Original Article

Control Banding for Chemical Health Risk Assessment (CHRA) Conducted at Quarry Industries.

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ABSTRACT: *Quarrying activities have tendency to generate a number of safety, health and environment issues. An assessment of the adverse health effects should be done properly in managing risk at the industry. However, current CHRA assessment varies from one organization to other organizations, depending on assessor's own perspective. Therefore, this study evaluates the findings of CHRA report from various quarry organizations, aiming to compare an existing method with control banding method in conducting CHRA at quarry industries. A control banding method is used to analyze the chemicals involved in CHRA reports and further compared the control measure findings with the result of CHRA method done by assessors. It was found that there are inconsistency of hazard rating and control measure assessed by the assessors. Based on the findings, the control banding is proposed to be used by the CHRA assessors at quarry industries. This control banding approach is simpler and comprehensive in controlling the chemical hazard as compared to the CHRA method. The level of adequacy of control in the studied quarries was observed at moderate level which was around 35.1%. The employers and employees shall have the responsibility to prevent the adverse effects of chemical exposure by practicing a healthy and safe work culture at workplace.*

Keywords: *Chemical Health Risk Assessment, Control Banding, Control Measures, Health Risk Assessment; Quarry*

1.0 INTRODUCTION

The use of chemicals is widespread throughout the world to meet various aspects of human life. Chemicals can be found in variety of forms namely liquids, gases and solids. In Malaysia, the uses of chemicals in any industries need to comply with act and regulations under the Occupational Safety and Health Act 1994 and Factories and Machinery Act 1967. According to Occupational Safety and Health (Use and Standards of Exposure of Chemicals Hazardous to Health) Regulations 2000 (USECHH Regulations), chemicals are defined as elements, compounds or mixture whether natural or synthetic (DOSH, 2000).

The operation of the quarry often uses chemicals that are hazardous to health in their activities. Each chemical could give hazardous effect to the human health depending on the type of chemicals. The classification of hazardous effects are varies such as corrosive, toxic, flammable, explosive, radioactive or reactive. According to the International Labour Organization(ILO, 2013), one worker dies from a work related accident or disease in every 15 seconds, and 151 workers have work-related accident in every 15 seconds Quarrying industry has often been termed as particularly 'unhealthy industry' due to the high number of accidents, injuries, illnesses and fatalities (Smallwood J.J and Haupt T.C., 2000). Apart from that, quarrying also has been reported as one of the most dangerous industries to work due to its contributions toward the number of accidents (HSE, 2018b; Okafor,

2006). HSE UK website has reported that since 2000, around 3500 workers have suffered an injury and 31 of those being fatal.

In 2017, around 242 quarries registered their activities with the Department of Occupational Safety and Health Malaysia (DOSH, 2017). All of them are actively operated up to now. Under the USECHH Regulations 2000, it is requirement for quarry operators to perform the chemical health risk assessments (CHRA). This assessment should cover the chemicals that are produced, processed, used, stored, transported, disposed and treated at the quarry site.

A CHRA assessor is responsible to carry out the assessment at quarry industry. However, current CHRA assessment are varies from one organization to other organizations, depending on assessor's own perspective. Nowadays, there are several methods available to conduct the chemical health risk assessment. A suitability and effectiveness of each method need to be evaluated in order to improve a chemical risk management. Although CHRA has been carried out, we are still witnessed an increasing cases related to safety and health issues in these industries. This reflects that the current practice of occupational safety and health management required improvement to make it more relevant to the quarry industry. Therefore, this study evaluates the findings of CHRA report from various quarries organization, aiming to compare an existing method with control banding method in conducting chemical health risk assessment at quarry industries.

2.0 METHOD

This study used both primary and secondary resources. The primary data was obtained through site observation and in-depth interview with quarry personnel and assessor that conduct the CHRA in quarry. The secondary data was obtained from the chemical health risk assessment report conducted at thirteen quarries located in east Peninsular Malaysia. An explanatory sequential mixed method with both evaluation approaches, quantitative and qualitative, were used in this study. Qualitative data is necessary to explain the details of the data obtained from quantitative findings (Cresswell, 2013). The CHRA reports contain information that valuable in this study. From the report, the information that were reviewed include the worker at risk, work unit involved in the process, degree of hazard in quarry, exposure evaluation, control measure and the methodology of the assessment. All of this information were recorded and grouped into the same category for each report.

Site Observation was used in this study to evaluate the real situation during normal quarry operation. The unstructured observation was performed to observe and record behaviour without the use of a pre-determined guide. All senses were used to examine people and environment in natural setting or natural occurring situations. The purpose of this observation was to get information about people behaviour toward chemical handling and their nature and culture of work in quarry industry. Two quarries were observed in this study.

CHRA Assessor who conducted the CHRA in quarry industry was chosen to have a one to one structured interview session. Interviewees were selected based on their experience in conducting CHRA at various quarries operation and facilities in east peninsular Malaysia. The questions were open-ended, and aimed to obtain further details and explanation about the CHRA results. The collected answers were analyzed to identify how the CHRA was conducted and how the control measures were proposed to the industry.

Then, the gathered information was assessed by using control banding approach. Guidelines from NIOSH control banding method and COSHH Essentials were used. The hazard was band according to three tiers method which includes tier 1, tier 2 and tier 3. In tier 1, the chemical are band by using GHS information, tier 2 is banding the chemical which is beyond the GHS information and tier 3 is using expert judgments to evaluate data experiment (HSE, 2018a; NIOSH, 2017).

