AN ENHANCED AIR POLLUTION INDEX VIA AGGREGATION OF SUBJECTIVE AND OBJECTIVE WEIGHTS OF THE POLLUTANTS

NUR SYAMIMI BINTI MUHAMAD FAUZI

MASTER OF SCIENCE (DECISION SCIENCE)

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Awang Had Salleh
Graduate School
of Arts And Sciences

Universiti Utara Malaysia

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Abstrak

Pengukuran kualiti udara ambien di Malaysia diperihalkan sebagai Indeks Pencemar Udara atau Indeks Pencemaran Udara (IPU). Secara amnya, IPU sedia ada untuk tempoh masa tertentu ditakrifkan sebagai nilai sub-indeks maksimum enam bahan pencemar iaitu sulfur dioksida (SO_2), nitrogen dioksida (NO_2), karbon monoksida (CO), ozon (O_3), habuk halus diameter aerodinamik kurang daripada 10 mikrometer (PM_{10}) dan habuk halus diameter aerodinamik kurang daripada 2.5 mikrometer($PM_{2.5}$). Walaupun penyelidikan telah menunjukkan bahawa pendedahan jangka panjang dan pendek kepada toksik terampai udara mempunyai kesan toksikologi yang berbeza terhadap manusia, namun IPU masih menganggap bahan pencemar ini mempunyai kesan berbahaya yang sama kepada manusia. Oleh itu, tujuan kajian ini adalah untuk mencadangkan IPU yang dipertingkatkan dengan merangkumi pemberat yang mewakili tahap berbahaya yang berbeza bagi bahan pencemar ini dalam pengiraannya. Gabungan pemberat subjektif dan objektif bagi enam pencemar masing-masing ditentukan menggunakan kaedah peruntukan titik dan entropi berdasarkan data kepekatan bahan pencemar harian untuk 2018 di seluruh Malaysia. Tiga jenis IPU telah dibina iaitu IPU dengan pemberat subjektif, objektif dan tergabung. IPU dengan pemberat tergabung terbukti sebagai IPU terbaik kerana ia dapat mengatasi kelemahan kaedah subjektif dan objektif. Keputusan menunjukkan bahawa $PM_{2.5}$ didapati sebagai bahan pencemar paling berbahaya kerana nilai pemberat tergabungnya adalah yang tertinggi berbanding bahan pencemar lain. Selain itu, didapati bacaan IPU tertinggi dan terendah masing-masing dicatatkan pada 14 Ogos dan 10 Mac 2018. Kajian ini memberikan pandangan baharu dalam membina IPU secara khusus. Bacaan IPU yang dipertingkatkan dengan pemberat tergabung didapati memberi gambaran yang lebih baik tentang kejadian pencemaran udara di Malaysia khususnya. Seterusnya ia juga menyumbang kepada pengukuran kualiti udara yang lebih komprehensif dan tepat untuk membantu pihak berkuasa dalam menangani isu pencemaran.

Kata Kunci: Kaedah pemberat subjektif, Kaedah pemberat objektif, Pemberat tergabung, Indek pencemaran udara, Tahap berbahaya.

Abstract

The ambient air quality measurement in Malaysia is described as Air Pollutant Index or Air Pollution Index (API). Generally, the existing API for a given period of time is defined as the maximum sub-index value of six pollutants namely sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), particulate matter with aerodynamic diameter less than 10 micrometers (PM_{10}) and particulate matter with aerodynamic diameter less than 2.5 micrometers ($PM_{2.5}$). Although research has shown that long and short-term exposure to air suspended toxicants have a different toxicological impact on human, the API still considers these pollutants as having equal hazardous impacts on human. Hence, this study aims to propose an enhanced API that includes weights representing different hazardous levels of these pollutants in its calculation. An aggregation of subjective and objective weights of the six pollutants respectively was determined using the point allocation and the entropy methods based on the daily pollutant's concentration data for 2018 in Malaysia. Three types of APIs were constructed based on subjective, objective and aggregated weights. The latter one is proven to be the best API as it copes well with the disadvantages of subjective and objective methods. The results show that $PM_{2.5}$ is found to be the most hazardous pollutant as its aggregated weight value is the highest compared to the others. Additionally, the highest and lowest API readings took place on the 14th of August and 10th of March 2018 respectively. This study provides a new insight in constructing API specifically. It is argued that the enhanced API with aggregated weights of the pollutants gives a more reliable readings of air pollutions and produces a better picture about the occurrence of air pollution in Malaysia in particular. Furthermore, it also contributes a more comprehensive and precise air quality measurements that can help the authorities in dealing with air pollution issues.

Keywords: Subjective weighting method, Objective weighting method, Aggregated weights, Air pollution index, Hazardous levels.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Pollution is described as additional of harmful substances or material into the environment at a rate faster than it can be dispersed. There are generally three major types of pollution which are water pollution, land pollution and air pollution. Other forms of pollution such as noise pollution, light pollution and plastic pollution are also concerns that has been highlighted in today's modern society (Nathanson, 2020). However, this study only focuses on one type of pollution which is air pollution.

Air pollution is defined as an air quality disturbance that can be characterised by the measurement of chemical, biological or physical pollutants in the air. Air pollution is a global crisis that is experienced by nearly every populated land on earth. Thus, air pollution has become a major threat to humans and the climate (World Health Organization (WHO), 2020). For instance, in 2015, illegal open burning in Indonesia resulted in a disaster known as the Southeast Asian Haze (Ghani, Redzuan, Nasir, & Selamat, 2017). Specifically, swathes of rainforest in Sumatera were periodically burnt off to open up land for oil palm plantations, agriculture or commercial purposes.

