Impact of Bauxite Mining on Quality of Life: An Analysis of Road Users

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Impact of Bauxite Mining on Quality of Life: An Analysis of Road Users

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Abstract. Mining activities are often associated with various adverse effects. Until now, most research focuses on the environmental, occupational, and health impacts of mining activities. However, existing literature lacks information on mining activities' impact on the quality of life of surrounding road users. Therefore, this research aims to compare the quality of life of road users between bauxite and non-bauxite areas. To achieve that objective, questionnaire survey data from road users were collected and analyzed. The findings suggest that the affected road users have an overall significantly lower health-related quality of life than the control group. Specifically, the affected road users have significantly lower physical-, psychological-, and social-related quality of life. While numerous other factors might influence the participants' quality of life, respondent demographic and road satisfaction variables have a low to a negligible relationship with the quality of life in this study. This research's key contribution is by identifying the impact of mining activities on road users in a developing country.

Keywords: Sustainable Development, Mining Industry, Quality of life, Roads and Streets, Road Users, Human

1. Introduction

Unregulated mining activities can have an adverse environmental side effect [1]. Mining activities negatively impact the human, animal, and environment surrounding the mining sites [1]. In the case of bauxite mining, red bauxite particles (in the form of mud and dust) are produced from alumina refining of bauxite ore with high pH value that contains a certain amount of caustic alumina soda, ferrotitanium oxide, and a small number of rare metals [2]. Any leaching of these red bauxite particles into water sources resulting in reduced soil fertility and affecting agricultural food products and aquatic life [3]. Also, the inhalation of these particles might harm human health. In other words, similar to other mining activities, bauxite mining is hugely affecting the life and health of surrounding areas. The major bauxite mining activities in Malaysia take place at Bukit Goh and the communities at Felda Bukit Goh. These mining activities are suggested to potentially contaminate the treated water at the nearest four water treatment plants located downstream of the mining site. The Bukit Goh Water Treatment Plant was closed at least once due to suspicion of pollution contamination [4]. As a result, several tests were conducted, and the water was retreated to ensure the water is clean and safe before distributing it to the public. To avoid this issue from recurring, the Malaysian government has banned all bauxite mining activities in early 2016 because it might lead to environmental pollution, including water, air, and soil pollution. However, the government might consider allowing the bauxite mining activities to resume once any concerns on its environmental impact are addressed. In a nutshell, while the environmental impact of bauxite mining activities can be tackled, the indirect effect of mining activities, such as psychosocial impact, should also be investigated. Addressing the indirect implications of such activities ensure all economic developments are not directly nor indirectly negatively impacting the general well-being of surrounding communities (i.e., quality of life).

Specifically, the World Health Organization (WHO) defines the quality of life as an individual's perception of their position in life in the context of the culture and value systems in which they live and their goals, expectations, standards, and concerns [5]. In addition to the surrounding communities, the route to transport the material (hereafter mining transportation route) might cause discomfort or anxiety among road users. Therefore, identifying the impact of the mining transportation route on road users is critical to avoid reducing the public's quality of life. This study aims to compare the quality of life of road users between bauxite and non-bauxite areas. To achieve that objective, this study analyzes questionnaire survey data that adopt WHO's approach in measuring quality of life. This study contributes to the existing body of knowledge by identifying the impact of mining activities from a different perspective – road users. Researchers and practitioners can use the findings to justify the need for resources to reduce mining activities' impact on communities and individuals traveling in the area. Reducing the environmental impact of mining activities can benefit nations in achieving sustainable cities and communities.

2. Literature review

2.1. Impact of Mining Activities

Mining activities are suggested to expose individuals to physical and chemical hazards, including noise, heat, humidity, and ergonomic problems such as vibration, ultraviolet radiation, and radioactive materials [3]. The sound produce by the machine and equipment is producing noise from the blasting process, drilling process, excavating, and crushing process that can affect the human ear. Specifically, noise within 10m is potentially detrimental to health if the noise level range is from 85 decibels to 106 decibels [3]. Besides, dust from the blasting and crushing process is a chemical hazard because some particles are biologically inert [3]. Miners might experience health complications from frequent exposure, such as cough, wheeze, and rhinitis [3]. The environmental issues of mining activities include water, and soil pollution due to dust and leaching [3]. Soil pollution or soil contamination can occur because waste products during the mining process are absorbed into the soil. The soil's unbalanced pH will affect agricultural activities, including destroyed agricultural products or unsafe crops, which eventually leads to economic problems. Contaminated water that contains aluminum hydroxide, iron oxide, and heavy metals can harm our health. Aluminum is a neuro-toxin and has been linked to Alzheimer's and bone diseases [3]. Meanwhile, iron oxide in bauxite can potentially cause iron overload upon chronic ingestion, leading to gastrointestinal symptoms, hepatic disease, cardio-myopathies, diabetes, and hyperpigmentation [3].

