REVIEW OF MALAYSIA'S ENVIRONMENTAL WATERWAY COMPLIANCES WITH INDUSTRIAL EFFLUENT DISCHARGE

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ABSTRACT

It is necessary to continuously monitor industrial wastewater discharges to maintain a clean and healthy environment in waterways. There is an increase in the number of industries in Malaysia and a significant increase in polluted and slightly polluted rivers. As a result, this article describes the concept and categorisation of industrial effluent compliance. It considers the urgent need to improve Malaysia's river water quality and the contribution of the industrial sector to river water pollution. The overarching aim is to identify the rating assessment of industrial effluent compliance discussed in the literature, and to investigate the compliance status of industries in Malaysia. It is necessary to continuously monitor industrial wastewater discharges to maintain a clean and healthy environment in waterways. There is an increase in the number of industries in Malaysia and a significant increase in polluted and slightly polluted rivers. As a result, this study describes the concept and categorisation of industrial effluent compliance. It considers the urgent need to improve Malaysia's river water quality and the contribution of the industrial sector to river water pollution.

This paper presents the argument on the critical issues of industry compliance and river pollution, with a focus on Industrial Effluent Regulation 2009. As part of this review, readers will understand the various concepts of rating assessments used to measure compliance with industrial effluent discharges. In this paper, the author seeks to identify the themes discussed in the literature concerning measuring compliance. A discussion of alternative compliance rating assessments based on research findings and document review. There were four themes identified in the literature research related to compliance with industrial effluent discharge: policy, testing/laboratory requirements, consent requirements and regulatory standard. As part of the compliance monitoring process, community empowerment, regulatory, plant operations, environmental audits, and environmental risk and emergency planning, are often covered in papers.

Keywords: River water quality, compliance, Malaysian industries, river pollution

INTRODUCTION

An organization’s ability to create an enterprise-wide data strategy allows the consolidation of regulatory reporting requirements, and the integration of all data from various business areas is a fundamental component of compliance (Vikas S Shah, 2016). How do we choose the right relative rating assessments to measure compliance? A typical method for industrial effluent discharge involves analysing the water quality of the final discharge and comparing it with the appropriate standard limit of concentration limit in the regulation. However, this frequently provides information of non-compliance that is too late, and by the time accredited lab findings are received, most of the discharged effluent has already entered the waterway.

One way to eradicate this is to control pollution at the source because the sources are regularly monitored. However, despite the increase in industries, the number of regulatory officers is not sufficient to ensure compliance and inspections are conducted on all premises. Water quality degradation in major urban rivers is becoming a major concern in many countries because of point and non-point sources (Aftab et al., 2017; Xia et al., 2017). Numerous factors contribute to this, including rapid urbanisation, population growth, and booming industries, which result in policies and infrastructure failing to combat water pollution (Rene et al., 2018; Vidyarthi et al., 2020). Consequently, compliance rating assessments beyond adherence to regulations are essential for Malaysia to become a globally competitive country.

Water quality must satisfy a certain standard because river water is an essential asset for humans and serves various purposes such as drinking water, hygiene, aquaculture fostering, farming, and energy creation (Khullar & Singh, 2021). Water is the main basic resource for human survival and environmental biodiversity. Water quality has been affected by water pollution, which is clearly an over-aching issue (Shamsuddin et al., 2022). Numerous instances of water pollution caused by industrial discharges have resulted in the closing of Malaysian water treatment facilities, causing water disruptions for account users (Lee Goi, 2020). Understanding the connection between an increase in the number of industries, river water quality, and reflection on industry compliance with a rise in pollution cases can help us better justify the inclusiveness when compliance assessment being carried out, and consequently, will have a significant effect on lowering the pollution of waterways. In light of this, the main objectives of this study are i) to examine the literature regarding industrial effluent compliance, ii) to determine how industries discharge industrial effluent into waterways to comply with regulatory requirements, and iii) to understand the relationship between industrial pollution and river water quality. By providing an understanding of the compliance practices of the industry, this paper will contribute to a better management of industrial effluents. It has become increasingly important for Malaysia as it progresses from a developing country to a developed country to comply beyond the regulations and practice environmental sustainability for better environmental waterways.

For Peninsular Malaysia, a monitoring programme was initiated in 1978 by the Department of Environment (DOE). The Islands Monitoring Program was implemented in 1998 after the program's subsequent expansion in the states of Sabah and Sarawak in 1985.(*Environmental Data Center – Department of Environment*, n.d.). Comprehensive and sustainable river basin management faces significant challenges due to river degradation and loss of ecosystem services caused by pollution and deforestation. Approximately two-thirds of Malaysia's rivers have lost ecosystem services because they are classified as polluted or slightly polluted (Khalid et al., 2018). Hence, it is important to investigate what is causing this and how we can manage our river to preserve its natural elements.

Because systematic reviews are thorough, reproducible, and precise in their results reporting, they were chosen for this study. This enables actual progress monitoring (Siddaway et al., 2019). To the best of the author's knowledge, there is currently no systematic review of the compliance analysis of industries that discharge effluent into waterways in Malaysia. Ariffin & Sulaiman discussed managing sewage pollution in Malaysian rivers and its challenges, but they did not address the industrial effluent sourced from industries that discharge their effluents into the rivers (Ariffin & Sulaiman, 2015). Iloms et al. investigated the impact of industrial effluent discharges toward municipal wastewater treatment plants in Vaal, South Africa (Iloms et al., 2020); hence, the importance of this study as to date, no current systematic review has been conducted in Malaysia to investigate the correlation of compliance of industrial effluent discharges with river water quality.

As part of the analysis conducted are by reviewing previous studies on industrial effluent discharge and compliance themes, industry compliance measurement, Sustainable Development Goals (SDG), methods of studies, and compliance-related contents were examined (legal, community empowerment, operation, system implementation, risk and emergency planning, and environmental audit). The results are summarised in Table 1.

