Water Quality and Economic Development: A Review of Time Series Methodologies

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Background

Wastewater treatment plants that are used to clean our reclaimed, industrial, and even domestic water supply use biochemical oxygen, or the amount of oxygen consumed by bacteria to decompose organic waste found in water. Effluents resulting from development such as chemical and organic waste can be seen to infiltrate our rivers and lakes. The United States is expected to see a rise in biochemical oxygen from industrial, manufacturing firms, and agricultural production in the U.S. 2021-2022 by 0.7 percent. Due to economic development, the number of purchased National Pollution Discharge Elimination System Major and Non-Major Individual facility permits (NPDES) for the United States has risen significantly from 2021-2022 by 429 purchased major and non-major permits with pollutant loadings. These permits allows cetin industrial, manufacturing and agricultural sites to transmit chemicals into a designated region of land. Interestingly, regulators have raised the maximum allowed point source chemical pollutant for permit holders seen in the decreased water quality standards per state depicted in the National Analysis Report below 2017-2022. As a result, sewage treatment plants require more biochemical oxygen to combat water pollution. Thus, the Environmental Kuznets Curve (EKC) examines the hypothetical relationship between economic development measured by individual major and non-major facility permits and water pollution measured as biochemical oxygen demand BOD. The EKC curve analyzes a wide variety of indicators of environmental degradation in relation to per capita income.

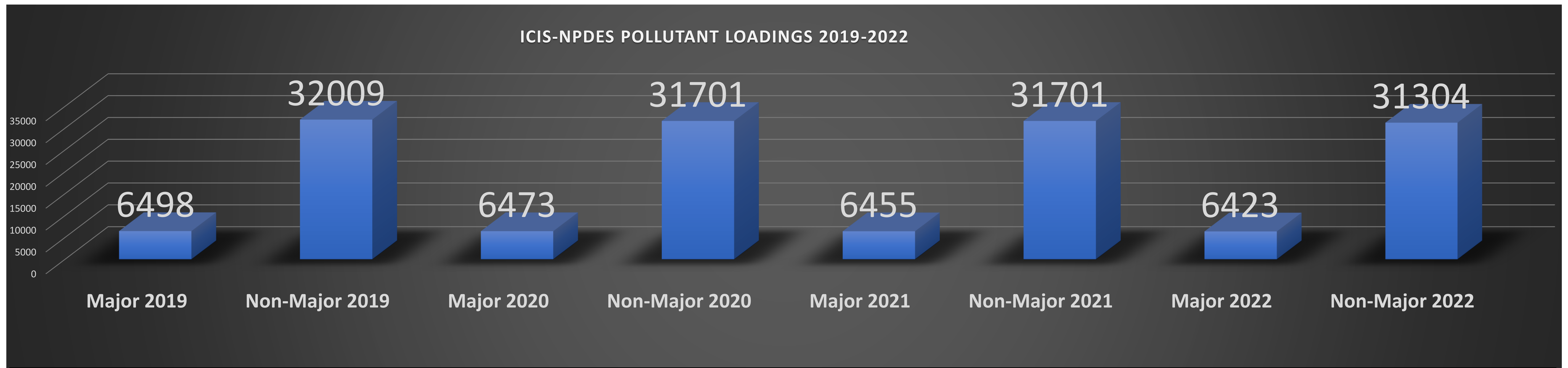
The research will be analyzing which models best fits the hypothesized relationship between biochemical oxygen demand and gross domestic product (also known as the Kuznets Curve hypothesis).

Research Questions

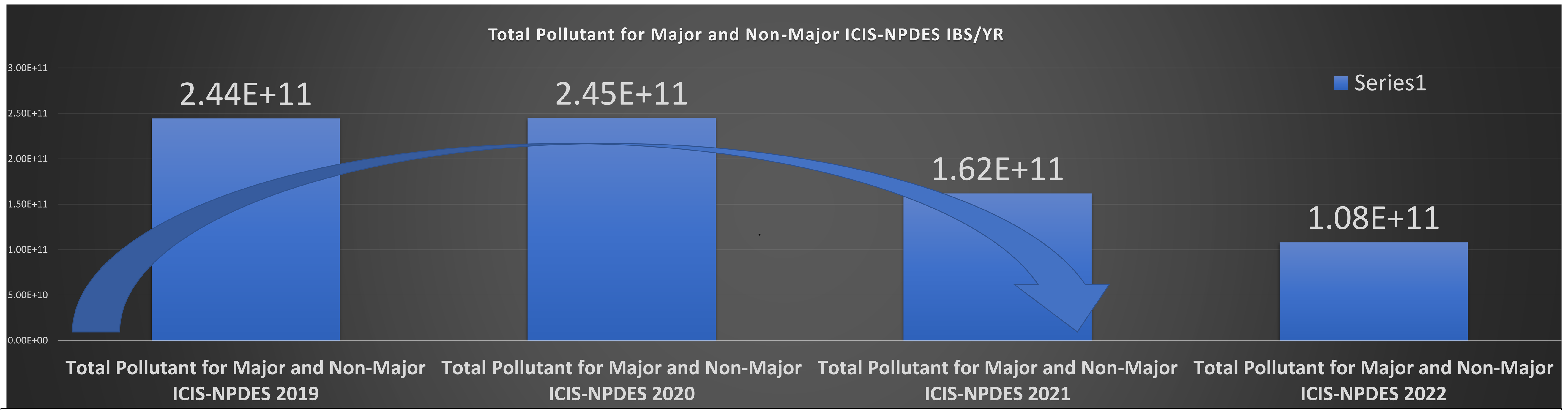
This study will aim to answer the following research questions:

1. Does water pollution decrease as economic development flourishes?
2. Based on the idea that higher levels of BOD is associated with high levels of water pollution, how does BOD relate to economic development in relation to the defined term above?
3. Based on a review of the literature, which models best fits the hypothesized relationship between Biochemical oxygen demand and Gross domestic product (also known as the Kuznets Curve)?

