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To cite this article: N A Mokhtar *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **875** 012020

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Investigation of Air Pollution Impact on Kinta River Water Quality at a Tropical Region

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Abstract. Critical air quality levels lead to an unhealthy environment which disrupts physical activities and human health. Wet deposition of air pollutants might cause a high concentration of water pollution due to rain water washout of nitrate and particulate matter (PM). This study aimed to investigate the impacts of air pollutants deposition on river water quality in Malaysia. The methodology involved in the analysis of secondary data (January to December 2013) for air quality and river water quality using factor, correlation, and regression. Parameters of air quality were PM₁₀, Nitrate (NO₃), ozone (O₃) and temperature while water quality data were turbidity, Nitrate and PM₁₀ (Ca, As, Hg, Cd, Cr, Pb, Zn, Cl, Fe, K, Mg, Na). The results show that there were positive correlations between air quality indicators and Kinta river water quality parameters. Correlation matrix shows that in terms of turbidity, air and water data were having 96% similarities. Regarding Nitrate concentrations, air and water records had only 30% of correlation matrix, which can be due to other sources of Nitrate which was agriculture activities near Kinta River. The factor analysis results showed that PM was the main contributor to river water quality particles with 94%.

1. Introduction

Air quality and river water quality are the most crucial pollution that need to be taken seriously. Both pollutants affect human health and cause fatality if they are excessive intake of polluted water and toxic air. Air pollution is the accumulation of substances in the atmosphere which then can be cleansed by wet and dry depositions [1]. Wet and dry depositions consist of soluble and insoluble particles which usually affect river water quality [2, 3]. In Malaysia, the data for air quality and river water quality sample were collected by sampling site and measurement of airborne particles [4].

The existing data from air quality station and river water quality station were used for analysis to determine the impacts on air pollution to river water quality. Prior to the water quality, the wet and dry depositions might be divided into three main sources: coastal, riverine and atmospheric inputs [5]. This means that the quantity of nitrate and PM₁₀ from air particles can be found in the river water particles.



2. Materials and Methods

The scope of this study focused on the analysis of PM₁₀, nitrate, ozone, temperature, and turbidity from existing data situated at Ipoh, Perak.

Correlation analysis means a statistical measure that indicates the extent to which two or more variables fluctuate together. For this study, data from the existing air pollution and river water quality are correlated together based on its parameters. If the parameters for both data are majorly same with each other, therefore, it shows that there is a correlation between air quality and river water quality.

Factor analysis means a statistical data reduction which helps to obtain maximum common characteristic from the data to the factor score [6]. The number of iterations and the matrix show the relation between air quality and river water quality based on the parameter used by calculating the factor scored. For example, the data of PM₁₀ for both air and river water quality will be analyzed and the factor pattern will show same value if there is a relationship between both data.

Regression model is a multivariate statistical method with a powerful pattern recognition capability. It is used for a simultaneous observation and analysis of more than one variable [7, 8]. It is used to reveal the variability that exist between a dependent and independent variable.

3. Results and discussions

3.1. Air Quality and River Water Quality Relationships under Weather Influence.

For PM₁₀, the highest value was during the dry season in June which was 56.4 $\mu\text{g}/\text{m}^3$ and 64.4 $\mu\text{g}/\text{m}^3$ as shown in Figure 1. The lower amount of precipitation during dry season causes less particulate matter in the atmosphere to be cleansed by rain. As the amount of particulate matter increases, PM₁₀ were settle down as dry depositions and settled at the surface of river water and eventually soluble in water. Then, for the lowest value of PM₁₀ was in April which was after wet season. The value of PM₁₀ was 32.6 $\mu\text{g}/\text{m}^3$ and 43.6 $\mu\text{g}/\text{m}^3$ for air and river water quality respectively.