Table 1: Summary of the review of studies on the application of compliance themes for industrial effluent discharges

Aim/Objectives	Industries Compliance Measurement			SDG			Methods			Relative Contents					
	Final Discharge	Load Estimates	River Condition	Water Quality	Climate Change	Sustainable Management	Surveys	Documents Review	Semistructured Interviews	Legal Compliance	Community Empowerment	Compliance Operations	System Implementation	Risk and Emergency Plan	Environmental Audit
Assessing the discharge limit/standard (37)	e, g, u	i, m, n	a, b, c, h, j	a, c, e, g, n, p	b, d	a, h, t, v		e, h	a, h	e, q	a, h	f, o, r	h	b	u
Centralized Industrial Treatment Plant (2)			m	w											
Policy related to water pollution (21)	c, d, h	n	c	d, t	h	d, u, v		f	h, q	c, d, e	h	q, u	t		
Maximum pollutants entering the waterbody (8)	i, j	m	j	j, m		n			p						
Comparative loading with concentration discharge limit (9)	i, j			h, s		j				s		p, m	o		
Regulation and acts to control water pollution (16)	c, e, f, j		q	g, j, q		j, q, t			q	g, q	h				r

a. (Hegarty et al., 2021)
b. (Isahak et al., 2018)

c. (Afroz et al., 2014)
d. (Papadimitriou et al., 2020)
e. (Lee Goi, 2020)
f. (Chia, 2019)
g. (Fitri et al., 2020)
h. (Toriman et al., 2012)
i. (Ying, 2020)
j. (Osmi et al., 2016)
k. (Afroz & Rahman, 2014)
l. (Loi et al., 2022)
m. (Che Osmi et al., 2018)
n. (Adnan et al., 2022)
o. (Khullar & Singh, 2021)
p. (Shamsuddin et al., 2022)
q. (Khalid et al., 2018)
r. (Xu et al., 2022)
s. (Taghipour et al., 2019)
t. (Bai et al., 2021)
u. (Yessenamanova et al., 2022)
v. (Mustapha et al., 2017)
w. (Al Hadidi & Al Hadidi, 2021)

Table 1 summarizes the common themes found in the literature for monitoring compliance with discharge limits in terms of final effluent quality, load estimates, and river conditions. Among the Sustainable Development Goals that are often discussed are water quality, climate change, and sustainable management. Document review and semi-structured interviews were used to cover the content of legal compliance, community empowerment, compliance operations, system implementation, risk and emergency plans, and environmental auditing.

According to the analysis of the literature objectives covered, the majority of papers address the assessment of discharge and limit standards (37), followed by policy related to water pollution (21), regulation and acts to control water pollution (16), comparison loading with concentration discharge limits (9), maximum pollutants entering water bodies (8), and centralized industrial treatment plants (2). Effluent standards are established through concentration limits specified in regulations, which are the primary means of eradicating water pollution. It is possible to address pollutant concentrations in receiving waters by adjusting discharge permits in an adaptive manner using loading estimation to balance environmental gains.

RIVER WATER QUALITY IN MALAYSIA: CONCEPT AND CLASSIFICATION

The river water quality monitoring programme has been implemented by the Malaysia Department of Environment (DOE) since March 1978. This programme assesses the condition of the water, spot changes, and pinpoints the cause of river pollution. The river water quality monitoring initiative has been running since 1978 at 503 stations throughout Peninsula Malaysia. Up until 2016, there were 891 river monitoring sites across the country. In 2017, the DOE river water quality monitoring station network was improved under the Environmental Quality Monitoring Program (EQMP) and consists of 1353 manual monitoring stations and another 30 automatic stations that monitor the desired 672 rivers in Malaysia. The network of automatic stations monitoring observe data for 13 parameters every 30 min and operates throughout the year. This station monitors the status of river water quality for the water treatment plant located 2–5 km downstream of the station. The distribution of the locations of the river quality monitoring stations is shown in Figure 1.

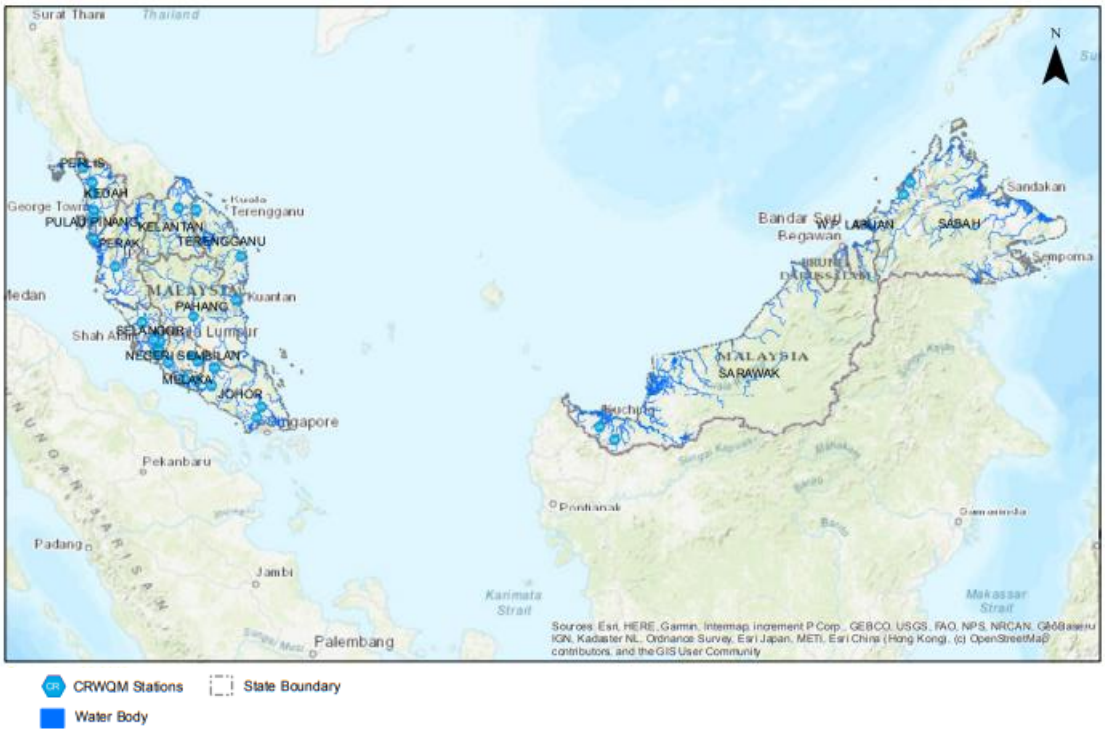

Figure 1: Distribution of locations of river water quality monitoring automatic stations in Malaysia

The manual monitoring stations perform sampling 6 times a year and analyse the river water to produce data for 35 parameters each time sampling (*Environmental Data Center – Department of Environment*, n.d.). The statistics for the Malaysian river water quality from 2011 to 2022 are shown in Figure 2.

