



Overview Of Pollution and Health Perceptions among Fishers in The Central Mahakam River Basin

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Abstract. The Central Mahakam River Basin is a vital ecosystem supporting local fishers' livelihoods. Yet, it faces significant pollution challenges that may adversely affect both environmental health and the well-being of these communities. This study aimed to describe the perceptions of fishers from this area regarding pollution and its effects on their health. This study employed an analytical, quantitative design, with fishers and/or their family members from 15 villages across five districts in Kutai Kartanegara Regency as the respondents, selected through accidental sampling. The variables analyzed included perceptions of pollution-related activities and health symptoms. Three hundred seventy-five fishers were included in the study, aged 46.30 ± 11.48 years old. Most of them (61.33%) recognized some pollution from the river, with each village mainly mentioning 2 (26.82%) potential sources. 240 (64%) fishers claimed that they consume fish on the day. History of diarrhea was reported from a family of 81 (21.6%) fishers, 80 (21.33%) reported paleness, 155 (41.33%) reported headache, and 59 (15.73%) reported menstrual disorder. There was a significant association between recognition of pollution and a history of paleness ($p=0.040$) and between several potential sources of pollution with a history of menstrual disorder ($p=0.014$) within the fishers' family.

Keywords: Pollution, fishing, health perceptions, Mahakam River basin, fish consumption.

1 Introduction

Environmental health studies interactions between ecological factors and human health, especially the impact of pollution on public health. Studies have shown that exposure to various pollutants, including agricultural runoff and industrial emissions, is closely linked to a range of health issues, including diarrhea, cardiovascular diseases, respiratory conditions, and mental health disorders [1-4]. The relationship between perceived environmental pollution and health outcomes is particularly noteworthy, as individuals' perceptions can influence their behaviors and overall health [5].

The fishing industry, which often depends on clean aquatic ecosystems, is particularly vulnerable to the impacts of environmental pollution. Fishers' health and livelihoods are directly affected by the degradation of water environments due to pollution, which can lead to declines in fish populations and the quality of catch [6]. The health

status of fishers is often compromised due to their exposure to hazardous substances in polluted waters, which can lead to various health complications [7]. Furthermore, environmental pollution can also have an economic impact, influencing healthcare expenditures and economic growth. Research indicates that as pollution levels rise, the costs associated with healthcare are also increasing, worsening public health burdens [8]. This relationship highlights the necessity for effective environmental regulations and policies to reduce pollution and its associated health impacts [9]. Therefore, exploring aspects of the environment, pollution, and the fishing community is necessary to develop potential interventions to protect public health and water environments.

The Mahakam River Basin in East Kalimantan, Indonesia, has an extensive river network complemented by rich biodiversity. At approximately 920 kilometers, the Mahakam River is the second-longest river in Kalimantan, draining an area of about 77,700 square kilometers [10]. This basin supports local communities and provides vital resources such as freshwater, fisheries, and plantations. The river is influenced by both tidal and fluvial processes, which contribute to the formation of the Mahakam Delta, with its diverse ecosystems and significant economic potential [11], [12]. The tropical rainforest climate of the region, marked by high humidity and warm temperatures, increases the basin's biodiversity, making it a habitat for various aquatic and terrestrial species [13], [14]. The basin is home to endangered species such as the Irrawaddy dolphin or *Orcaella brevirostris* [15].

Nonetheless, the Mahakam River Basin currently faces numerous environmental challenges. Industrial activities, including oil and gas extraction, coal mining, and palm oil production, have led to significant pollution and habitat degradation within the basin [16], [17]. These human activities threaten the health of aquatic ecosystems and the livelihoods of local communities that depend on the river [18]. Therefore, this study was conducted to describe and analyze the association between the perception of pollution and the health condition of fishers in the central Mahakam River basin.

2 Material and Methods

This study used an observational analytical design. The respondents were fishers from 15 villages of 5 districts in Kutai Kartanegara regency, East Kalimantan province, Indonesia. These villages were chosen as they are part of the central Mahakam River basin area with an estimated minimal total sample size of 382 and stratified into 17 respondents for each village. Fishers were selected using accidental sampling methods and included in the study if they were adult aged 18 years or older and stated that they had been working as fishers, which may be proven by showing their license as fishers (Kartu Nelayan). Exclusion criteria were refusal or withdrawal from the study.

