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Review

A review of the active industrial area at Pasir Gudang area, Johore: Some notes and knowledge gaps

Chee Kong Yap[1,*], Nur Faradilla Mohd Sabri[1], Krishnan Kumar[2], Mohamad Saupi Ismail[3], Rosimah Nulit[1], Hideo Okamura[4], Yoshifumi Horie[4], Meng Chuan Ong[5,6], Ahmad Dwi Setyawan[7,8], Chee Wah Yap[9], Hishamudin Omar[1], Kennedy Aaron Aguol[10], Wan Hee Cheng[2], Chee Seng Leow[11]

[1] Department of Biology, Faculty of Science, Universiti Putra Malaysia, UPM Serdang, Serdang 43400, Malaysia
[2] Faculty of Health and Life Sciences, INTI International University, Persiaran Perdana BBN, Nilai 71800, Malaysia
[3] Fisheries Research Institute, Batu Maung, Pulau Pinang 11960, Malaysia
[4] Graduate School of Maritime Sciences, Faculty of Maritime Sciences, Kobe University, Kobe 658-0022, Japan
[5] Faculty of Science and Marine Environment, Universiti Malaysia Terengganu, Kuala Nerus 21030, Malaysia
[6] Ocean Pollution and Ecotoxicology (OPEC) Research Group, Universiti Malaysia Terengganu, Kuala Nerus 21030, Malaysia
[7] Department of Environmental Science, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret, Kota Surakart 57126, Indonesia
[8] Biodiversity Research Group, Universitas Sebelas Maret, Kota Surakart 57126, Indonesia
[9] MES SOLUTIONS, 22C-1, Jalan BK 5A/2A, Bandar Kinrara, Puchong 47100, Malaysia
[10] Centre for Promotion of Knowledge and Language Learning (CPKLL), Universiti Malaysia Sabah, Kota Kinabalu 88400, Malaysia
[11] Humanology Sdn Bhd, 73-3 Amber Business Plaza, Jalan Jelawat 1, Kuala Lumpur 56000, Malaysia
*** Corresponding author:** Chee Kong Yap, yapchee@upm.edu.my

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Abstract: This study aimed to examine the literature on Pasir Gudang, analyse the gathered material, and identify areas lacking knowledge. The literature research reveals that the published studies may be classified into hydrological, monitoring and forecasting, social, economic, and environmental issues. Nevertheless, the subjects of conservation, preservation, pollution recovery, and bioremediation, particularly environmental, social, and governance (ESG) concerns, have been of recent interest. Thus, these information gaps are strongly advised to be addressed in future research in and around the busy Pasir Gudang industrial sector.

Keywords: industrial area; Pasir Gudang; Johore

1. Introduction

The literature contains investigations conducted in Pasir Gudang [1–28]. The pollution in Pasir Gudang, mostly resulting from urbanisation, industrialization, and agricultural activities, has a substantial influence on the environment. The pollution has a dual impact, both on the water quality of the Kim Kim River and on the air pollution levels in the vicinity [29]. Water pollution in Pasir Gudang has had a significant surge and variety due to the rapid growth of its industry-driven economy [10]. Pasir Gudang is a crucial location for scientific research because of its extensive industrial operations and the considerable environmental consequences it generates [30,31]. The fast expansion, industry, and urbanisation of Pasir Gudang have led to significant worries over rainfall and pollution in the area [4]. Furthermore, the occurrence of illicit hazardous garbage in 2019 emphasised the susceptibility of Pasir Gudang to environmental contamination [4]. This can be supported by the recent observational research conducted in the Pasir Gudang area, namely in Sungai Kim Kim, Kg. Pasir Puteh, Kg. Kuala Masai, and Kg. Teluk Jawa, between the dates of 26th October and 26th November 2022 (**Figure 1**).

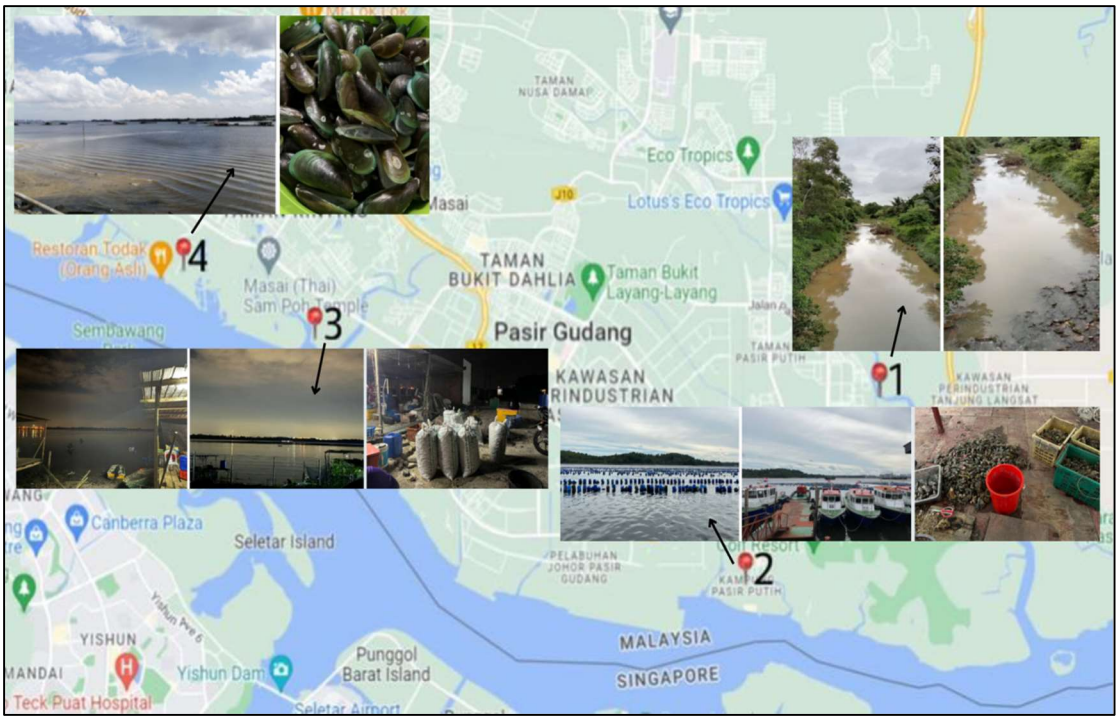

Figure 1. Observational activities around Pasir Gudang area at (1) Sungai Kim Kim, (2) Kg. Pasir Puteh, (3) Kg. Kuala Masai, and (4) Kg. Teluk Jawa from Google Maps (Accessed from 26th October 2022–26th November 2022).

The objective of this study was to review the publications on Pasir Gudang and to discuss the reviewed information, and to understand the knowledge gaps.

2. Methodology

Information relating to daily data on rainfall and water level was collected through reports from the official website of the Public Infobanjir (https://publicinfobanjir.water.gov.my/?lang=en; assessed between 21st October 2022 to 9th November 2022). For water quality data collection, the observation method captured situations in Sungai Kim Kim, Kg. Pasir Puteh, Kg. Kuala Masai, and Kg. Teluk Jawa. Model iPhone 13 was used throughout the observation process. In addition, local and international research was also represented. The terms "Sungai Kim Kim," "Kg. Pasir Puteh," "Kg. Kuala Masai," and "Kg. Teluk Jawa," "flood," "rainfall," and "water level" were used as keywords.

On 18 December 2023, 36 papers were reached using the Scopus database using the keywords' Pasir Gudang'. After checking the relevancy of the papers, only 28 papers were retained. Bibliometric analyses are an established method to evaluate research literature, particularly in scientific fields benefiting from computational data treatment and witnessing increased scholarly output [32]. VOSviewer is a software that generates a clear graphical representation of bibliometric maps, especially for extensive datasets [33]. To highlight the trends of studies conducted on the topic of 'Pasir Gudang', from 1983–2023 (on 29 papers from the Scopus database; **Table 1**), we performed a bibliometric analysis using the VOSviewer software (VOS stands for visualization of similarities—see www.vosviewer.com).

Table 1. Studies conducted on the topic of 'Pasir Gudang', from 1983–2023 based on the Scopus database.