The effect of this burning did not only affect Indonesia itself, but also contributed to haze problems Malaysia, Singapore and parts of Thailand which spanned for over a month. This phenomenon forced schools to close and heavily disrupted air travel. Thus, Malaysia is also a country that struggled with this critical issue. Then, the government of Malaysia invented an air pollution index (API) to ambient the air quality and indirectly it can control the air pollution issues in Malaysia

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APPENDIX A

Result of Accuracy Measurement

1) Accuracy measurement: Hwang and Yoon method.

Accuracy measurement	PM_{10}	$PM_{2.5}$	SO_2	NO_2	O_3	CO
Hwang & Yoon	0.1861	0.2064	0.2330	0.1362	0.0962	0.1420
Actual weight	0.1683	0.1841	0.1914	0.1535	0.1324	0.1702
|e|	0.0178	0.0223	0.0416	0.0173	0.0362	0.0282
e^2	0.0003	0.0005	0.0017	0.0003	0.0013	0.0008
APE=|(e/y)*100|	10.5607	12.1359	21.7168	11.2769	27.3378	16.5520

2) Accuracy measurement: Zeleny method.

Accuracy measurement	PM_{10}	$PM_{2.5}$	SO_2	NO_2	O_3	CO
Zeleny	0.1537	0.1497	0.1463	0.1792	0.1839	0.1872
Actual weight	0.1683	0.1841	0.1914	0.1535	0.1324	0.1702
|e|	0.0147	0.0344	0.0451	0.0257	0.0515	0.0170
e^2	0.0002	0.0012	0.0020	0.0007	0.0027	0.0003
APE=|(e/y)*100|	8.7059	18.6941	23.5786	16.7312	38.8710	10.0092

3) Accuracy measurement: Gaussian Kernel method.

Accuracy measurement	PM_{10}	$PM_{2.5}$	SO_2	NO_2	O_3	CO
Gaussian Kernel	0.1566	0.2010	0.1954	0.1422	0.1108	0.1939
Actual weight	0.1683	0.1841	0.1914	0.1535	0.1324	0.1702
|e|	0.0117	0.0169	0.0040	0.0113	0.0217	0.0237
e^2	0.0001	0.0003	0.0000	0.0001	0.0005	0.0006
APE=|(e/y)*100|	6.9553	9.2049	2.0885	7.3596	16.3505	13.9374

APPENDIX B

Questionnaire of the Study

IMPACT OF AIR POLLUTANTS TOWARDS AIR QUALITY AND HUMAN HEALTH.

Dear Mr./ Mrs./ Miss

I am Nur Syamimi Bt Muhamad Fauzi, a master's student in Decision Science at School of Quantitative Sciences, Universiti Utara Malaysia. Currently, I am conducting a research on A Novel of Air Pollution Index via Aggregation of Subjective and Objective Weights, under the supervision of Assoc. Prof. Dr. Maznah Binti Mat Kasim and Dr. Nor Hasliza Binti Mat Desa. In order to complete this research, the following questionnaire have been designed to conduct a survey that can determine the importance level of air pollutants towards air quality and human health. Therefore, respondents are required to indicate the answer for all the questions in every section based on the scale provided. You are advised to answer the questions sincerely as your opinion is important for my research. Please note that all information is strictly used for the purpose of research and will be kept as private and confidential. Your co-operation to fill up this survey is highly appreciated. If you have any query to know about the result and findings of this research, please do not hesitate to contact me via my phone number: +6013-4085745 or via email: syamimifauzi07@gmail.com, or my supervisor's email: maznah@uum.edu.my.

I really appreciate your cooperation and time. Thank you.

Yours Respectfully
Nur Syamimi.

* Required

SECTION A: DEMOGRAPHIC INFORMATION

Fill in the blank with the appropriate information.

1. Name *

2. Age *

3. Position *

_____

4. Working experience *

Mark only one oval.

- ◯ below 3 years
- ◯ 3 - 5 years
- ◯ 5 - 10 years
- ◯ 10 years and above

5. State

Mark only one oval.

- ◯ Perlis
- ◯ Kedah
- ◯ Perak
- ◯ Kelantan
- ◯ Terengganu
- ◯ Pahang
- ◯ Negeri Sembilan
- ◯ Melaka
- ◯ Selangor
- ◯ Johor
- ◯ Sabah
- ◯ Sarawak
- ◯ Pulau Pinang
- ◯ W.P Putrajaya
- ◯ W.P Labuan
- ◯ W.P Kuala Lumpur

SECTION B: IMPORTANCE LEVEL OF AIR POLLUTANTS

In this section, the respondent is required to allocate some point according to the air pollutants' importance towards the air quality and also human health. 100 points is given to the respondent in order to allocate the point based on the respondent's opinion regarding this issue.

INSTRUCTIONS:
The most important air pollutant towards air pollution and human health, allocate with higher point.
The least important air pollutant towards air pollution and human health, allocate with lower point.

For Example:
PM10: 20
PM2.5: 35
SO2: 17
NO2: 10
CO: 13
O3: 5
TOTAL POINTS: 100

6. 1) particulate matter with aerodynamics diameter less than 10 micrometer (PM10) *

7. 2) particulate matter with aerodynamics diameter less than 2.5 micrometer (PM2.5) *

8. 3) sulphur dioxide (SO2) *

9. 4) nitrogen dioxide (NO2) *

10. 5) carbon monoxide (CO) *

11. 6) ozone (O3) *