Based on the Environmental Quality Report (EQR) of the Department of Environment, Malaysia, the number of rivers classified as 'Clean' increased from 73% in 2021 to 74% in 2022. Increasing clean river percentages starting in 2017 could also be attributed to more rivers being monitored; however, the number of slightly polluted and polluted rivers remains significant. In addition, the number of rivers classified as 'polluted' has increased from 23 rivers in 2021 to 29 in 2022, representing a 26% increase. As specified in Table 2, the Water Quality Index (WQI) displays statistics about water quality on a scale of 1 to 100, with higher numbers reflecting higher quality. A standard justified in Table 2 will be used to determine the quality of the river's water. The river will be classified as clean, slightly polluted, or polluted. These are the three main parameters used in the DOE Water Quality Index Reporting.

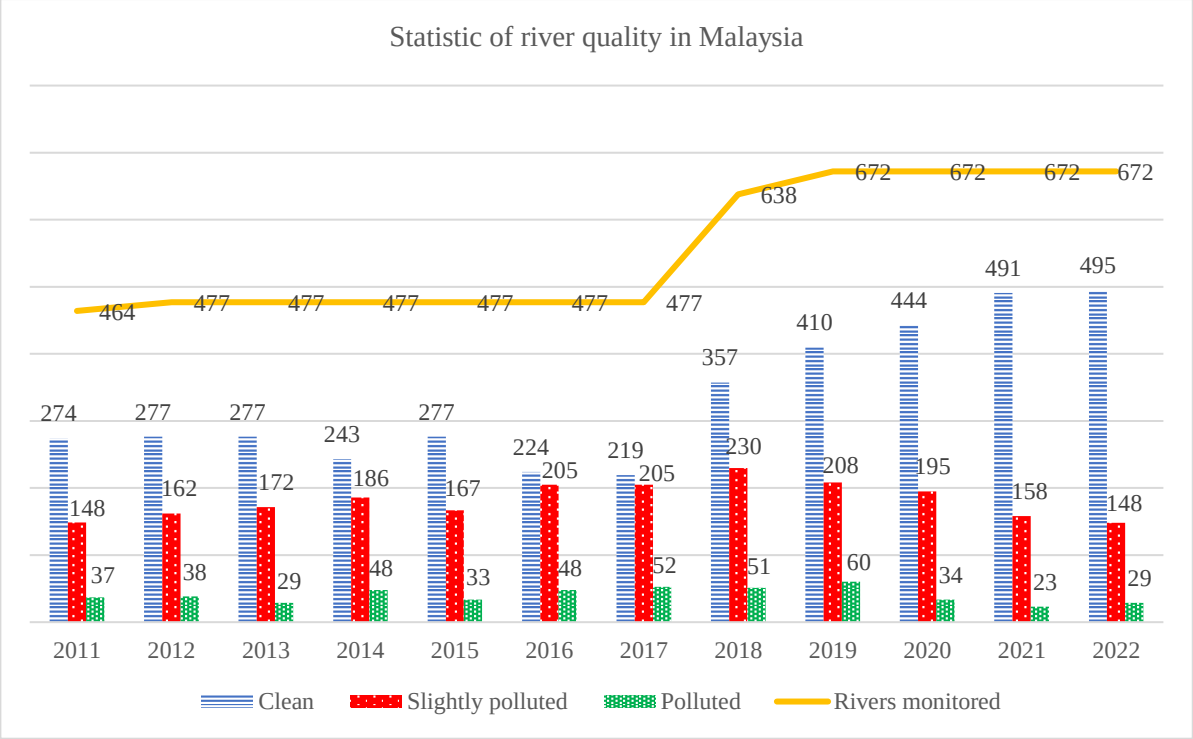

Figure 2: Statistics of river quality in Malaysia

Based on the statistical water quality trend based on Biochemical Oxygen Demand (BOD), Ammoniacal Nitrogen (NH_3-N), and Suspended Solids (SS) Sub-Index from 2017 to 2022 in Table 3, an elevated levels of Biochemical Oxygen Demand (BOD) affects 18 rivers, and Suspended Solids (SS) affect 16 rivers, from the total monitoring stations. It is also important to note that, from Figure 2, the number of polluted and slightly polluted rivers is still high at 177 in 2022.

Indicators such as BOD, AN, and SS are used to assess water quality since they are closely associated with pollution caused by pollution loads discharged from either point sources or non-point sources (Rodríguez-Jeangros et al., 2018). The continuous discharge of industrial effluents is associated with high BOD levels. Animal husbandry and household sewage are causing AN, while uncontrolled land clearing and improper earthwork activities are causing SS to spike.