2.2. Assessing Bauxite's Impact

In 2017, from a previous study done by a group of researchers from University Sultan Zainal Abidin (UNISZA) on the water quality assessment of the river near the bauxite mining area. The river involved in the evaluation is the Kuantan River, Riau River, Pinang River, and Pandan River. The water samples from each river were tested for its temperature, pH, dissolved oxygen (DO), total dissolved solids (TDS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammonia-nitrogen (NH3-N), turbidity, and total suspended solids (TSS). These parameters are used to determine the Water Quality Index (WQI). WQI is to identify the river classification, and from the result obtained, it can decide if the water is clean or not. The river that is nearby the mining bauxite site has the potential of water contamination that will affect the quality of the drinking water. From the result obtained, the WQI of the Kuantan River, Pandan River, Riau River, and Pinang River were 77.141, 77.478, 81.238, and 83.164, respectively. All these rivers were classified into class II based on the Interim National Water Quality Index for Malaysia (INWQS) and required conventional treatment for water supply purposes [7]. The current water treatment plant can still treat the severely polluted water, but if the pollution is too high, it cannot treat the water.

Psychosocial defines as a combination of an individual psychological and social. From the previous study that been done by University Putra Malaysia (UPM), they categorized the psychosocial impact score into three categories, which are low, medium, and high. The psychosocial impact is also from the environmental factor. The environmental factors of the psychosocial effects were mostly due to bauxite trucks driving in and out of narrow routes, the noisy sound produced, and the houses and facilities turned to red because of dust emitted from their loads, which caused stress [6]. They think it is very uncomfortable to keep staying in their house and cannot freely go outside because they need to avoid dust. This will affect their mental health as well because they will feel pressure and lead to stress.

2.3. Positioning this Study

Bauxite activity is giving a negative effect on the human, animal, and the environment that is near the bauxite mining site. Bauxite particles (the red mud and dust) are one of the effects that can harm human health. It also causes the pollution of water, air, sound, and soil. Most research focuses on the environmental impact, occupational health impact, psychosocial impact, and potential health impact. However, there is limited study in the term of accessing the quality life of the road users. The quality of life of road users is also essential to maintain their emotions and behavior while they on the road. The condition of the road at the bauxite area may be uncomfortable compared to the non-bauxite site. However, limited studies are accessing the impact of mining activities on road users' quality of life. Based on the literature above, most of the research focused on the effects of bauxite mining activities. Therefore, this research will assess the quality of life of road users at bauxite and non-bauxite areas.

3. Methodology

3.1. Questionnaire Design

The questionnaire survey consists of items referring to the respondent demographic, their satisfaction as road users, and their quality of life. The demographic includes inquiring about the respondents' age, income, sex, and the frequency of traveling the current route. Questions related to road satisfaction was adopted from Transport for NSW (New South Wales) Road Customer Satisfaction Index [8]. On the other hand, questions related to the quality of life were directly adopted from WHO standard items to access the quality of life, health, and other related areas. Specifically, the self-reported HRQOL was measured using the abbreviated version of the WHOQOL-BREF, which affords composite measures of physical (7 items), psychological (6 items), and social (3 items) HRQOL [9]. The WHOQOL-BREF has two generic items asking about general health and overall quality of life, and an additional domain measuring and environmental QOL (8 items) [9]. The questionnaire was titled 2019 Well-being and Road Customer Satisfaction Survey, designed to avoid bias among the participants by masking the study's real intent. The questionnaire was prepared in two versions - in English and Malay (the national language of Malaysia). This ensures the survey can be understood by all respondents regardless of their age and educational background. The English version of the questionnaire is attached in the appendix.

3.2. Data Collection

The data collection is conducted at the generally known bauxite transportation route and a control route (which is from Jalan Gambang to Kuantan city). The survey was distributed to a few points along with the focused location, such as gas stations. The questionnaire was also distributed to all companies and stores available along the area. Respondents were randomly chosen from the selected point to fill in the questionnaire. The data are collected from all ages and gender that uses the road as road users can be anyone who makes a trip from the origin point to the destinations.