No.	Authors	Title	Year	Source title	Volume	Issue
1	Lee JH et al. [1]	Water Distribution System Modelling in Pasir Gudang, Johor with EPANET	2023	Lecture Notes in Civil Engineering	293	-
2	Syed Mahdzar SS [2]	Streets for people: Sustaining accessible and sociable streets in Pasir Gudang City Centre	2013	2013 International Space Syntax Symposium	-	-
3	Sahrani FK et al. [3]	Isolation and identification of marine sulphate-reducing bacteria, Desulfovibrio sp. and Citrobacter freundii from Pasir Gudang, Malaysia	2008	Sains Malaysiana	37	4
4	Ibrahim MF et al. [4]	The impacts of illegal toxic waste dumping on children's health: A review and case study from Pasir Gudang, Malaysia	2021	International Journal of Environmental Research and Public Health	18	5
5	Ismail SNS et al. [5]	A case study of Pasir Gudang chemical toxic pollution: A review on health symptoms, psychological manifestation and biomarker assessment	2020	Malaysian Journal of Medicine and Health Sciences	16	-
6	Abdul Majid Z and Zain RB [6]	The dental health of factory workers in Pasir Gudang, Johor (Malaysia).	1988	Dental journal of Malaysia	10	1
7	Ahmad NA et al. [7]	A Community-Based Emergency Response Management in Pasir Gudang, Johor: Theoretical Framework	2020	IOP Conference Series: Materials Science and Engineering	808	1
8	Tajik E et al. [8]	Unhealthy diet practice and symptoms of stress and depression among adolescents in Pasir Gudang, Malaysia	2016	Obesity Research and Clinical Practice	10	2
9	Teh BT et al. [9]	Determinant factors of industrial symbiosis: Greening Pasir Gudang industrial park	2014	IOP Conference Series: Earth and Environmental Science	18	1
10	Desa MS M et al. [10]	Water Quality Assessment and Characterization of Rivers in Pasir Gudang, Johor via Multivariate Statistical Techniques	2023	Pertanika Journal of Science and Technology	31	1
11	Zulkifli SN et al. [11]	Analysis of bacterial contaminant in Pasir Gudang, Johor tap water supply–Varies pH value observation	2018	International Journal of Engineering, Transactions B: Applications	31	8
12	Mahat NA et al. [12]	Toxic metals in Perna viridis mussel and surface seawater in Pasir Gudang coastal area, Malaysia, and its health implications	2018	Environmental Science and Pollution Research	25	30
13	Rahman NH A et al. [13]	Univariate and multivariate short-term solar power forecasting of 25MWac Pasir Gudang utility-scale photovoltaic system using LSTM approach	2023	Energy Reports	9	-
14	Mohamad Nor Zaki NK and Ahmad Bari NA [14]	A Study on the indoor air quality (IAQ) at primary school in Industrial Area: A case study to Sekolah Kebangsaan Pasir Gudang 3(SKPG3)	2022	IOP Conference Series: Earth and Environmental Science	1067	1
15	Eric J [15]	Paka and Pasir Gudang: fast track combined cycles for Malaysian IPP	1996	Turbomachinery International	37	2
16	Misnan MF et al. [16]	Smart Sustainable Water Monitoring System via Internet of Things (IoT) for Water Retention Pond UiTM Cawangan Johor, Kampus Pasir Gudang	2022	International Journal of Sustainable Construction Engineering and Technology	13	-
17	Ahmad NA et al. [17]	Appropriate Community-Based Emergency Response Elements for Toxic Gas Release in Pasir Gudang, Johor	2022	Lecture Notes in Civil Engineering	214	-

Table 1. (*Continued*).

No.	Authors	Title	Year	Source title	Volume	Issue
18	Zakari MD et al. [18]	Mapping and detection of hotspot sources from industrial area heat (IAH) using aerial and satellite-based TIR data in Pasir Gudang	2023	International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives	48	-
19	Zulkifli NM et al. [19]	Performance of Several Statistical Methods in Forecasting Particulate Matter Concentrations in Pasir Gudang, Johor	2022	Studies in Systems, Decision and Control	444	-
20	Wan Ibrahim WY et al. [20]	Green space audits on its accessibility in Pasir Gudang	2013	Planning Malaysia	11	-
21	Latiff LA et al. [21]	Psychosocial problem and its associated factors among adolescents in the secondary schools in Pasir Gudang, Johor	2017	Malaysian Journal of Medicine and Health Sciences	13	1
22	Abas A and Din L [22]	Heavy Metal Concentration Assessment Using Transplanted Lichen Usnea Misaminensis at Pasir Gudang, Johor	2020	IOP Conference Series: Earth and Environmental Science	549	1
23	Ghafar AA et al. [23]	Comparison of leaf area index from four plant species on vertical greenery system in Pasir Gudang, Malaysia	2020	Pertanika Journal of Science and Technology	28	2
24	Thakar VS et al. [24]	Mathematical modelling of hydrothermal recirculation for Pasir Gudang Power Station, Malaysia	1983	Conference on Waste Heat Management and utilization. Miami Breach; USA, University of Miami; DA. 1981; PP. IV.A.51-IV.A.53		-
25	Siddique Md NI et al. [25]	Kinetic Modeling of Peroxydisulfate Pre-Treatment of Algae Slurry (Pasir Gudang, Malaysia) for Increasing Methane Generation from Anaerobic Digestion: Fertilizer Recovery	2022	Asian Journal of Chemistry	34	-
26	Yahya NYB et al. [26]	Preparedness towards Chemical, Biological, Radiological, Nuclear, and Explosive (CBRNE) threats among healthcare personnel in Pasir Gudang, Johor, Malaysia	2022	International Journal of Disaster Risk Reduction	82	-
27	Mohammad Z et al. [27]	Fundamental Study of Energy Control System Lockout and Tagout (LOTO) Implementation in Manufacturing Industry at Pasir Gudang, Johor	2019	Test Engineering and Management	81	-
28	Sabeen AH et al. [28]	Minimizing the cost of municipal solid waste management in Pasir Gudang Johor Malaysia	2016	Journal of Materials and Environmental Science	7	5
27	Abdullah et al. [29]	Incidents of Poisonous Gas Spreading in Pasir Gudang, Johor, Malaysia: Responsibilities, Roles and Social Impacts on Communities	2023	Resmilitaris	13	1