Table 2: National Water Quality Standards in Malaysia

Sub Index & Water Quality Index	Unit	Index Range		
		Clean	Slightly Polluted	Polluted
Biochemical Oxygen Demand (BOD)	mg/l	91-100	80-90	0-79
Ammoniacal Nitrogen (NH3-N)	mg/l	92-100	71-91	0-70
Suspended Solids (SS)	mg/l	76-100	70-75	0-69
Water Quality Index (WQI)		81-100	60-80	0-59

Table 3: Malaysian river water quality trends based on BOD, AN, and SS Sub-Index from 2017 to 2022

BOD sub-index (2017 - 2022)				
Year	Clean	Slightly Polluted	Polluted	**Total**
2017	**98**	**654**	**598**	**1350**
2018	**218**	**607**	**528**	**1353**
2019	**216**	**597**	**540**	**1353**
2020	**718**	**462**	**173**	**1353**
2021	**1049**	**175**	**127**	**1351**
2022	**1060**	**148**	**145**	**1353**

AN Sub-Index (2017 2022)

Year	Clean	Slightly Polluted	Polluted	**Total**
2017	**98**	**654**	**598**	**1350**
2018	**218**	**607**	**528**	**1353**
2019	**216**	**597**	**540**	**1353**
2020	**718**	**462**	**173**	**1353**
2021	**685**	**175**	**398**	**1351**
2022	**641**	**323**	**389**	**1353**

SS Sub-Index (2017 - 2022)

Year	Clean	Slightly Polluted	Polluted	**Total**
2017	**743**	**67**	**540**	**1350**
2018	**746**	**158**	**449**	**1353**
2019	**837**	**158**	**358**	**1353**
2020	**850**	**150**	**353**	**1353**
2021	**1037**	**123**	**191**	**1351**
2022	**1028**	**118**	**207**	**1353**

Data obtained from: The Marine and Water Division, Malaysian Department of Environment, Putrajaya on December 4, 2023

There are 74 parameters in the National Water Quality Standard (NWQS) that will be monitored triennially by concession appointed by DOE so further conclusions can be drawn for any disturbances in the waterways. NWQS monitored to understand the beneficial use of the river and has also considered the dilution factor of the river, which is why it is giving data at a higher ambient level. On the other hand, under the Industrial Effluent Regulation 2009, Standard A and Standard B limits provide a snapshot of the discharge effluent concentration at a given time. These limits must always be adhered to by industries. Therefore, improving industry compliance will improve water quality (Fitri et al., 2020; Hegarty et al., 2021; Lee Goi, 2020). Monitoring effluent levels is imperative for ensuring compliance with environmental regulations (Osmi et al., 2016; Ying, 2020). Corrective action should be taken if necessary. Compliance with the regulations should also be monitored regularly through audits (Xu et al., 2022; Yessenamanova et al., 2022) and proper compliance rating assessments. As a final note, wastewater treatment technology should be invested in by industries as a means of reducing environmental pollution.

The classification according to Class I, IIA/IIB, III, IV, and V will then be justified in accordance with the mathematical model to obtain the final index value. In WQI computation, several parameters are selected, sub-index values are generated, parameter weights are generated, and index aggregation techniques are selected, and no universally acceptable approach exists. A comparison of this final index with the WQI range determines the water quality class (Shamsuddin et al., 2022).

INDUSTRIAL POLLUTION IN MALAYSIAN WATERWAYS

Rivers and streams in a watershed are known to experience stress from development activities such as industrialisation (Whelan et al., 2022), agricultural (Hughes et al., 2020) and urbanisation (Luo et al., 2020). These activities cause pollutants runoff (Santy et al., 2020) such as pesticides and heavy metals such as chromium and arsenic (Briffa et al., 2020) wastewater treatment plants discharged effluent and the release of raw wastewater or sullage from residential regions (Woodward et al., 2021).

In Malaysia, the number of industries has progressing exponentially over the years. Statistically from 2011 until 2022, the exponentially progressing number of industries can be viewed in Figure 3:

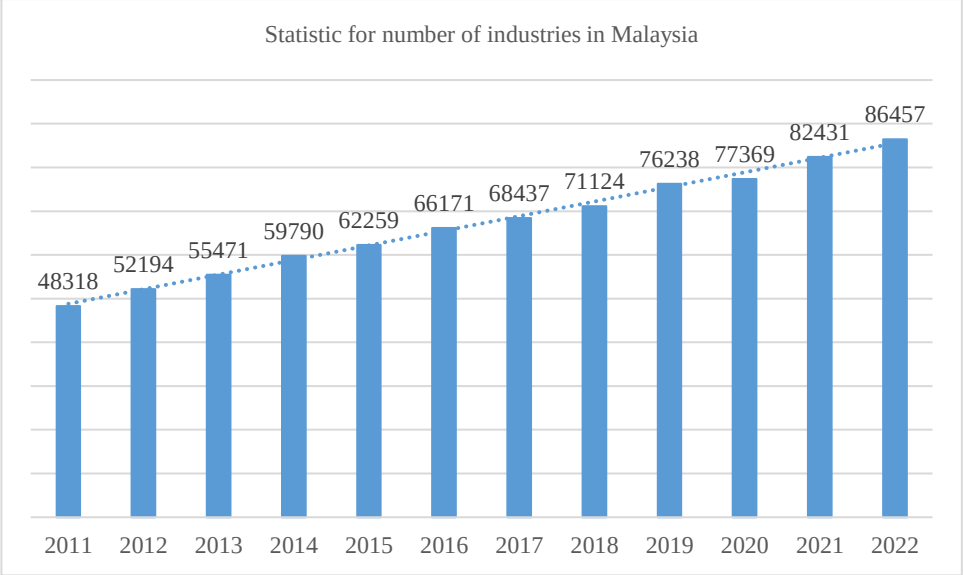

Figure 3: Statistic number of industries in Malaysia

This is indeed a challenge for a country like Malaysia. With an increasing number of industries, there will be more effluent generated and discharged into waterways. Statistically, in 2022, from 86457 number of industries, 63361 are in operation and a total of 3611 are producing industrial effluent discharge. Due to intensification of economic activities such as land use change for urban, industrial, domestic sewage, population growth, the level of pollution of many rivers in Malaysia might be significantly increased (Fitri et al., 2020).

For last year, from the Department of Environment Malaysia inspection data of 32 types of industrial sectors for the year 2021, the percentage of non-compliance of these industries is tabulated in Table 3. Compliance with three main regulations, namely, *Industrial Effluent Regulation 2009 (IER 2009), Clean Air Regulation 2014 (CAR 2014)* and *Scheduled Waste Regulation 2005 (SW 2005)* is being observed. From the total compliance, none of the industrial sectors had 0% non-compliance for the particular year. However, it is in the interest of this research on river pollution from industrial discharge, hence the data for *IER 2009* will be monitored. Only three industrial sectors have 0% non-compliance with *IER 2009*: agriculture, sports game & equipment, and workshop.

Table 4: Percentage of Non-Compliance by Industries

Nu	SECTOR	NUMBER OF INSPECTIONS	% OF NON-COMPLIANCE			
			IER 2009	*CAR 2014*	*SW 2005*	TOTAL
1	Metal Finishing and Electroplating	186	20%	8%	29%	40%
2	Metal Fabrication	412	5%	7%	34%	36%
3	Paper	322	15%	6%	25%	33%
4	Animal Husbandry	32	16%	9%	9%	31%
5	Metal Manufacturing	1084	7%	13%	26%	31%
6	Plastic	950	9%	12%	20%	30%
7	Agriculture	204	0%	0%	30%	30%
8	Leather	14	14%	7%	29%	29%
9	Non-Metallic Minerals	247	13%	11%	21%	28%
10	Cement	192	4%	14%	17%	27%
11	Refinement of Edible Oil	152	13%	9%	10%	27%
12	Machinery	145	3%	1%	27%	27%
13	Power Plant	134	17%	5%	9%	27%
14	Textile	195	14%	3%	16%	26%
15	Foods and beverages	1337	18%	6%	10%	26%
16	Office Equipment and Stationery	27	22%	4%	11%	26%
17	Printing	322	6%	3%	22%	25%
18	Chemical Industry	898	6%	5%	20%	24%
19	Rubber Based	560	10%	7%	15%	22%
20	Livestock Food	95	2%	12%	16%	22%
21	Vehicle	297	2%	2%	22%	22%
22	Water Treatment Plant	177	13%	5%	16%	21%
23	Umbrella Manufacturing and Others	213	2%	8%	18%	21%
24	Quarry	305	1%	6%	17%	21%
25	Sports Equipment and Games	5	0%	0%	20%	20%
26	Workshop	1863	0%	2%	20%	20%

Nu	SECTOR	NUMBER OF INSPECTIONS	% OF NON-COMPLIANCE			
			IER 2009	*CAR 2014*	*SW 2005*	TOTAL
27	Petroleum Refining	139	10%	6%	12%	19%
28	Wood Based	1079	1%	12%	10%	18%
29	Warehouse	268	1%	3%	16%	17%
30	Electric and Electronic	822	4%	4%	16%	17%
31	Rice Mill	115	3%	13%	2%	17%
32	Medicine	802	1%	1%	14%	15%

- *Data obtained from the Industrial Compliance Section, Enforcement Division, Department of Environment, Putrajaya, Malaysia on 15th October 2022*

This draws a great understanding of the requirement to closely monitor the pollution impact from point sources, i.e., from industries. This can come in the forms of compliance status. Hence, the big question is how can compliance be monitored apart from abiding by the laws and regulations, and what are the rating assesments in measuring compliance of industries towards industrial effluent discharge? For an environment strategy to provide a competitive advantage, Kapsis suggested that it must be future-oriented and go beyond adherence to regulations (Kapsis, 2020).

We can see in Table 4 that the number of inspections conducted in 2021 was relatively low (21% of the total in operation industries). Increasing the number of officers can take several years or decades since it requires revision of policies and budget allocations. A higher number of inspection visits may not always be beneficial for regulatory effectiveness since a risk-focused and risk-proportionate approach involving engagement, guidance, responsive enforcement, and targeted inspections may result in better results. Comprehending the complexity of factors and processes that influence compliance is essential (Blanc, 2018). Consequently, it is essential that the compliance concept incorporates activities other than managing discharges in industries, such as sampling and sending to accredited laboratories. A large amount of effluent will have already entered the waterways by the time the laboratory results are released. The management and computation of compliance must also take into account non-inspected premises. The compliance ratings must, however, be calculated based on reliable assessments of compliance.

Compliance with industrial effluent regulations can be achieved through a combination of statistical sampling strategies, regulatory approaches based on risk, continuous monitoring of effluent, and strategies such as self-reporting and targeted inspections, and computation of alternative compliance rating assessments. By employing these strategies, industrial effluents can be managed efficiently and sustainably.

As stated in the *Environment Quality Act 1974*, pollution includes direct or indirect alteration of any quality of the environment or any part of it. Pollution could reduce the beneficiary's use or impose danger towards the safety and health of people, animals, or the environment or any discharge of pollutants over the standard limit stated in the act. There are two sources of river polluters as shown in Figure 4. Point sources are industries that consist of prescribed and non-prescribed premises. There are several types of prescribed premises, such as palm oil mills, raw natural rubber, and licenced premises under Section 18 of the Act, such as plants that recycle and recover scheduled wastes. It is mandatory for them to have a licence for the prescribed use and occupancy of the premises. To observe compliance with industrial effluent discharges, these premises must be inspected. Non-point sources include agricultural activities and surface runoff, which do not have specific release points. Because some of these establishments operate without a licence, measuring compliance can be difficult. In any case, local governments will handle these issues according to their specific laws and regulations. Industrial effluent discharges from point sources will be the focus for this research.

COMPLIANCE: ELUSIVE CONCEPT

Measurement of discharge compliance from industries is usually done towards abiding by certain legislations and regulations pertaining to standards and classification (Endlay et al., 2022). Imposing fines for cases of non-compliances(Shi et al., 2022) are an efficient way to get polluters to comply since penalties dissuade them from repeat offences (Haque, 2018); however, is that the only way to warrant industry compliance and how do we measure compliance?

Hence, this paper aims to investigate what does compliance of industrial effluent discharged mentioned in the literature. To refine the scope of the review and select the data sources, search strategies were employed. The Selection criteria included papers that clearly contributed and had valid study and data (Snyder, 2019). Figure 5 illustrates the components of the systematic review used in this study.