3.3. Data analysis

3.3.1 Bivariate correlation analysis. This research analyzed the relationship between respondent demographic, road satisfaction related, and quality of life variables using the bivariate correlation analysis. The bivariate correlation analysis calculates the correlation coefficient between those variables. The correlation coefficient value represents the intensity of the relationship between two variables. This study interprets the strength of correlation as per Table 1 [10]. This approach was also adopted to evaluate the relationship between different skills among individuals [11].

Table 1. Strength of correlation

Size or r	Interpretation
0.90 to 1.00	Very high correlation
0.70 to 0.89	High correlation
0.50 to 0.69	Moderate correlation
0.30 to 0.49	Low correlation
0.00 to 0.29	Little if any correlation

3.3.2 Mean Score with Analysis of Variance (ANOVA). This study employed scale-ranking analysis to rank the different HQROL domains. The one-way ANOVA was performed in this study to identify any significant differences between the bauxite and control groups. A p-value of less than 0.05 suggests a significant difference in the groups [12].

4. Results and Discussion

4.1. Respondent profile

Table 2 summarizes the respondents' profiles for this study's survey. Both bauxite and control groups have more female respondents than male respondents, although Malaysia has almost the same male-female ratio. The table also illustrates that the survey data is equally distributed between the age group 18 to 20, 21 to 30, and 41 to 50 years, which provides a good representation of the working population in Malaysia. Also, according to income, the respondents' proportion is somewhat as per Malaysia's income group of below 40, middle 40, and upper 20 of household incomes. Furthermore, most respondents visit the designated survey location more than five times a week (90% for the bauxite group and 84% for the control group). Thus, while the male-female ratio does not represent Malaysia's gender ratio, the respondents consist of working individuals utilizing the bauxite and non-bauxite routes that can provide useful insights for the study.

Table 2. Respondent profile of the bauxite and comparison group

Variables	Bauxite group (n=176) n (%)	Comparison group (n=66) n (%)	Variables	Bauxite group (n=176) n (%)	Comparison group (n=66) n (%)
Sex			Income		
Male	68 (39)	20 (30)	Below RM3,500	104 (59)	50 (76)
Female	108 (61)	46 (70)	RM3,500 – RM6,800	35 (20)	10 (15)
Age group, years			Above RM6,800	37 (21)	6 (9)
18-20	11 (6)	3 (5)	Frequency visiting survey location		
21-30	44 (25)	24 (36)	1 time/week	4 (2)	2 (3)
31-40	57 (32)	25 (38)	2 times/week	2 (1)	0 (0)
41-50	50 (28)	12 (18)	3 times/week	8 (5)	7 (11)
Above 50	12 (8)	2 (3)	4 times/week	3 (2)	1 (2)
			5 times/week	55 (31)	19 (29)
			Above 5 times/week	104 (59)	37 56)

4.2. HRQOL scores: Bauxite group vs. control group

Table 3 shows the mean, standard deviation, and ANOVA results for the four HRQOL domains of the WHOQOL-BREF and overall scores. In other words, the table compares the HRQOL scores between the comparison and bauxite group of respondents. The results illustrate that compared to the bauxite group, the control group has higher scores for all four HRQOL domains (physical, psychological, social, and environmental) and overall HRQOL scores. Furthermore, the results suggest a significant difference between the mean of those groups for three of the HRQOL domains (physical, psychological, and social) and overall HRQOL scores. Therefore, the results suggest that road users of the bauxite transportation route have a lower health-related quality of life than other users.

Table 3. Mean, standard deviation (SD), and ANOVA results for the four HRQOL domains of the WHOQOL-BREF and overall scores, presented for both comparison and bauxite groups

Measure	Bauxite group		Control group		ANOVA
	Mean	SD	Mean	SD	α
Physical	21.955	2.723	22.742	2.289	.0377[a]
Psychological	20.460	2.458	21.394	2.486	.0093[a]
Social	9.523	1.489	10.061	1.518	.0135[a]
Environmental	23.682	3.319	24.470	3.824	.1163
Overall	75.619	7.966	78.667	8.164	.0090[a]

4.3. Correlation between respondent demographic, road satisfaction, and HRQOL variables

Table 4 shows the Pearson product-moment correlation coefficients (r) for respondents' demographics, road satisfaction-related, and HRQOL variables. The results illustrate that there are moderate correlations between some of the variables, especially between the HRQOL domains. However, the results also show a lack of correlation between the HRQOL variables and both respondent demographic and road satisfaction variables. Specifically, only 'information about road closures before driving' (Satisfaction#7) is moderately correlated with HRQOL overall scores. In other words, both respondent demographic (gender, age, and income) and road satisfaction are not affecting HRQOL scores in this study.