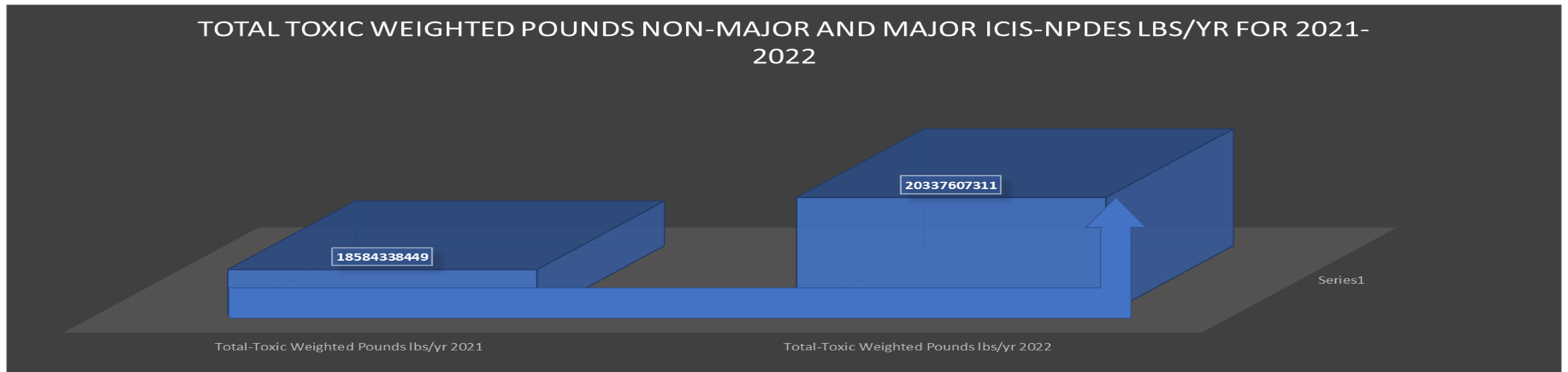
Graphs



(Tb.2) Reflects the increase in purchased Major and Non –Major Individual facility permits (NPDES) with pollution loading in the United States from 2019-2022



(Tb.3) Reflects the decrease in Total Pollution in Individual facility permits NPDES lbs/yr in the United States from 2019-2022



(Tb.4) Reflects the increase in Total Toxic Weight from both Non-Major and Major pollutant loadings in the United Sates from 2021-2022

Key Findings

Each of the following case studies resulted in an inverted U-Shape relationship (Grossman and Krueger 1995, Halkos 2003, Cole 2004, Tsuzuki 2009). This is due to the foundational empirical formula found in the Grossman and Krueger 1995. Grossman and Krueger drew from total of 58 countries from 1979-1980 and implemented a generalized least squares model (GLS). This econometric technique is proved useful for its estimation of unknown coefficients and residuals seen in the table above (Tb.1).

Conclusion

Using the literature case studies above, the linear regression model that best fits the hypothesized relationship between biochemical oxygen demand and gross domestic product is the (Grossman and Krueger 1995) linear regression model with the implementation of the GLS econometric technique. This technique significantly impacted the causation relationship between biochemical oxygen demand and gross domestic product. This is because the GLS economic technique allowed for an approximation of coefficients of an explanatory value. least The EKC hypothesis is found and is demonstrated as U-shaped curve.

Policy Recommendations

The reformation of the 1972 NPDES program under the Clean Water Act may aid in the seen increased toxic pollutant loadings by reducing the acreage and maximum level of pollutant per permit shareholder. This would de-incentivize shared permit holders from attaining maximum levels of pollutants. This policy reformation would also aid in the BOD shortage seen in the year 2021-2022 used to combat both water pollution and pandemic in the United states.

Future Directions

The relationship between biochemical oxygen demand and economic development should be further assessed through the exploration of the generalized methods of moments and general least square econometric techniques.

Common Methodologies

Study Equations	Variables
Grossman and Krueger (1995)	y_{it} water pollution
$y_{it} = G_{it}(B1) + G_{it}^2(B2) + G_{it}^3(B3) + G_{it}(B4) + G_{it}^2(B5) + G_{it}^3(B6) + X_{it}(B7) + E_{ui}$	i sample size
	G_{it} average GDP per capita over the prior three years
	B parameter
Mathew A. Cole (2004)	X_{it} a vector of other covarities
$InE_{it} = Y + F_i + kt + S(in) \ldots. cont$	E pollutant
Migletta , Leo and Toma (2016)	i region
Linear Regression	t time
$log\left(\frac{WF}{N}\right) = B_0 + B_1 \, log\left(\frac{GNI}{N}\right) + E$	GNI gross national income
$log\left(\frac{GWF}{N}\right) = B_0 + B_1 \, log\left(\frac{GNI}{N}\right) + E$	E error
	N sample size

Table 1. Refers to the analyzed equations that differed throughout the literature review. The (2016) study linear regression model was most significantly different than the following case study equations used in the EKC hypothesis such as the (1995) and (2004) equation model. The (2016) model did not produce an error equation like the (1995) case study but implemented a standard error variable throughout each linear regression model. Although the (1995) and (2004) models consisted of time series analyses, the (2016) model investigated 94 countries using a cross sectional analysis for the following duration (1996-2005). The 2016 model provides an accurate generalized methods of moments econometric technique factoring population and GNI change.

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