Scopus comprises many significant research papers and offers integrated analysis tools for creating informative visual representations [34]. VOSviewer was employed to analyze each keyword, calculating links, total link strengths, and co-occurrences with other keywords.

3. Results

From all the literature reviews [1–28], they covered the significant themes of hydrology [1,24], monitoring and forecasting [14,16,18,19], environment [4,5,10–

12,20–23,27], social [2,6–8,17,26], and economy [9,28]. The following discussion will be based on the above significant themes.

4. Discussion

4.1. Hydrological aspect

Lee et al. [1] presented a water supply distribution system for the Pasir Gudang area in Johor by using EPANET software. The water distribution network that is modelled with EPANET consists of 26 water tanks, 38 junctions, 65 pipes, and one water treatment plant. The total amount of Epanet computed water demand is 215,160 million litres per day, which is higher than the required water demand of 206,070 million litres per day. Therefore, there is no shortage of water to affect the Pasir Gudang area, according to their study.

Rainfall data is an essential component for mathematical models dealing with extreme hydrological events, including droughts and floods, and for the evaluation of surface and groundwater resources and their quality [35,36]. **Figure 2** shows rainfall variation in different sites.

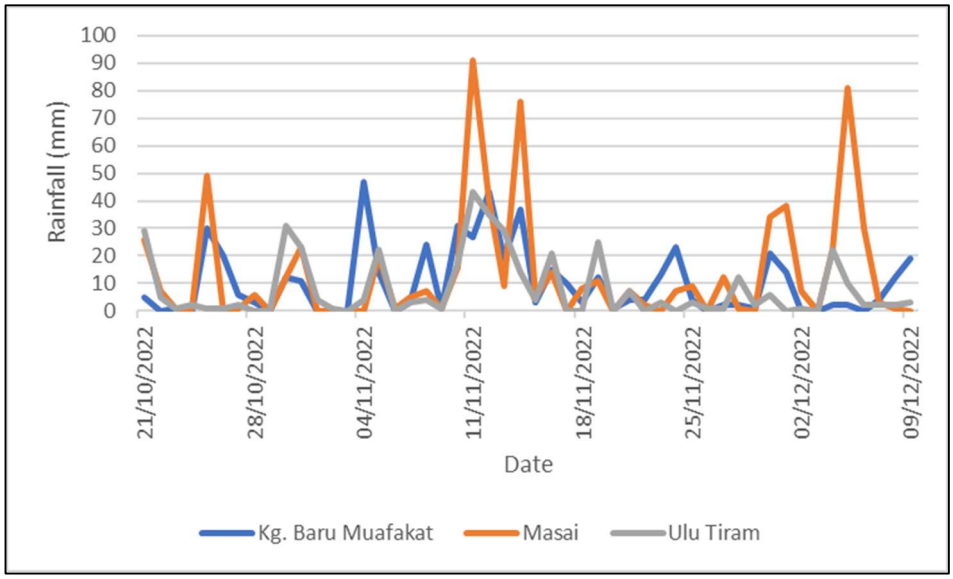

Figure 2. Rainfall variation from 21st October 2022 to 9th November 2022. Data cited from InfoBanjir (https://publicinfobanjir.water.gov.my/?lang=en; Accessed from 21st October 2022–9th November 2022).