Table 4. Pearson product-moment correlation coefficients (r) for respondents' demographics, road satisfaction-related, and HRQOL variables. Statistics to the right of the major diagonal are for the bauxite group, while those to the left are for the control group

	Sex	Age	Income	Frequency	Satisfaction#1	Satisfaction#2	Satisfaction#3	Satisfaction#4	Satisfaction#5	Satisfaction#6	Satisfaction#7	Satisfaction#8	Satisfaction#9	Physical	Psychological	Social	Environmental	Overall
Sex	**1.000**	0.196	0.272	-0.073	-0.142	-0.099	0.073	-0.123	0.019	-0.109	-0.199	-0.138	-0.139	0.023	-0.019	0.057	-0.112	-0.034
Age	-0.009	**1.000**	0.016	0.004	0.123	0.144	0.218	-0.025	0.110	0.110	0.027	0.058	0.083	0.214	0.106	0.106	0.058	0.150
Income	0.151	0.086	**1.000**	-0.112	0.067	0.128	0.182	0.071	0.137	-0.117	-0.074	-0.097	-0.097	0.155	0.062	0.099	0.199	0.174
Frequency	-0.113	0.062	-0.013	**1.000**	0.002	0.058	0.034	0.170	0.024	0.100	0.103	0.069	0.150	0.120	0.090	-0.047	0.060	0.085
Satisfaction#1	-0.203	0.030	-0.161	0.053	**1.000**	**0.672**	0.260	0.208	0.394	0.309	0.366	0.390	0.329	0.177	0.110	0.204	0.283	0.251
Satisfaction#2	-0.123	0.154	-0.024	0.207	**0.701**	**1.000**	0.416	0.440	0.424	0.388	0.426	0.192	0.409	0.264	0.201	0.260	0.377	0.358
Satisfaction#3	0.067	0.198	0.085	0.171	0.267	0.434	**1.000**	**0.565**	0.411	0.280	0.249	0.125	0.277	0.223	0.041	0.165	0.252	0.225
Satisfaction#4	-0.085	0.095	0.000	0.237	0.379	**0.553**	**0.805**	**1.000**	0.407	0.274	0.307	0.075	0.287	0.251	-0.044	0.025	0.285	0.196
Satisfaction#5	-0.009	0.063	-0.084	-0.082	0.402	0.390	0.356	0.405	**1.000**	**0.557**	0.430	0.359	0.366	0.288	0.063	0.180	0.314	0.282
Satisfaction#6	-0.041	-0.032	-0.338	0.068	0.324	0.293	0.308	0.398	0.470	**1.000**	0.410	0.418	0.458	0.308	0.082	0.193	0.349	0.312
Satisfaction#7	-0.089	0.006	-0.105	0.081	0.483	**0.520**	0.481	0.481	**0.637**	0.390	**1.000**	**0.629**	**0.531**	0.092	0.041	0.203	0.351	0.229
Satisfaction#8	-0.257	-0.002	-0.146	0.134	0.478	0.214	0.222	0.242	0.422	0.443	**0.649**	**1.000**	**0.663**	0.131	0.096	0.167	0.318	0.238
Satisfaction#9	-0.185	-0.001	-0.310	0.138	0.344	0.125	0.253	0.240	0.307	0.438	**0.599**	**0.843**	**1.000**	0.247	0.139	0.267	0.403	0.345
Physical	-0.317	0.259	0.070	0.187	0.448	0.393	0.391	0.424	0.251	0.287	0.382	0.421	0.354	**1.000**	0.135	**0.790**	0.161	**0.839**
Psychological	-0.133	0.105	0.206	0.156	0.241	0.226	0.156	0.187	0.132	-0.111	0.355	0.154	0.148	0.359	**1.000**	-0.235	**0.762**	**0.836**
Social	0.189	-0.127	0.169	-0.116	0.086	0.073	0.004	0.072	0.228	-0.010	0.361	0.130	0.143	0.115	**0.666**	**1.000**	-0.246	**0.786**
Environmental	-0.140	-0.014	0.211	-0.045	0.204	0.104	0.227	0.266	0.354	0.166	0.475	0.383	0.380	0.466	**0.652**	**0.634**	**1.000**	**0.868**
Overall	-0.161	0.075	0.214	0.057	0.312	0.242	0.265	0.315	0.320	0.123	**0.507**	0.370	0.350	**0.632**	**0.837**	**0.721**	**0.919**	**1.000**