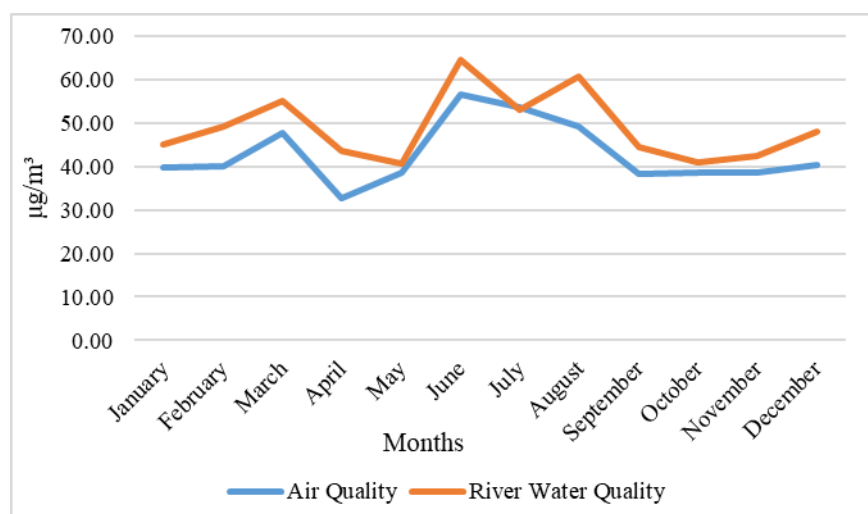


Figure 1. Correlation between air and water quality

As shown in Figure 2, Turbidity has highest value of 31.7 NTU in June which also considered as dry season. Hot weather affected the solubility of ozone in water and leads to inefficient purifying of river water. Ozone is known as a natural method to purify river water and can be done efficiently if the temperature of river water was at room temperature. It was a strong oxidation agent for water treatment from 100 years back [7]. Turbidity of river water increases when solubility of ozone decreases especially during dry season on June. In the month of December, the turbidity was the lowest due to lower temperature which was 31.2 NTU.

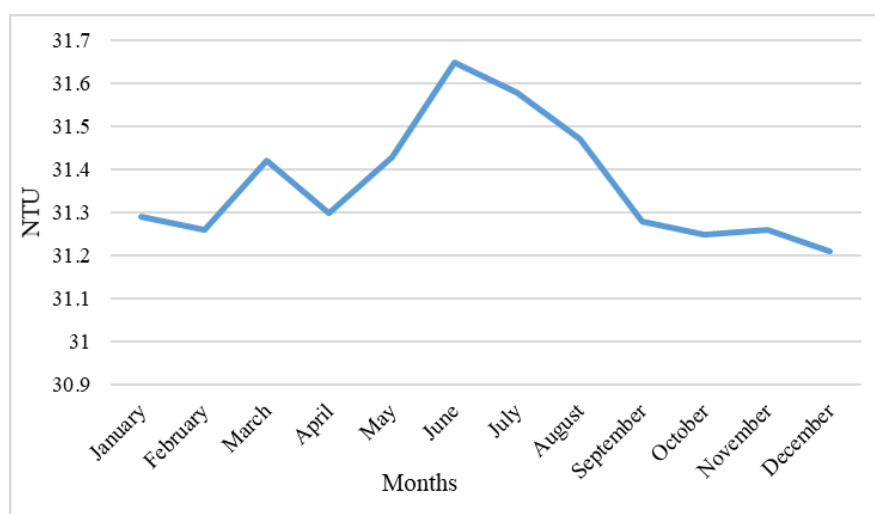


Figure 2. Monthly monitoring of turbidity in Kinta river

3.2. Correlation Analysis.

From both air quality and river water quality data in Table 1, the correlation matrix between air temperatures with turbidity was 0.96. The correlation matrix supported the factor analysis score for temperature and turbidity since temperature effect the solubility of ozone in water which then also effected the turbidity of water. There was a strong relationship between air temperature and turbidity due to concentration of dry and wet deposition.

Table 1. Correlation Matrix for Temperature, Ozone, pH value and Turbidity

Parameter	Air Temperature	Ozone	pH	Turbidity
Air Temperature	1.00	-	-	-
Ozone	0.37	1.00	-	-
pH	0.04	0.84	1.00	-
Turbidity	0.96	0.34	0.02	1.00

For ozone and pH of water, it stated that there is a relationship between them because the correlation matrix was 0.84. When solubility of ozone in water is higher, the pH value increases. As mentioned above, ozone is a natural method to purify water and by that, the pH value of water will not be too acidic and nearly neutral. Based on air quality data for July, the highest concentration of ozone was 0.022 DU. As ozone settle down into river water and as oxidizing agent, it helped in purify the river water. So, when the concentration of ozone was 0.022 DU, the pH value of Kinta river water was 7.02. meanwhile, when the ozone concentration was 0.01 DU in May, the pH value of river water was 6.04 which means it is acidic.