During analysis to formulate preliminary inclusion exclusion criteria in the literature review, the author used four keywords in the Scopus review. According to the author's analysis of 153 journals on compliance of industrial effluent discharge dated from 1975 to 2022, the striking themes of compliance can be grouped into compliance to regulatory standards, policy, consent condition, and testing and laboratory requirement. This can be further explained by Figure 6.

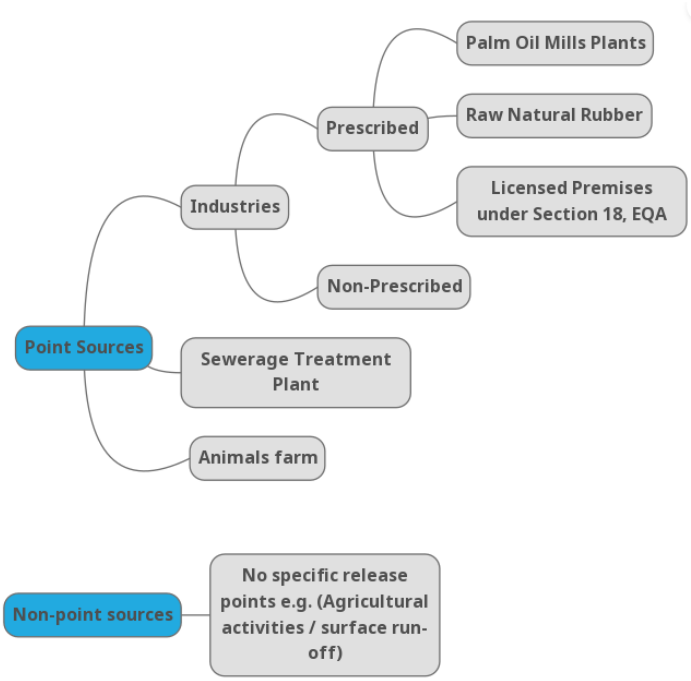

Figure 4: Industries that discharge effluents into waterways in Malaysia

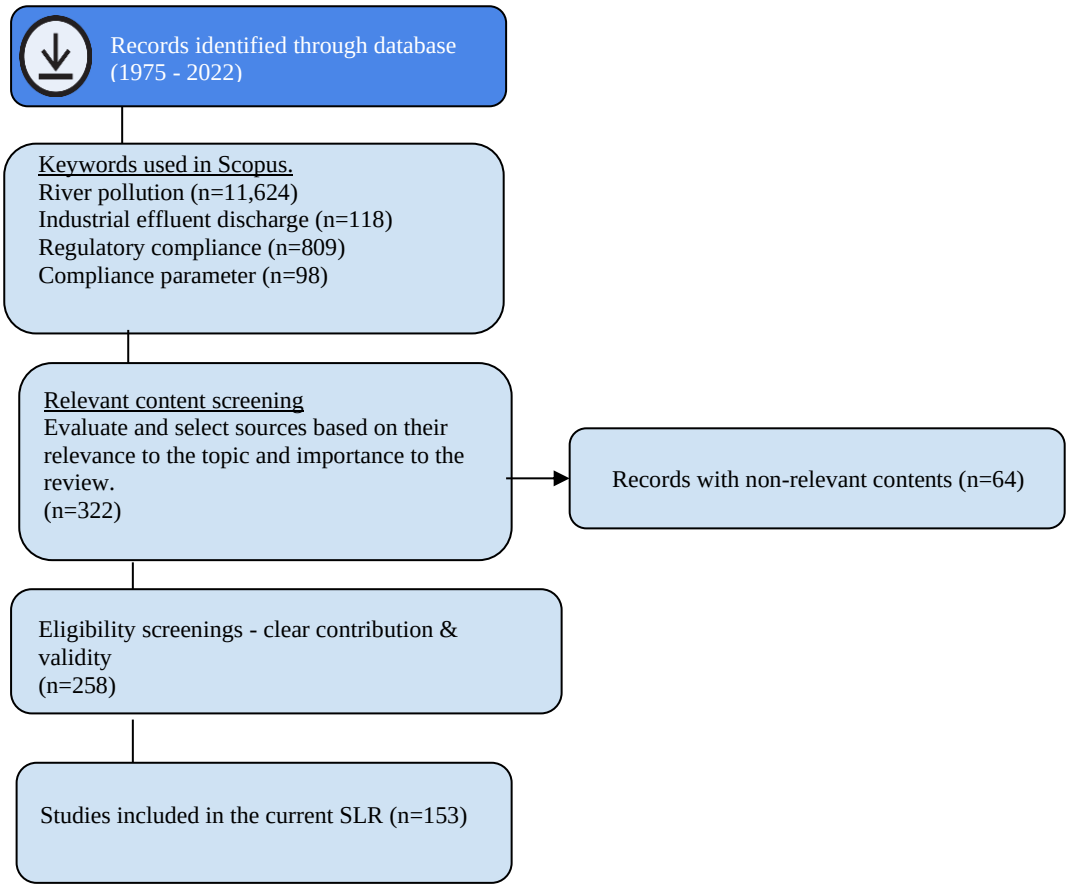

Figure 5: Flowchart of the literature review adopted in the study

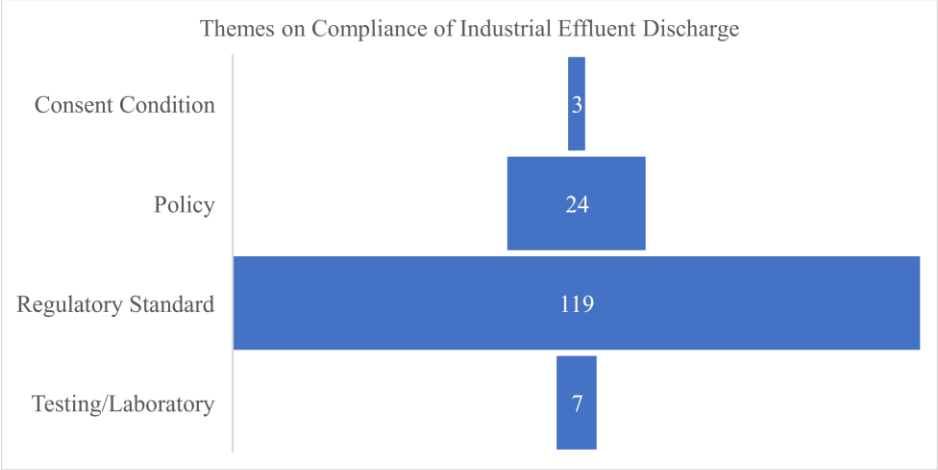

Figure 6: Themes on compliance of effluent discharge in the literature review

From the four themes under compliance with industrial effluent discharge, we conducted further analysis on any parameter of compliance discussed in the paper that is included in the systematic literature review. *Plant operations* are often monitored by field measurements at prescribed intervals to ensure compliance with discharge limit and standards (Chia, 2019; Khullar & Singh, 2021; Xu et al., 2022). Developing social capital enhances the ability to access outside resources (Hegarty et al., 2021; Toriman et al., 2012) which is essential to sustainable *community development*; hence, community empowerment is also important in ensuring compliance of industries. Risk-based management and approach have also been discussed in assessing the discharge standards of industrial effluent (Caldwell et al., 2016; Karman & Smit, 2019; Toriman et al., 2012) thus enlarging the focus on the need to assess *environmental risk and emergency plans* to measure compliance. Requirement on *regulatory* is the main observation when measuring compliance (Fitri et al., 2020; Khalid et al., 2018). The United States Environmental Protection Agency (EPA) discovered that to comply with the standards, conventional administrative and judicial enforcement methods are not always adequate as part of developing compliance strategies for environmental statutes. This problem has been addressed by the EPA by exploring *environmental auditing* as a solution to promote increased compliance by regulated communities (Shamsadini et al., 2022).