Note

Satisfaction#1 = Safe driving by others; Satisfaction#2 = Courteous driving by others; Satisfaction#3 = Adequacy of direction signs; Satisfaction#4 = Clarify of road signs; Satisfaction#5 = Condition of road surfaces; Satisfaction#6 = Number of heavy vehicles on the road; Satisfaction#7 = Information about road closures before driving; Satisfaction#8 = Information about delays before driving; Satisfaction#9 = Availability of information to help plan my trip

5. Conclusion

This study aims to compare the quality of life between road users of bauxite and non-bauxite areas. To achieve that objective, this study analyzes questionnaire survey data that adopt WHO's approach to measuring the quality of life from various domains. The major findings include:

- Road users of the bauxite transportation route have an overall significantly lower health- related quality of life than other road users.
- Specifically, road users of the bauxite transportation route have an overall significantly lower physical-, psychological-, and social-related quality of life than other road users.
- While numerous factors might exist, respondent demographic (gender, age, and income) and road satisfaction variables have a low to a negligible relationship with the participants' quality of life.

These findings highlight the need to identify approaches for reducing bauxite mining's adverbial impact or change to the environment. Researchers and industry practitioners can use these findings to justify the time and resources necessary to formalize strategies for mining-related activities. This research's key theoretical contribution is by identifying the impact of mining in a developing country from the perspective of road users that utilize the mining activities' transportation route.

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Appendix

2019 Well-being and Road Customer Satisfaction Survey

1. Please indicate your age: _____years old

2. What is your gender? Male Female

3. Please indicate your monthly household income: RM_____/month

4. Where did you begin your trip today?

   _____ _____ _____
   City/Town/Place Name State Zip Code
   Check one: ☐ Home ☐ Work ☐ Store ☐ School ☐ Other

5. Where was your previous stop?

   _____ _____ _____
   City/Town/Place Name State Zip Code
   Check one: ☐ Home ☐ Work ☐ Store ☐ School ☐ Other

6. Where is your next stop?

   _____ _____ _____
   City/Town/Place Name State Zip Code
   Check one: ☐ Home ☐ Work ☐ Store ☐ School ☐ Other

7. How frequently do you visit your current location?
   a. 1 time per week
   b. 2 times per week
   c. 3 times per week
   d. 4 times per week
   e. 5 times per week
   f. More than 5 times per week

8. Please select the answer that best applies to your most recent trip

I am satisfied with the	**Strongly disagree**	**Disagree**	**Agree**	**Strongly agree**
Safe driving by others	1	2	4	5
Courteous driving by others	1	2	4	5
Adequacy of direction signs	1	2	4	5
Clarify of road signs	1	2	4	5
Condition of road surfaces	1	2	4	5
Number of heavy vehicles on the road	1	2	4	5
Information about road closures before driving	1	2	4	5
Information about delays before driving	1	2	4	5
Availability of information to help plan my trip	1	2	4	5

Appendix

Question09

The following questions ask how you feel about your quality of life, health, or other areas of your life. **Please choose the answer that appears most appropriate.** If you are unsure about which response to give to a question, the first response you think of is often the best one.

Please keep in mind your standards, hopes, pleasures, and concerns. We ask that you think about your life **in the last four weeks.**

Item	**Strongly disagree**	**Disagree**	**Agree**	**Strongly agree**
I am satisfied with my quality of life	1	2	4	5
I am satisfied with my health	1	2	4	5
I have physical pain that prevents me from doing what I need to do	1	2	4	5
I need medical treatment to function in my daily life	1	2	4	5
I enjoy life	1	2	4	5
I feel my life is meaningful	1	2	4	5
I am able to concentrate	1	2	4	5
I feel safe in my daily life	1	2	4	5
I feel my physical environment is healthy	1	2	4	5
I have enough energy for everyday life	1	2	4	5
I can accept my bodily experience	1	2	4	5
I have enough money to meet my needs	1	2	4	5
I have the information that I need for my day-to-day life	1	2	4	5
I have the opportunity for leisure activities	1	2	4	5
I can get around	1	2	4	5
I am satisfied with my sleep	1	2	4	5
I am satisfied with my ability to perform my daily living activities	1	2	4	5
I am satisfied with my capacity for work	1	2	4	5
I am satisfied with myself	1	2	4	5
I am satisfied with my relationships	1	2	4	5
I am satisfied with my sex life	1	2	4	5
I am satisfied with the support I get from my friends	1	2	4	5
I am satisfied with the conditions of my living place	1	2	4	5
I am satisfied with my access to health services	1	2	4	5
I am satisfied with my transport	1	2	4	5
I often have negative feelings such as blue mood, despair, anxiety, depression	1	2	4	5

--- Thank you for your participation---

For completion of student

Location of data collection: