

Illegal Toxic Waste Dumping

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Poor management of hazardous waste can lead to environmental pollution, injuries, and adverse health risks. Children's exposure to hazardous waste may cause serious acute and chronic health problems due to their higher vulnerability to the toxic effects of chemicals.

Keywords: environmental exposure ; environmental pollution

1. Introduction

Poor hazardous waste management has become a serious issue in developing countries ^{[1][2][3]}. Most cities in those nations are rapidly industrializing, leading to a greater generation of hazardous waste ^{[4][5]}. There are inadequacies in the implementation of regulations related to hazardous waste treatment and final disposal of hazardous materials, which have posed significant risks to the environment, ecology, and human health ^{[6][7][8]}. The impacts of illegal waste dumping vary depending on the scale, source, and waste characteristics ^[9]. Among the factors that have influenced the hazardous waste management practice in developing countries are disposal technological capability, supervision and enforcement, waste management policy, and compliance from the corporate companies ^{[10][11]}.

Waste management has been a long-standing issue in Malaysia ^{[12][13]}. One of the main challenges in waste management is managing the scheduled waste that involves collection, transportation, treatments, and disposal of the scheduled waste ^[14]. The Environmental Quality (Scheduled Wastes) Regulations 2005 (amendment 1989) defined scheduled wastes as any waste falling within the categories of waste listed in the First Schedule, which includes 77 scheduled waste code categories ^[15]. Some categories of waste in the Schedule are classified as hazardous waste due to their toxicity and hazardous characteristics ^[16]. Since 1995, Kualiti Alam Sdn Bhd, a privately owned company, has been given exclusive rights and responsibilities to integrate the collection, treatments, and disposal of scheduled waste in Malaysia ^[17]. Despite having regulations and establishment of the hazardous waste management policies, the event of illegal dumping of hazardous waste has occurred sporadically in the country ^{[18][19]}.

The Department of Environment (DOE) under The Ministry of Environmental and Water is the responsible agency to ensure the industry's compliance with the environmental protection rules and regulations. However, several obstacles present challenges to the implementation of scheduled waste regulations. A study by Khoo et al. ^[20] found that manufacturing industries in the state of Malacca generally had poor compliance to all the three occupational and environmental health-related laws in Malaysia, which are the Occupational Safety and Health Act (OSHA) 1994, Environmental Quality Act 1974 (Act 127) and Guided Self-Regulation Environmental Mainstream Tools (EMT). In 2004, metal hydroxide sludge from Taiwan was illegally imported and stored at Simpang Renggam, Johor ^[21]. Another similar incident was in Segamat, Johor that caused the evacuation of 300 villagers from their homes after 300 tons of toxic waste was buried at an illegal dumpsite, emitting ammonia fumes ^[22]. In 2019, Malaysia was shocked by an incident of chemical poisoning in Pasir Gudang that caused thousands of people to feel sick after being exposed to a mixture of chemicals illegally dumped into the Kim Kim River, Pasir Gudang, Malaysia ^{[23][24][25][26]}. Although there are many studies involving incidents of illegal waste disposal that have been documented ^{[18][19][20][25][26]}, to date, no studies have examined the health impact of improper disposal of hazardous waste on children in Malaysia.

The objective of this study is to identify and estimate the potential health risks to children associated with poor hazardous waste management based on a case study in Pasir Gudang, Malaysia. Health risk assessment of a chemical incident on children is generally conducted by evaluation and quantification of contaminants for children ^{[27][28][29]}. However, this approach is not always possible in a real crisis or disaster ^[30]. Hence, this study introduced a risk assessment based on a real case scenario relating to environmental contamination of chemical compounds and the analysis of its possible health-related effects to children. The findings will serve as an important reference to researchers and policy makers in improving policies on environmental protection and public health.