INDUSTRIAL EFFLUENT DISCHARGE COMPLIANCE WITH LEGISLATION

When it comes to measuring industrial effluent compliance and environmental quality, for example, externality issues are not adequately addressed by industries, which implies that government regulation can at least be beneficial(Ju et al., 2020). There are many regulations on abiding by the standards of discharge, particularly into inland water in Malaysia, and relevant agencies that oversee the compliance. One of the Acts that that monitored and enforced by the Department of Environment Malaysia, is the *Environmental Quality Act, 1974* (Abdul Rahman, 2021).

There are many times we see failure of compliance from industries towards these regulations, which is translated into court cases and penalties. For the year 2021, according to the Department of Environment Malaysia annual report, we can further acknowledge this as a source of compliance report for the particular year. Although monitoring programmes and enforcement activities have been carried out regularly, river pollution persists, and this is being translated into the number of court vases and fines incurred in the Environmental Criminal Court for the year of 2021, as shown in Figure 7.

In total, 64 (23.9%) court cases involved the *Industrial Effluent Regulations 2009* with a total fine of RM1,305,000, while 159 (59.32%) involved other *Environmental Quality Act, 1974* violations. This shows the perceived need to look into industrial effluent compliance to understand the main contributing factors to non-compliance and to further analyse what the industry understands about compliance. The highest number of court cases for *Industrial Effluent regulation 2009* showed that this is one of the most contributors to environmental criminal cases, hence the validity of this study.

To better understand how experiences, knowledge, and perceived requirements relate to environmental compliance in Malaysian industries, statistics from the six years with the lowest compliance records in those industries were gathered. To do that, this study suggests that a focus on the legal framework to understand how Malaysian industries are regulated to prevent the pollution of rivers and to develop rating parameters that can be used for measuring environmental compliance of industrial effluent discharge in view the of main stakeholders in Malaysia is required.