From a social perspective, rainfall data helps humans decide how much water is needed for plants between rainfalls and know the best times for planting. Next, help identify weather patterns for the plan of outdoor activities. This can also help humans understand climate change and its effects on our environment. **Figures 3** and **4** show that the water level data is not significant for the sites. However, there could be an association between rainfall and water level data, namely that the water level increased along with an increase in rainfall data. More future studies are needed to understand groundwater flow systems, contributing to the preservation of river flow continuity.

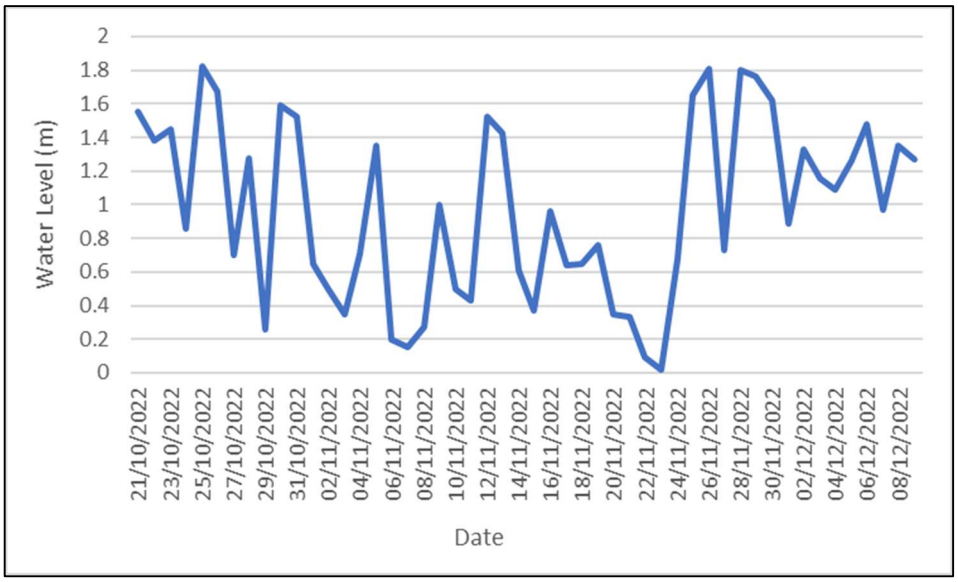

Figure 3. Water level variation in Sg. Tebrau, Kg. Sri Pandan from 21st October 2022 to 9th November 2022. Data cited from InfoBanjir (Accessed from 21st October 2022–9th November 2022).

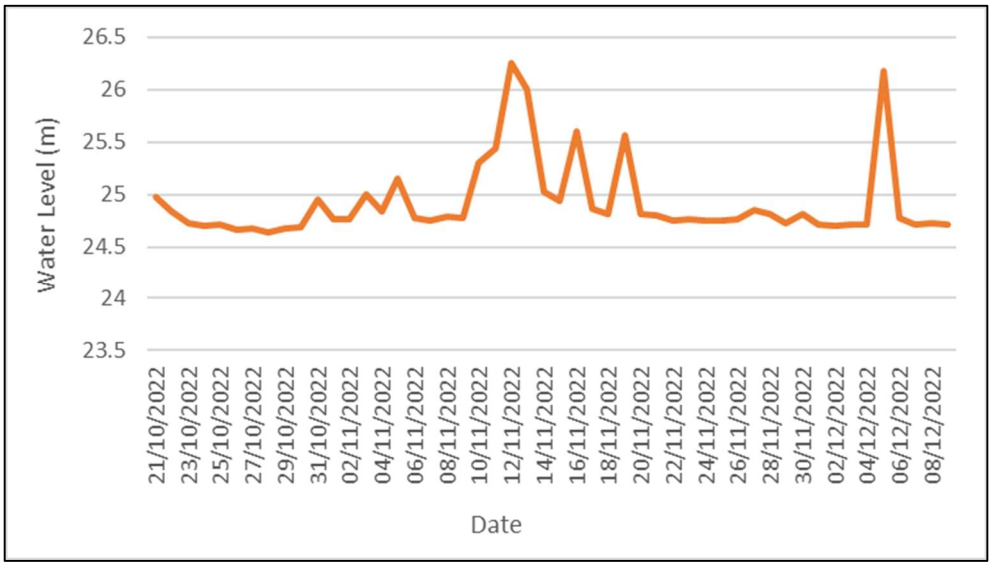

Figure 4. Water level variation in Sg. Tiram, Ulu Tiram from 21st October 2022 to 9th November 2022. Data cited from InfoBanjir (Accessed from 21st October 2022–9th November 2022).