Data was collected for each respondent by interview using a questionnaire and body measurement. Variables included were general characteristics, fishers' activity and consumption, their perception of pollution, anthropometric data and health perception. Data was analyzed using descriptive statistics, and hypotheses were tested using Mann-Whitney U and Pearson chi-square tests. Significance was established if the p-value of the tests was less than 0.05, and all analyses were conducted using STATA 17.0 SE.

Ethical Committee on Social Studies and Humanities of Indonesian National Research and Innovation Agency number 088/KE.01/SK/02/2024 has approved the ethical clearance.

3 Result

This study found 375 respondents from 15 villages of the central Mahakam River basin; all were from Kutai Kertanegara regency. The characteristics of the respondents can be seen in Table 1, where most respondents were male (83.73%), with 55% being older than 45 years. Almost all were married (92.58%), with most only having elementary-level education (63.69%). While 81.60% claimed their main occupation was fishing, only 6.66% claimed fishing as their secondary occupation.

Table 1. Characteristics of respondents

Characteristics	Frequency (percent) / average \pm standard deviation / median (first; third quartile) N=375
Age (years)	46.30 \pm 11.48
Male	314 (83.73%)
Marital status	
Married	337 (92.58%)
Unmarried	18 (4.95%)
Widower	5 (1.37%)
Widow	4 (1.10%)
Education	
<i>Not in school</i>	1 (0.28%)
<i>Elementary</i>	228 (63.69%)
<i>Junior high</i>	70 (19.55%)
<i>Senior high</i>	48 (13.41%)
<i>Tertiary</i>	11 (2.93%)
Main occupation	
Fishers	306 (81.60%)
Self-employed	32 (8.53%)
Housewife	14 (3.74%)
Government employee	12 (3.21%)
Private employee	10 (2.67%)
Secondary occupation	
Self-employed	114 (30.40%)
Private employee	75 (32.05%)
Fishers	25 (6.66%)
Government employee	15 (6.41%)
Housewife	5 (2.14%)
Length of career (years)	25 (16; 35)
Resident status	
Native	269 (73.10%)
Immigrant	99 (26.90%)
Length of residence (years)	40 (28; 50)
Ethnicity	

Characteristics	Frequency (percent) / average \pm standard deviation / median (first; third quartile) N=375
Kutainese	245 (67.31%)
Banjarese	113 (31.04%)
Bugisnese	4 (1.10%)
Others	11 (2.93%)

Regarding respondents' perception of pollution (Table 2), 61.33% recognized pollution in their environment, and most of them could mention two potential sources of pollution (18.67%). Meanwhile, when asked about their activity as fishers (Table 3), most of them claimed that they eat freshwater fish every day (55.73%) and even that they eat freshwater fish on the day of the interview (64%). Most species of fish caught or farmed and consumed by the respondents were gabus (stripped snakehead, *Channa striata*), biawan (kissing gourami, *Helostoma temminckii*), and sepat Siam (snakeskin gourami, *Trichopodus pectoralis*).

Table 2. Perception of pollution

Variables	Frequency (percent) N=375
Recognize pollution	
Yes	230 (61.33%)
No	123 (32.80%)
Don't know	6 (1.60%)
No response	16 (4.27%)
Recognize the number of potential sources of pollution.	
1	19 (5.07%)
2	70 (18.67%)
3	42 (11.20%)
4	36 (9.60%)
5	50 (13.33%)
≥ 6	44 (11.73%)

Table 3. Fisher's activity

Variables	Frequency (percent) N=375
Caught or farmed fish	
Gabus (stripped snakehead, <i>Channa striata</i>)	225 (60.00%)
Biawan (kissing gourami, <i>Helostoma temminckii</i>)	216 (57.60%)
Sepat siam (snakeskin gourami, <i>Trichopodus pectoralis</i>)	140 (37.33%)
Repang (<i>Puntioptiles waandersi</i>)	112 (29.87%)
Kendia (<i>Thynnichthys thynnoides</i>)	104 (27.73%)
Lele (catfish, <i>Clarias sp.</i>)	100 (26.67%)
Patin (shark catfish, <i>Pangasius sp.</i>)	74 (19.73%)
Baung (<i>Hemibagrus sp.</i>)	73 (19.47%)
Papuyu (<i>Anabas testudineus</i>)	66 (17.60%)
Nila (Nile tilapia, <i>Oreochromis niloticus</i>)	66 (17.60%)
Consumed fish	

