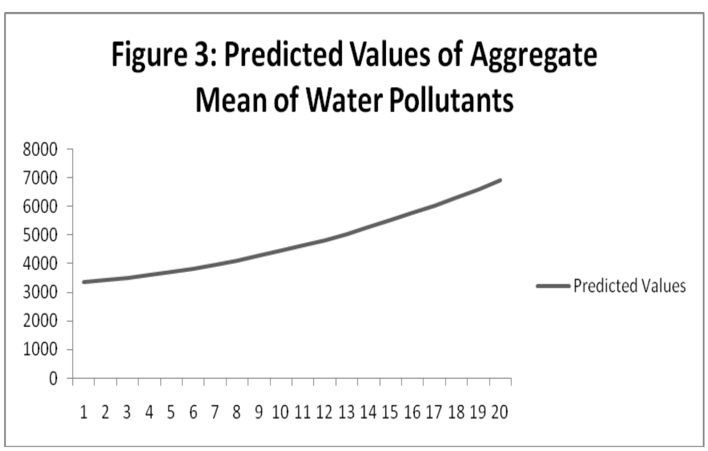
Trend Models	R^2
Quadratic	0.50
Exponential	0.44
Linear	0.43



Predictions

TABLE 3: Predicted Values of Aggregate Mean of Water Pollutants

Serial Number	Year	Quarter	Water Pollutants (mg/l^3)
1	2011	q1	3371.25
2		q2	3438.72
3		q3	3519.45
4		q4	3613.44
5	2012	q1	3720.69
6		q2	3841.20
7		q3	3974.97
8		q4	4122.00
9	2013	q1	4282.29
10		q2	4455.84
11		q3	4642.65
12		q4	4842.72
13	2014	q1	5056.05
14		q2	5282.64
15		q3	5522.49
16		q4	5775.60
17	2015	q1	6041.97
18		q2	6321.60
19		q3	6614.49
20		q4	6920.64



The predicted values showed an increasing trend. The implication of this is that if the regulatory measures are not enforced there is the likelihood of increase of water pollutants discharge in streams and rivers in the nearest future.

CONCLUSION

Time and trend plots were used to study the direction of aggregate mean of water pollutants discharge in streams and rivers in Ibadan. The study reveals the aggregate mean of water pollutants quarterly, the time plots showed the movement of the water pollutants and it was noticed from the time plot the gradual decrease in water pollutants over time. The trend plot showed gradual decrease till the end of 2009. In 2010 we have gradual increase in water pollutants discharge and this is the beginning of the gradual increase in water pollutants in the predicted values. And this is a pointer for the government so that the regulatory measures would be enforced to check the discharge of water pollutants in streams and rivers in Ibadan.

RECCOMENDATIONS

Against the backdrop of the analysis above, the following recommendations are proposed to ameliorate water pollution and make Nigeria's environment healthier and better:

1. Incentives to enhance the purchase of pollution control equipment.
2. Data collection, analysis and dissemination should be a well entrenched, and a smooth functioning activity of every tier of government with a common environmental data centre for achieving a high degree of standardisation.
3. The link between environmental infrastructure and private investment needs should be adequately addressed. Environmental Impact Assessment (EIA) guidelines should be further emphasized and monitored for investors. Similarly, project approvals by lending institutions should be contingent upon the EIA outcomes.
4. A set of comprehensive goals, objectives and policies pertaining to long-term water resources development should be developed. These should be detailed in the areas of: social well being; environmental quality; national economic development; and international dimensions.
5. The office of the Attorney-General of the Federation and Inspector General of Police who are responsible for prosecution should give more attention to environmental offences, particularly those relating to water pollution.
6. There should be an effective enlightenment campaigns in the states and local governments on how to keep the environment free from pollution and degradation.
7. The strategies for enhancing development initiative towards exploiting environmental challenges and managing the environmental problems should form a comprehensive package of policy perspectives in Nigeria.

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Received for Publication: 09/03/12
Accepted for Publication: 25/05/12