4.2. Monitoring and forecasting

Previous studies have demonstrated that classrooms can contain significant quantities of air pollutants that may harm children's health and academic performance [14]. In Pasir Gudang, Johor Bahru's industrial district, Zaki and Bari [14] assessed a school's indoor air quality (IAQ). Formaldehyde (HCHO), TVOC, and PM were measured in the classroom. The classroom's physical characteristics were good, but the relative humidity was too high. On chemical contaminants, the classroom PM, HCHO, and TVOC concentrations are still within acceptable limits. The last proposals

emphasize correct design, construction, and maintenance to improve classroom interior quality.

Misnan et al. [16] built a sustainable water monitoring system with IoT technologies for UiTM Pasir Gudang to handle campus overflow. They discovered that their method allows anyone to check the water quality in that area from anywhere. Based on the characteristics of the characteristics of water data, the designed system monitors water parameters efficiently. Thus, early action can prevent environmental damage from bad intervention.

Zakari et al. [18] detected Pasir Gudang industrial area heat (IAH) automatically. The accuracy of IAH detection methods dominates. IAH represented 20% of the study' s cool and hot spots. The mean IAH rise was 34.7 ℃ to 58.5 ℃ between the most extreme cool- and hot-spot levels (LEVEL-3) for PG in the industrial region. Zulkifli et al. [19] tried to find the best statistical approach for predicting particulate matter concentration in Pasir Gudang, Johor. Modelling and forecasting daily maximum particulate matter concentrations uses Multiple Linear Regression, Principal Component Regression, and Time Series Analysis. Multiple Linear Regression anticipates future concentrations best, followed by Principal Component Regression, and the time series model least accurately.

4.3. Environmental and pollution aspects

Environmental contamination, accidents, and health concerns can result from improper handling of hazardous waste [4]. Ibrahim et al. [4] examined the health effects of illicit chemical dumping on children in Pasir Gudang, Malaysia. A real-world scenario where measurement of chemical contamination was impossible was used to determine the danger of health impacts. On 6 March 2019, tons of hazardous trash were illegally dumped into Kim Kim River, Pasir Gudang, Malaysia. Benzene, acrolein, acrylonitrile, hydrogen chloride, methane, toluene, xylene, ethylbenzene, and d-limonene were detected. Chemical contamination caused respiratory illness in 975 nearby students. They found that more effective rules and preventative measures are needed to safeguard human health, especially children, from inappropriate hazardous waste disposal.

Chemically hazardous contamination in the Pasir Gudang industrial area of Johor Malaysia was described by Ismail et al. [5]. It covered health symptoms, child psychology, and chemical detection using biomarkers and monitoring devices. Methods: They found seven substances associated with this incidence in their literature review: methane, hydrogen chloride, acrylonitrile, acrolein, benzene, xylene, and methyl mercaptan. These compounds are mostly produced industrially and break down quickly with other chemicals and sunshine. These compounds cause headaches, nausea, vomiting, breathing problems, eye discomfort, chest tightness, and wheezing when inhaled. They found that industrial chemicals can mix with other compounds or rays to release hazardous gases that cause acute health problems.

Desa et al. [10] evaluated and explained massively complicated data for 32 parameters from 25 sample stations across 20 rivers in Pasir Gudang, encompassing 1500 observations from 2015 to 2019. They found that multivariate methods can detect geographical water features and pollution sources. The findings of this study may help

Pasir Gudang lawmakers manage waterways. Zulkifli et al. [11] examined Pasir Gudang tap water samples' pH and temperature. The pH value was compared to the recommended 6.5–8.5 range for tap and drinking water. Within the pH and temperature ranges of 6.00 to 8.65 and 19.20 to 32.00 ℃, respectively, observed values vary significantly. Statistically significant differences exist in pH values between sample locations (4,145 = 44.79, <0.05). Most intriguingly, tap water samples near the industrial Pasir Gudang area had considerable pH and temperature impacts. According to Mahat et al. [12], a substantial ($p < 0.05$) and strong relationship ($r = 0.787$) between Pb content in P. viridis mussel and surface seawater suggests its potential use for inferring Pb concentrations. Since both the computed target hazard quotient and hazard index for Pb and Cd exceeded 1, eating P. viridis mussels from this rearing location may harm humans.