Variables	Frequency (percent) N=375
Biawan	182 (48.53%)
Gabus	169 (45.07%)
Sepat siam	142 (37.87%)
Patin	132 (35.20%)
Lele	127 (33.87%)
Kendia	114 (30.40%)
Baung	113 (30.13%)
Papuyu	89 (23.73%)
Repang	83 (22.13%)
Lepok (butter catfish, <i>Ompok bimaculatus</i>)	68 (18.13%)
Last time, eat freshwater fish.	
Today	240 (64.00%)
Yesterday	14 (3.73%)
Within this week	5 (1.33%)
Within these 3 months	39 (10.40%)
Within these 6 months	30 (8.00%)
More than 6 months	7 (1.87%)
Frequently eating freshwater fish.	
Everyday	209 (55.73%)
Several days a week	33 (8.80%)
Several days a month	3 (2.13%)
Several days in 6 months	3 (2.13%)

Anthropometric measurements of the respondents (Table 4) showed body mass index (BMI) averaged at $22.73 \pm 3.78 \text{ kg/m}^2$. However, some of the respondents were overweight (30.93%) and even obese (10.13%), while 35 (9.33%) respondents were underweight. There was no significant difference in BMI between fishers who recognized pollution or not ($p=0.157$).

Meanwhile, most fishers complained of headache (41.33%) as the most perceived health symptom, followed by diarrhea (21.6%), paleness (21.33%) and menstrual disorder (15.73%). An association was found between the history of paleness within the fishers' families and recognized pollution ($p=0.040$, Table 4). There was a significant difference regarding the recognized number of potential sources of pollution between fishers' families with a history of menstrual disorder ($p=0.014$, Table 5). Those who recognized pollution had a 1.75 times risk of having a history of paleness compared to those who did not acknowledge pollution, which can range between 1.02 and 2.99 times.

Table 4. Association between pollution and BMI and perception of health

Variables	Recognized pollution		p-value	Odds ratio (95% confidence interval)
	Yes N=230	No N=145		
History of ...				
Diarrhea	54 (23.5%)	27 (18.6%)	0.266	1.341 (0.799; 2.250)
Paleness	57 (24.8%)	23 (15.9%)	*0.040	1.748 (1.022; 2.989)

Variables	Recognized pollution		p-value	Odds ratio (95% confidence interval)
	Yes N=230	No N=145		
Headache	103 (44.8%)	52 (35.9%)	0.088	1.450 (0.946; 2.224)
Menstrual disorder	42 (18.3%)	17 (11.7%)	0.090	1.682 (0.380; 1.084)
BMI (kg/m ²)*	22.41 (20.52; 25.04)	22.22 (19.72; 24.44)	0.157	

*BMI = body mass index presented as median (first; third quartile) and analyzed using the Mann-Whitney U test. Other variables were presented as frequency (percentage) and analyzed using the Pearson chi-square test. * marks significance*

Table 5. Association between recognized number of pollution sources and perception of health

History of ...	Mean rank for the recognized number of pollution source		p-value
	Yes	No	
Diarrhea	199.19	184.92	0.168
Paleness	194.91	186.13	0.398
Headache	180.42	193.34	0.135
Menstrual disorder	163.85	192.51	*0.014

*All variables were analyzed using the Mann-Whitney U test, * marks significance.*

Based on the results of the ANOVA table, we can analyze the effects of each factor (Layer Thickness, Infill Density, and Wall Thickness) on the dimensional accuracy of spur gears. For Layer Thickness (X1), the F-ratio is 20.0026 with a p-value of 0.0476, below the significance level of 0.05. This result suggests that we reject the null hypothesis (H0) and accept the alternative hypothesis (H1), indicating a significant average difference between layer thickness and the dimensional accuracy of the spur gears. For Infill Density (X2), the F-ratio is 14.8445 with a p-value of 0.0631 above 0.05. We fail to reject the null hypothesis, indicating no significant average difference between infill density and dimensional accuracy. Finally, for wall thickness (X3), the F-ratio is 7.0661 with a p-value of 0.1240 and above 0.05. We fail to reject the null hypothesis, indicating no significant average difference between wall thickness and dimensional accuracy. Thus, layer thickness has a substantial effect on dimensional accuracy.