2. Study Area

Malaysia is experiencing a rapid economy development and continuous improvement in living standards. Malaysia's economy is the most competitive economy among the developing countries in Asia. It ranked 25th out of 140 economies in the global index [31]. The growth of the economy and population is posing a burden on the environment due to greenhouse gases emission, environmental degradation, and waste generation, just to name a few. According to the UN environment report [32], Malaysia generated about 1,600,000 tons of all classes of hazardous waste per year, the third among Association Of Southeast Asian Nations (ASEAN) countries behind Thailand and Philippines, which generated about 3,300,000 and 1,700,000 tons per year, respectively. The manufacturing sector in Malaysia is the leading sector generating toxic and hazardous waste [33]. As waste generation is expected to rise with the population growth and economic development, Malaysia is likely to experience an increase in hazardous waste generation.

Pasir Gudang is a significant industrial and port city in Malaysia [34]. It is located at the southwestern part of Johor Bahru district, Johor, Malaysia (Figure 1). Established in 1918, Pasir Gudang was formerly a fishing village that was then transformed into a rubber estate during the British rule in Malaya. Subsequently, the area was further developed by the Johor State Government into residential and industrial areas [35]. In the present day, Pasir Gudang has developed into a port and industrial town. The main economic activities include transportation and logistics, palm oil storage, manufacturing of electronic goods, and other heavy industries such as petrochemicals and shipbuilding [36][37][38]. It has two ports, namely Johor Port and Tanjung Langsat Port, which are among the busiest ports in Malaysia.



Figure 1. Location of Pasir Gudang.

Residents of Pasir Gudang are prone to environmental pollution due to its rapid development and industrialization. Prior to the incident of illegal toxic waste in 2019, the environment in Pasir Gudang specifically and areas around the Johor Straits in general were exposed to pollutants resulting from anthropogenic activities [26][39]. The 15 km-long Kim Kim River, running from the Masai sub-district and flowing southward in Pasir Gudang into the Straits of Johor, is considered one of the most polluted rivers in Johor Bahru [40][41]. Keshavarzifard et al. [40] discovered a high level concentration of total polycyclic aromatic hydrocarbons (PAHs) on the surface of the Kim Kim River, which may increase the risk of developing cancer.

3. Respiratory Diseases

This study found that most of the children who were taken to hospitals were due to shortness of breath. Studies on environmental exposure largely found a relationship with respiratory symptoms and complications [42][43]. Exposure to benzene has been associated with increased risk of respiratory symptoms in children including wheezing and shortness of breath [44]. Children exposed to $1 \mu\text{g}/\text{m}^3$ higher levels of benzene and formaldehyde had a higher odds ratio (OR) of having rhinitis (OR 1.03, 95% confidence interval (CI) 1.01–1.06), exacerbation of bronchial asthma (OR 1.05, 95% CI 1.01–1.10) and dry cough (OR 1.05, 95% CI 1.01–1.10) [42]. Epidemiological studies on the long-term effects due to inhalation of acrolein and acrylamide have not been identified. However, animal and in vitro human airway tissue model studies showing exposure to acrolein and acrylamide were linked to oxidative stress [45][46][47] and inflammation response

[48], which led to increased mucus secretions, edema of the bronchial wall, bronchoconstriction, and tissue damage [49]. Hence, this chemical reaction indicated the possibility of children suffering from respiratory symptoms due to exposure to high concentrations of toxic chemicals from the illegal waste dumping site in the Kim Kim River incident.

In terms of the magnitude of disaster, the Pasir Gudang chemical incident was less severe in comparison to the infamous Bhopal disaster that occurred in 1984, whereby 40 tons of methyl isocyanate gas was released following an industrial-related accident [50]. While no human casualties were reported in Pasir Gudang, the Bhopal disaster had resulted in a loss of 10,000 lives within a few days of the occurrence [51]. Another example of a chemical incident that affected respiratory health occurred in 2013 when an ammonia leak incident was reported from a chemical plant located in Rouen, northwest France [52][53]. This chemical leak recorded no fatalities; however, the released chemical had wafted across the English Channel into England, resulting in a transboundary pollution in England. In the situation of the Pasir Gudang incident, there was no transboundary chemical pollution reported.