Ibrahim et al. [20] assessed Pasir Gudang Municipality's green spaces and promoted methods to enhance their utilisation to improve inhabitants' quality of life. Their study categorised Pasir Gudang's green spaces by size, purpose, usage, quality, area, accessibility, and facilities. Their analysis also indicated a possible access network that would make all green space locations more accessible to inhabitants, improving their quality of life. Abas and Din [22] used lichen transplanting to measure heavy metals in Pasir Gudang, Johor. Usnea misaminensis from the isolated National Park of Endau Rompin, Johor, has been transferred to the city. After 4–6 weeks after lichen transplanting, the greatest concentration of iron (Fe) was 84.43 μg/g, whereas the highest concentration of chromium (Cr) was 0.66 μg/g. Their findings revealed that Pasir Gudang's increased number of passenger automobiles will increase heavy metal pollution.

4.4. Social aspect

Latiff et al. [21] examined Pasir Gudang teenagers' depression, anxiety, and stress symptoms and causes. In Pasir Gudang, Johor, Malaysia, 10 secondary schools' students were sampled using cluster sampling in cross-sectional research. They found that teenage sadness, anxiety, and stress were impacted by sociodemographics and parents. Age, gender, and parental attachment were important predictors in the current study and should be the focus of future investigations to minimise psychiatric illnesses among Pasir Gudang adolescents. Syed Mahdzar [2] suggested design measures and implementations by relating social, socio-physical, and spatial (syntactical) factors to Pasir Gudang City Centre (PGCC) street behaviour and use. In November 1986, Abdul Majid and Zain [6] examined the oral health of 198 Antara Steel, Pasir Gudang, and Johor manufacturing workers. The sample included 107 smokers (54%), 41 of whom had significant nicotine stains (20.7%). A soft tissue examination revealed 111 (56%) recurring aphthous ulcers and 15 (7.6%) herpes labialis. Five participants (2.5%) had denture stomatitis, although other soft tissue infections were rare.

Ahmad et al. [7] sought to improve Pasir Gudang community emergency response by creating a theoretical framework. Their theoretical framework would help managers understand community-based emergency response and develop effective methods. Tajik et al. [8] examined eating habits, stress, and depression in teenagers in Pasir Gudang, Malaysia. Teens' bad eating habits affect mental health, according to

their results. Mental health should be improved by targeted education. Ahmad et al. [17] identified Pasir Gudang's community-based hazardous gas response components. The emergency response construct has a logit mean of 0.00 and a score mean of 3.67–5.00. This shows that major building elements are widely agreed upon. Yahya et al. [26] assessed Pasir Gudang healthcare workers' CBRNE crisis readiness. They suggested that CBRNE preparation measures would raise awareness forever. This study would allow management to assess the readiness of other important healthcare professionals or first responders and improve healthcare staff catastrophe service.

4.5. Economic aspect

The green industry has been seen as a crucial component in achieving enhanced sustainability [9]. The study by Teh et al. [9] aims to analyse the elements that influence the establishment of industrial symbiosis in different nations to facilitate the growth of such networks in Pasir Gudang. The results indicated that several factors, such as institutional framework, legal and regulatory systems, financial resources, awareness and capacity-building initiatives, technological advancements, research and development efforts, information availability, collaborative efforts, market conditions, geographical closeness, environmental concerns, and industry structure, together influence the establishment of industrial symbiosis.

Sabeen et al. [29] sought to ascertain the financial expenditure associated with solid waste management in Pasir Gudang, Johor, Malaysia. A one-year composition study was done in the Tanjung Langsat Landfill. The present municipal solid waste management was assessed to determine the transportation costs from different areas within the municipality to the Tanjung Langsat dump. Their suggested strategy could decrease solid waste management expenses from RM 7,130,884.00 to RM 6,093,872.00, resulting in a cost savings of RM 1,037,012.00, or a 14.5% annual cost reduction. This might potentially extend the longevity of the landfill in the studied location.

4.6. Knowledge gaps

This gives a holistic overview of the past research based on keywords' co-occurrences with 'Pasir Gudang' (**Figure 5**). The analysis reveals a discernible prominence reflecting three principal domains of investigation, namely three significant clusters that can be identified based on visualization in **Figure 5** (top panel): a) human-related studies; b) risk assessments, male and female-related studies, water quality, depression, and stress; c) adolescents' behaviors, adolescents' diseases, body weight, and body mass. Many researchers [1–28] have recently focused on studies such as water monitoring, dumping, children, acrolein, methane, slurry, large-scale solar, etc. (**Figure 5**; bottom panel).

However, topics on conservation, protection, or pollution recovery/bioremediation, mostly recently on environment, social, and governance (ESG), are not mentioned based on all the literature reviewed and visualized (**Figure 5**). Therefore, these could be the knowledge gaps for the near future studies when rivers near Pasir Gudang Industrial Area, such as Kim Kim River, have always been categorized as 'polluted' status since 1980 [12,29].