The next step is to analyze the S/N ratio response with the characteristics of the more minor, the better the quality, and to determine the optimal control factor for dimensional accuracy of the mold using JMP software. The optimal parameter combinations obtained were 0.2 mm layer thickness, 60% infill density, and 0.4 mm wall thickness.

4 Discussion

The population of fishers in the Mahakam River tends to skew towards middle-aged males. Fishers from other developing countries had similar age ranges [19] and gender [20], although women's participation in this industry is increasing. Lower educational background is similar to similar sites within developing countries [19], [21], which is

quite concerning as access to modern fishing technology can be limited by this and can be a factor for poverty and limit the socio-economic mobility of fishing families [22]. Like many other regions, the Central Mahakam River Basin faces environmental threats where it has been significantly impacted by pollution. Fishers in Indonesia are acutely aware of the pollution in their rivers [23], which can affect their occupation and health [24].

Pollution in this area, primarily from industrial waste and agricultural runoff, might introduce various endocrine-disrupting chemicals into the environment. These pollutants have been linked to hormonal imbalances that can lead to menstrual disorders [25]. The previous study showed that exposure to pollutants can disrupt hormonal regulation, contributing to conditions such as endometriosis, which is characterized by painful and irregular menstruation [26]. The implications of pollution extend beyond individual health, where stress associated with living in polluted environments can further complicate menstrual health, as stress has been shown to influence menstrual cycle regularity and pain levels [27], which inadequately reported in public health.

On the other hand, water pollution in the Central Mahakam River Basin significantly affects other health complaints, such as anemia, which is characterized by paleness and fatigue due to a deficiency in red blood cells or hemoglobin. The agricultural runoff and industrial discharges can introduce toxic substances that interfere with the body's ability to produce healthy blood cells [28]. Additionally, contaminated water can lead to gastrointestinal infections, exacerbating anemia by causing the malabsorption of essential nutrients like iron [29]. Furthermore, a previous study proved how the decline in biodiversity due to water pollution could lead to reduced availability of fish and other protein sources crucial for maintaining healthy iron levels in diet [30]. Finally, microplastics and other contaminants in the water can lead to bioaccumulating harmful substances in fish, which may pose additional health risks when consumed [31]. Thus, water quality degradation not only directly affects health outcomes but also compromises nutritional security, exacerbating the risk of anemia.

The cumulative impact of these health challenges underscores the urgent need for comprehensive public health strategies to mitigate the effects of water pollution. Effective management practices, including stricter regulations on waste disposal and public awareness campaigns, are essential to safeguard the health of communities reliant on the Central Mahakam River for their water supply. Continued research and monitoring of water quality, along with fishers' community engagement in health education, will be critical in mitigating the adverse effects of pollution and promoting a healthier environment for future generations [32].

Finally, the limitation of this study was its reliance on interviews using questionnaires to assess participants' perceptions of environmental pollution and their health status, including reported symptoms, which are often subjective. Such self-reported data may introduce recall bias or personal interpretation, potentially affecting the accuracy and reliability of the findings. However, measures were taken to minimize this bias by employing a highly detailed questionnaire and reducing ambiguity. Additionally, the study limited the recall period of questions to ensure that participants' responses reflected more recent experiences.

5 Conclusions

Most of the fishers (61.33%) in the Central Mahakam Basin area recognized some pollution from the river, each mainly mentioning 2 (26.82%) potential sources. History of diarrhea was reported from the family of 81 (21.6%) fishers, 80 (21.33%) reported paleness, 155 (41.33%) reported headache, and 59 (15.73%) reported menstrual disorder. There was a significant association between recognition of pollution and a history of paleness ($p=0.040$) and between the number of potential sources of pollution with a history of menstrual disorder within the fishers' family ($p=0.014$).

Acknowledgments. This research was part of the BRIN-funded study (Indonesian National Research and Innovation Agency, Award Number 40/II.7/HK/2023).