4. Cancer

From the result of this study, the risk of developing cancer resulting from the exposure of chemical agents in the Kim-Kim River incident needs further investigation. However, a few studies have investigated the relationship between exposure to benzene and other volatile organic compounds (VOCs) [54][55]. Benzene exposure during childhood was associated with acute lymphocytic leukemia and acute myeloid leukemia of relative risk (RR) 1.0 (95% CI: 0.6–1.7) and RR 1.9 (95% CI: 0.3–11.1) [55]. In general, VOCs can be found around the Pasir Gudang area due to industrial activities such as ship washing activities, and petrochemical and plastic production [56]. As such, poor management of industrial hazardous waste may result in an increase in the risk of developing cancer to the surrounding population.

5. Mental Health

Exposure to traumatic events either, experiencing or witnessing a harmful situation, poses a threat to an individual's or population's mental health. Such events may include, among others, natural disaster, motor vehicle accident, physical injury, and exposure to hazardous material. Approximately 10% of children who were exposed to such events will develop post-traumatic stress disorder (PTSD) [57]. Children with PTSD may experience intrusive memories, avoidance, negative changes in thinking and mood, and changes in physical and emotional reactions. Even though children are generally exposed to the same spectrum of stressors with adults, they are more vulnerable because their emotions and cognition are still immature, they have limited life experience and they lack in coping strategies. Although PTSD was not reported among children following the events in Pasir Gudang, they are at risk of developing PTSD as the onset may develop between 3–12 months post-traumatic event [58].

6. Limitations

There are several limitations in this study that need to be highlighted. First, this study did not obtain the victims' biological markers and level of ambient air chemical concentration, due to data confidentiality. Hence, the findings from this research must be interpreted cautiously. Secondly, this study included only children (6–17 years old) from the five affected schools. In reality, there were more children exposed to the hazardous chemical, but due to limitations, it was not possible to measure the whole population of children affected. Therefore, caution should be taken with generalizing the findings to the wider population. Finally, this study only assessed limited numbers of hazardous chemicals involved in the incident. Future research should consider including substantial environmental emissions associated with respiratory diseases among children. The incident in Pasir Gudang may be aggravated by the industrial activities in the area that have now reached saturation level [59].

7. Policy Implication

The pollution in Pasir Gudang is an example of the failure to learn from past incidents that had occurred in Johor specifically and other places in the country in general [18][19][21][22]. Past experience on similar incidences should be translated into preventive measures as scientific evidence has shown that pollution incidents in the Straits of Johor and Johor's rivers had been documented and is a repeated occurrence [60][61][62][63][64]. That scientific evidence is important and should be utilized by the relevant enforcement agencies in their effort to improve the quality of services and preventive measures. While the findings of this review may be inconclusive, it indicates that preventive measures are necessary to protect the public's health from the outcome of an improper hazardous waste disposal. Therefore, this study suggests several recommendations to be considered for future environmental and public health policy makers. First, the health risk assessment framework may be used to identify risks and possible health impacts related to environmental

issues. Findings of the health risk assessment may guide policy makers in making environmental policies to improve the situation in the country. Secondly, public health officers should implement the health risk assessment in high-risk areas such as Pasir Gudang to identify vulnerable populations for public health risk management and risk mitigation strategies. Thirdly, all parties should comply with existing environmental laws and regulations, such as the Environmental Quality Act 1974 (Act 127) [65]. Hazardous waste must be disposed of in designated facilities and should not be discarded into the environment such as rivers and landfills. Finally, collaboration between universities, industries and policy makers should be nurtured with the aim of discovering sustainable solutions to complex environmental, health, social, and economic challenges.

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