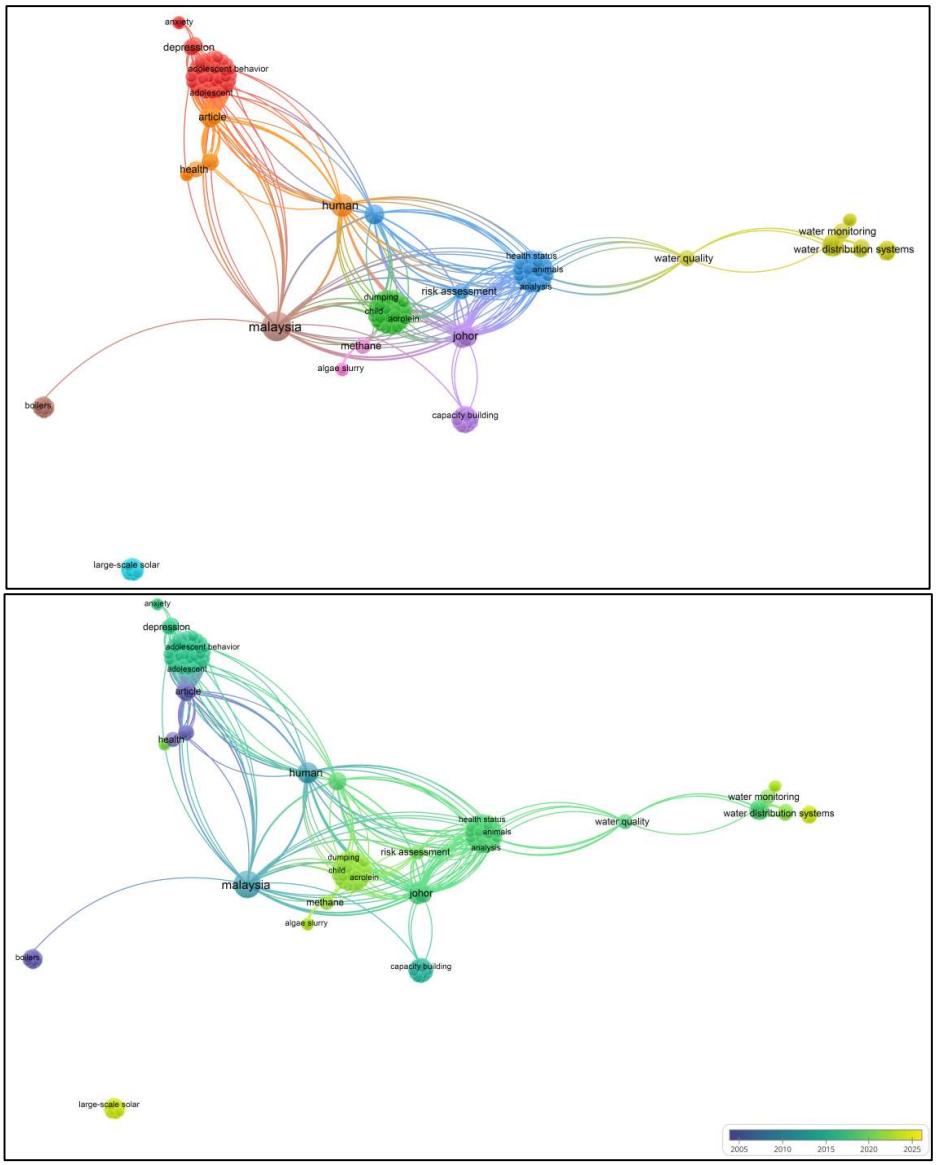

Figure 5. A bibliometric analysis of research themes on 'Pasir Gudang'. Top Panel: Visualization of the paper network confirming the main themes of research. Bottom Panel: Evolution of research trends between 1983 and 2023 based on Scopus database. The colours in the top panel indicate the themes of research that the papers are being discussed, while in the bottom panel the colours indicate the year of publication. N = 28 papers.

5. Conclusion

In sum, the present review identified that the published papers are mainly categorized into hydrology, monitoring and forecasting, social, economic, and environmental themes. However, topics on conservation, protection, or pollution recovery/ bioremediation, most recently on ESG. Therefore, these are considered knowledge gaps that are highly recommended in future studies at and around the active Pasir Gudang industrial area.

Conflict of interest: The authors declare no conflict of interest.

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