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

References

1. Lin, L., Yang, H., Xu, X.: Effects of Water Pollution on Human Health and Disease Heterogeneity: A Review. *Front. Environ. Sci.* **10**, (2022).
2. Kamimura, A., Armenta, B., Nourian, M.M., Assasnik, N., Nourian, K., Chernenko, A.: Perceived environmental pollution and its impact on health in China, Japan, and South Korea. *J. Prev. Med. Public Heal.* **50**, 188–194 (2017).
3. Sciascia, S., Gilcrease, G.W., Roccatello, L., Padovan, D., Peano, C., Ricceri, F.: Air Pollution from Global Health to Individual Risk Factor—Is It Time for Enviropathies in Everyday Clinical Practice? *Int. J. Environ. Res. Public Health* **19**, (2022).
4. Al-Kindi, S.G., Brook, R.D., Biswal, S., Rajagopalan, S.: Environmental determinants of cardiovascular disease: lessons learned from air pollution. *Nat. Rev. Cardiol.* **17**, 656–672 (2020).
5. Yang, T.: Association between perceived environmental pollution and health among urban and rural residents-A Chinese national study, 14 January 2020, PREPRINT (Version 5) available at Research Square [<https://doi.org/10.21203/rs.2.12990/v5>].
6. Bender, M.G., Floeter, S.R., Hanazaki, N.: Do traditional fishers recognise reef fish species declines? Shifting environmental baselines in Eastern Brazil. *Fish. Manag. Ecol.* **20**, 58–67 (2013).
7. Zhu, J., Lu, C.: Air Quality, Pollution Perception, and Residents' Health: Evidence from China. *Toxics* **11**, (2023).
8. Nasreen, S.: Association between health expenditures, economic growth and environmental pollution: Long-run and causality analysis from Asian economies. *Int. J. Health Plann. Manage.* **36**, 925–944 (2021).
9. Yang, N., Liu, Z., Lin, Y., Yang, Y.: Does environmental regulation improve public health? Evidence from China's Two Control Zones policy. *Front. Public Heal.* **11**, (2023).
10. Gustiano, R., Prakoso, V.A., Ath-thar, M. H. F.: Asian Catfish Genus *Pangasius*: Diagnosis and Distribution. *Indones. Fish. Res. J.* **24**, 99 (2018).
11. Zain, Z., Hutabarat, S., Prayitno, S.B., Ambaryanto, A.: Potency of Mahakam Delta in East Kalimantan, Indonesia. *Int. J. Sci. Eng.* **6**, 126–130 (2014).