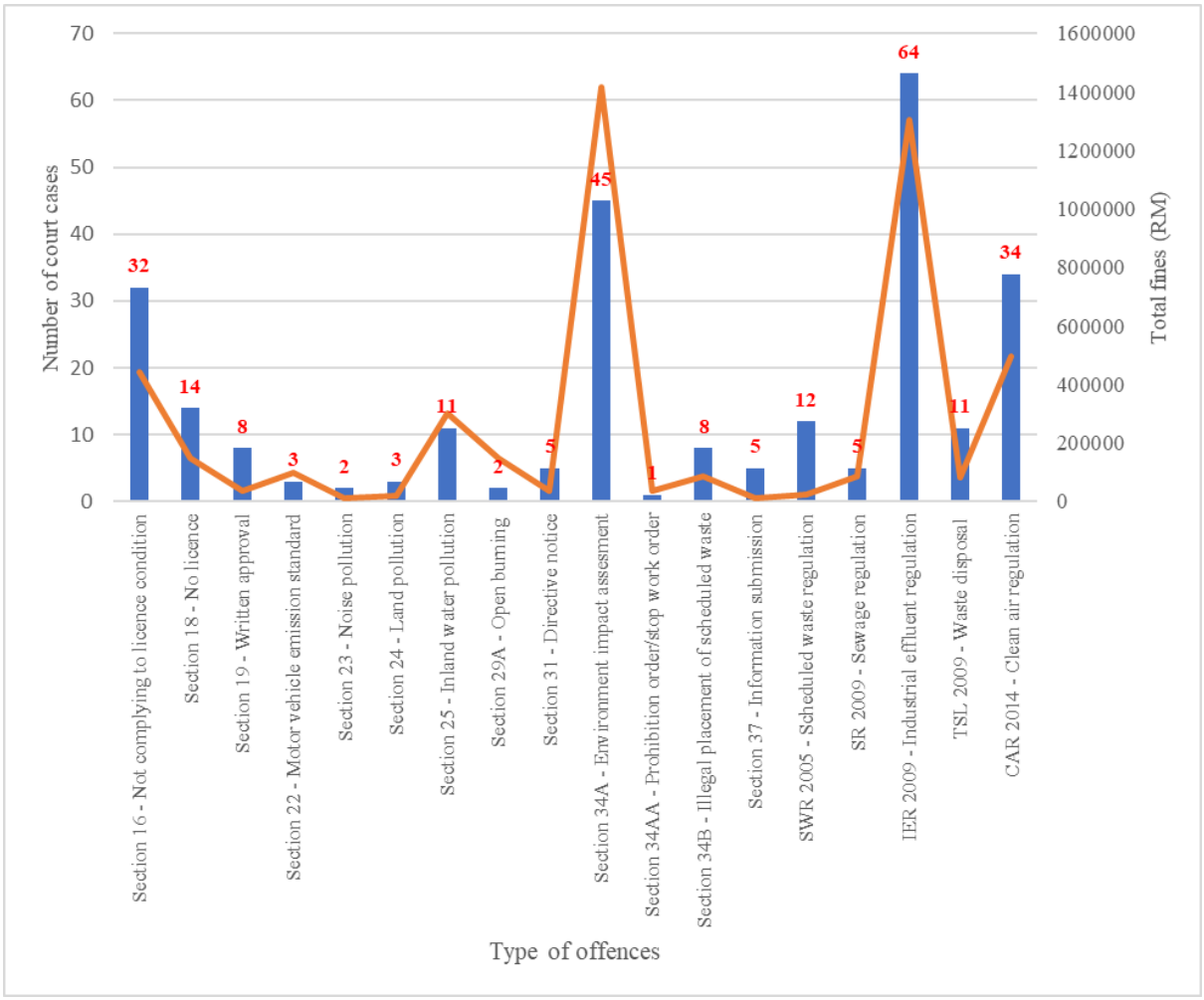

Figure 7: The Department of Environment, Malaysia's court cases and fines of industries in 2021 showed that the most cases of non-compliant are under Industrial Effluent Regulation

From data in Table 4, the statistics of eight most non-compliance industrial sectors in Malaysia for seven consecutive years (2016 to 2022) are computed. From Table 4, when the data are averaged throughout seven years span, metal manufacturing except machinery type of industry, is the most non-compliance industry with 59% average percentage followed by manufacture of base metal with 68%, manufacture of rubber and plastic and manufacture of other non-metallic mineral products both at 69%, manufacture of paper and paper products 71%, food products manufacturing 76%, manufacture of chemicals and chemical product with 78%, and lastly manufacture of coke and refine petroleum product 83%.

It is important to understand the perspectives of industries with low compliance records regarding the challenges they face in complying with current legislation, the acceptance of alternative rating assessments, and the disparity between experiences, knowledge, and perceived requirements regarding environmental compliance in Malaysian industries. This necessitates stakeholder engagement in subsequent research with industrial sectors that are experiencing difficulties managing their environmental compliance.

Stakeholder participation is essential to ensuring success, synthesizing evidence of what works, and where, and providing key benefits and challenges (Haddaway et al., 2017). Stakeholder participation is a key measure for addressing legitimacy deficits and non-compliance in sustainable governance (Birnbaum, 2016). Industry sectors is one of the main stakeholders in industrial effluent management. Therefore, understanding what challenges industries experience, and how to cope with these challenges is crucial to enhancing the quality of environmental decisions. Stakeholder participation and engagement should be ongoing to ensure environmental policy success. It is imperative to be sure that all industries play a meaningful role in the decision-making process and that their feedback is considered. Finally, it is critical to assess the effectiveness of the policy to ensure it achieves its objectives.

Table 4: Malaysian industries with the highest percentage of non-compliance with industrial effluent discharges

Type of Industry	2016	2017	2018	2019	2020	2021	2022	Average
Food products manufacturing	87%	77%	75%	68%	76%	73%	73%	76%
Manufacture of base metal	70%	75%	72%	63%	62%	69%	68%	68%
Manufacture of chemicals and chemical product	80%	82%	79%	76%	84%	76%	71%	78%
Manufacture of coke and refine petroleum product	74%	91%	87%	79%	92%	81%	77%	83%
Manufacture of paper and paper products	80%	72%	74%	65%	61%	67%	75%	71%
Manufacture of rubber and plastic	75%	63%	69%	64%	74%	70%	65%	69%
Manufacture of other non-metallic mineral products	67%	76%	80%	68%	68%	72%	54%	69%
Metal manufacturing except Machinery	59%	52%	70%	55%	64%	60%	56%	59%

- *Data obtained from the Industrial Compliance Section, Enforcement Division, Department of Environment, Putrajaya, Malaysia on 4th December 2023*

CONCLUSIONS AND RECOMMENDATIONS

This study performed an analysis of the literature and collected a substantial body of information on the compliance reports of several industrial sectors in Malaysia. From the literature review conducted for this study, it was found that there are four themes under compliance with industrial effluent discharge in the literature: regulatory standards, policy, testing/laboratory conditions, and consent conditions. Rating assessments that are often discussed in papers used to monitor compliance include plant operation, community empowerment, environmental risk and emergency plan, regulatory, and environmental audits. Industry compliance is often viewed from a legislative viewpoint. However, as Malaysia strives to become a competitive nation, compliance should be measured beyond legislation. Introducing alternative rating assessments to measure compliance is one way to ensure compliance inclusivity and cleaner environmental waterways.

As industries in Malaysia are increasing and have also impacted river water quality, improving industry compliance can ensure better environmental waterways. According to statistics on industry compliance and environmental cases under the *Industrial Effluent Regulation 2009*, and river water quality, industries that discharge industrial effluent should improve compliance.The implementation of proper waste management systems and compliance beyond regulations will improve river water quality from industrial activities.

Alternative rating assessments should be examined in the context of the main stakeholders to ensure that they are acceptable. This study also substantiated the types of industries with low compliance rates over the past seven years. To comply with industrial effluent discharge requirements, it is necessary to understand and investigate the challenges faced by these industries. An examination of industrial effluent compliance is necessary to determine the primary causes of non-compliance.

Accordingly, this study concludes that a strategy promoting experimentation and cooperation among businesses, the government, and environmentalists would have the greatest impact on Malaysia's ability to maintain a thriving economy and achieve clean water. This can be accomplished by involving stakeholders in alternative rating assessments for industrial effluent discharge compliance measurements. By doing so, we hope to raise awareness among Malaysian industries that discharge effluent into environmental waterways and enhance their compliance with applicable regulations.

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