The correlation matrix between air quality and river water quality was 0.88 and that means air and river water quality has a strong relationship between them. This correlation matrix also supported the factor analysis score to show a strong relationship between air quality and river water quality. The indicators for PM₁₀ in river water were Calcium (Ca), Arsenic (As), Mercury (Hg), Cadmium (Cd), Chromium (Cr), Lead (Pb), Zinc (Zn), Chlorine (Cl), Iron (Fe), Potassium (K), Magnesium (Mg) and Sodium (Na).

The correlation matrix for nitrate was 0.27. Atmospheric nitrate concentration between air quality and river water quality data are varied especially in this case where Kinta river located at the city of Ipoh, Perak. This is because the amount of nitrate dissolved in the river water also due to other factors like artificial fertilizers, disposal of wastes and the earth itself as organic matter contains nitrogen compounds [9]. The high differences between concentration of nitrate in air and river water are due to other sources that contribute to the concentration of nitrate as there was a previous study support this

result. From the study of analysis of surface water pollution in the Kinta river using multivariate technique, there were many sources of nitrate and one of them are artificial fertilizers [6].

3.3. Factor analysis.

From Table 2, the factor scores of PM was 0.94, PM from atmosphere are possible to dissolve in water as rainwater cleanse the atmosphere and therefore settle in the nearest water catchment area [10]. Factor score for air quality and river quality were the same because it showed the communality between them. For initial communality, the factor score was 0.78 and final communality was 0.88. Thus, from the communality and specific variance after 11 iterations been done to the data, the final factor score was 0.94.

Table 2. Correlation matrix for nitrate

	F1	Initial communality	Final communality	Specific variance
Air Quality	0.94	0.78	0.88	0.12
River Water Quality	0.94	0.78	0.88	0.12

3.4. Regression Analysis.

The first two parameters for regression analysis are turbidity and temperature. Multiple R basically a correlation coefficient which shows how strong the linear relationship between multiple data. From the regression statistic for turbidity and temperature in Table 3, the multiple *R* is 0.96 which indicates that there is a positive correlation.

Table 3. Regression analysis for temperature and turbidity

Multiple R	0.96
R Square	0.92
Adjusted R Square	0.91
Standard Error	0.17

The linear lines for turbidity and temperature show only slight different with actual data and the R square is 0.91% which means the relationship is strong as turbidity and temperature can affect each other by slowing down the solubility of ozone dissolved in water as the temperature increases and result to high water turbidity. Constant concentrations of nitrate from river water quality station showed Kinta River were closer to agricultural area since the fertilizers recharged by runoff [7]. For PM regression analysis, the result for multiple *R* is 0.88 thus shows a positive relationship between air and river water quality data.

4. Conclusion

During wet season, the concentration of PM and turbidity decreased as they were washed out and diluted by high amount of precipitation. However, the concentration of nitrate increased. The runoff soil from nearby agricultural area flows into Kinta River and consequently increased the concentration of nitrate from fertilizers. Moreover, pH value of river water decreases when the concentration of ozone decreases during dry season. The factor analysis showed that the parameters that contribute to river water pollution were temperature, ozone and particulate matter. These parameters showed a strong correlation between air and river water quality indicators as the factor score between temperature and turbidity was 96.1% while the factor score for particulate matter was 94% similarities. Furthermore, the correlation analysis supported the factor analysis as the correlation matrix was almost 100% for temperature, turbidity, and PM. On the contrary, nitrate's result showed slight differences between air and river water quality, which can be explained by the influence of other sources such as agricultural activity which surround Kinta

River. The runoff from the soil that contained fertilizers increased the concentration of nitrate in Kinta River, especially during wet season.

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