12. de Brye, B., Schellen, S., Sassi, M.G., Vermeulen, B., Kärnä, T., Deleersnijder, É., Hoitink, A.: Preliminary results of a finite-element, multi-scale model of the Mahakam Delta (Indonesia). *Ocean Dyn.* **61**, 1107–1120 (2011).
13. Jamaluddin, Wagreich, M., Gier, S., Schöpfer, K., Battu, D.P.: Sedimentary Environments and Paleoclimate Control of the Middle Miocene Balikpapan Group, Lower Kutai Basin (Indonesia): Implications for Evaluation of the Hydrocarbon Potential. *Minerals* **13**, (2023).
14. Hidayat, H., Teuling, A.J., Vermeulen, B., Taufik, M., Kastner, K., Geertsema, T.J., Bol, D. C.C., Hoekman, D.H., Haryani, G.S., Van Lanen, H.A.J., Delinom, R.M., Dijksema, R., Anshari, G.Z., Ningsih, N.S., Uijlenhoet, R. & Hoitink, A.J.F.: Hydrology of inland tropical lowlands: The Kapuas and Mahakam wetlands. *Hydrol. Earth Syst. Sci.* **21**, 2579–2594 (2017).
15. Rosmini, R., Zainuddin, Z., Aini, S. N.: Legal Protection of Mahakam Dolphins Through Water Conservation Areas in Kutai Kartanegara Regency. *Subst. Justice Int. J. Law* **5**, 1 (2022).
16. Ghitarina, G., Udayana, D., Pagoray, H.: Biodiversities and Abundance of Plankton and Benthos in Lake Jempang, West Kutai. *J. Wetl. Environ. Manag.* **6**, 6 (2019).
17. Sutapa, I.D.A., Nurhidayat, A., Prihatinningtyas, E.: Mahakam River Potency as Raw Water to Support Drinking Water Services and Sanitation in the New Territories of the State Capital, East Kalimantan. In: IOP Conf. Ser. Earth Environ. Sci. 1062, 12032 (2022).
18. Aisyah, Dharmadi, Nasution, S.H., Oktaviani, D., Hartoto, D.I.: Kondisi Kualitas Air Habitat Pesut Mahakam (*Orcaella brevirostris*). 47–53 (2008).
19. Ferdoushi, Z., Afrin, S., Gupta, N., Zafar, M.A., Ara Y., Rahman S. M. A. R.: Understanding the access to livelihood assets and fishers' perceptions towards local practice for wetland fisheries sustainability. *Egypt. J. Aquat. Biol. Fish.* **26**, 589–602 (2022).
20. Diaz-Reviriego, I., Fernández-Llamazares, Howard, P.L., Molina, J.L., Reyes-García, V.: Fishing in the Amazonian Forest: A Gendered Social Network Puzzle. *Soc. Nat. Resour.* **30**, 690–706 (2017).
21. Khan, M.I., Islam, M.M., Kundu, G.K., Akter, M. S.: Understanding the Livelihood Characteristics of the Migratory and Non-Migratory Fishers of the Padma River, Bangladesh. *J. Sci. Res.* **10**, 261–273 (2018).
22. Karimah, A., Susanti, H.: Gender Inequality in Education and Regional Economic Growth in Indonesia. *J. Ekon. Pembang.* **20**, 1–14 (2022).
23. Basuki, T.M., Indrawati, D.R., Nugroho, H.Y.S.H., Pramono, I.B., Setiawan, O., Nugroho, N.P., Nada, F.M.H., Nandini, R., Savitri, E., Adi, R.N., Purwanto, P., Sartohadi, J.: Water Pollution of Some Major Rivers in Indonesia: The Status, Institution, Regulation, and Recommendation for Its Mitigation. *Polish J. Environ. Stud.* **33**, 3515–3530 (2024).
24. Balabanič, D., Rupnik, M., Klemenčič, A.K.: Negative impact of endocrine-disrupting compounds on human reproductive health. *Reprod. Fertil. Dev.* **23**, 403–416 (2011).
25. Vallée, A., Ceccaldi, P.F., Carbonnel, M., Feki, A., Ayoubi, J.M.: Pollution and endometriosis: A deep dive into the environmental impacts on women's health. *BJOG An Int. J. Obstet. Gynaecol.* **131**, 401–414 (2024).
26. Novianto, S. A. R., Purwanto, B., Prasetyo, B.: Energy Adequacy, Body Composition, and Menstrual Cycle Disorder: A Correlation Study on Medical and Midwifery Students. *JUXTA J. Ilm. Mhs. Kedokt. Univ. Airlangga* **14**, 36–42 (2023).
27. Zhang, Y., Dudgeon, D., Cheng, D., Thoe, W., Fok, L., Wang, Z., Lee, H.W.J.: Impacts of land use and water quality on macroinvertebrate communities in the Pearl River drainage basin, China. *Hydrobiologia* **652**, 71–88 (2010).

28. Zaki, M.R.M., Zainuddin, A.H., Saifuddin, M.F.U., Razak, M.R., Isa, N.M., Ash'aari, Z. H., Aris, A.Z.: Microplastic Contamination and Ecological Risk Assessment in Tropical Riverine Surface Water of Selangor River Basin, Malaysia. *ACS ES T Water* **4**, 3225–3234 (2024).
29. Li, J., Meng, X., Zhang, Y., Li, J., Xia, L., Zheng, H.: Analysis of the temporal and spatial distribution of water quality in China's major river basins, and trends between 2005 and 2010. *Front. Earth Sci.* **9**, 463–472 (2015).
30. Castello, L., Macedo, M.N.: Large-scale degradation of Amazonian freshwater ecosystems. *Glob. Chang. Biol.* **22**, 990–1007 (2016).
31. Kahn, M. E., Li, P., Zhao, D.: Water pollution progress at borders: The role of changes in

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