3.0 RESULTS AND DISCUSSION

The number of chemicals that have been assessed by the assessors at 13 quarries are shown in Fig. 1. There were in a range of 9 to 27. There were four quarries exposed to 9 chemicals (quarry operator no. 3, 5, 9 and 13). Two quarries were exposed to 10 chemicals (quarry no. 2 and 3), 12 chemicals (quarry no.1 and 12) and 15 chemicals (quarry no. 8 and 10). The rest are quarry operator 6 that exposed to 14 chemicals, quarry operator 7 exposed to 20 chemicals and the highest number of chemical that had been exposed was 27 by quarry no.11. Based on the data in Fig. 1, it was found that each quarry had been assessed with different number of chemicals used due to their different inactivities. Some quarries have either a premix plant or concrete mix plant or both types. A number of chemical assessed by assessors is based on the registered chemicals by the quarry operator as well as at onsite observation.

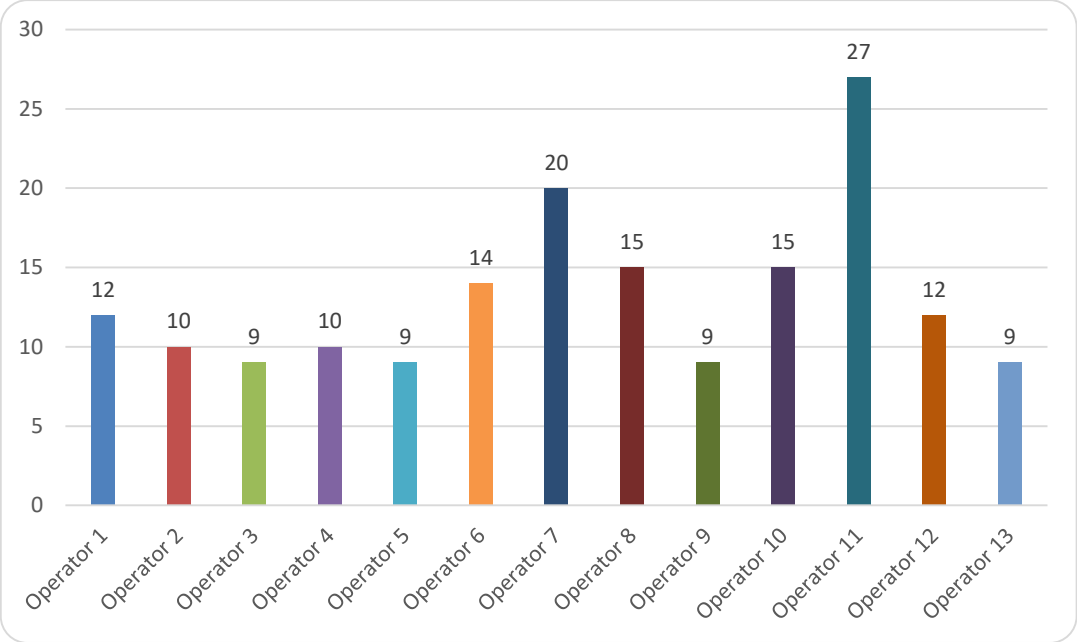

Figure 1 Number of Chemical Assessed at Each Quarry Operator

Table 1 shows a summary of hazard rating obtained from CHRA reports conducted by 8 assessors. It was found that the assessors gave different hazard rating (HR) in some of the chemicals that were exposed to the workers. . These include granite, acetylene, gear oil, engine oil, diesel, grease, compress oxygen, welding fumes, hydraulic oil and emulsion explosive. The rest of the chemicals listed in the Table 1 were consistently rated. Based on the structured interview with the assessors, they mentioned that the different rating for HR may be due to:

- Different interpretation or understanding of classification methods from the CHRA manual and Industrial Code of Practice (ICOP) 2014 on chemicals classification.
- Difficulty to choose most appropriate hazard rating due to conflicting data in Safety Data Sheet (SDS) e.g. toxicity data may not be similar with hazard identification mentioned in the same SDS. Most of the quarry do not have SDS for the product especially granite and quarry dust. Assessors have to search and download SDS for granite and quarry dust from internet. The hazard rating will be different from country to country as well as quarry operator depending on the mineral of soil.
- SDS data may not be reliably used with confidence and hence have to rely on classification from published literatures or ICOP 2014 chemicals classification.

Table 1 Hazard Rating Analysis Based on Chemical Assessed by Assessor

Chemical	Hazard Rating				
	1	2	3	4	5
Granite			✓	✓	
Limestone			✓		
Acetylene		✓	✓		
Gear oil	✓	✓	✓		
Engine oil	✓	✓			
Diesel		✓	✓		
Grease	✓	✓	✓	✓	
Compress oxygen		✓	✓		
Welding fume		✓	✓	✓	
Welding electrode		✓			
Hydraulic oil	✓	✓		✓	
Kerosene		✓			
Waste oil				✓	
Cement			✓		
Engine oil treatment	✓				
TMB power coolant			✓		
Chemicide 75				✓	
Glyphosate isopropylamine			✓		
Metsulfuron methyl			✓		
Bitumen			✓		
Asphalt			✓	✓	
Emulsion explosive		✓	✓		
Zinc dust		✓			
Bakelite powder	✓				
Ammonium nitrate			✓		
Repumpable matrix			✓		
calcium hidroxide			✓		
Sulfuric acid				✓	
Sodium cyanide				✓	
Cyanide				✓	
Hydrochloric acid				✓	
Nitric acid				✓	
Methylene chloride			✓		
Bituminoues solution			✓		
Ethyl alchohol				✓	
Thiourea				✓	

Table 2 illustrates the analysis of adequacy of control measures in each studied quarries obtained from CHRA reports. Based on the risk decision and the assessment of existing control measures, the risk that workers are being exposed concluded as C1, C2, C3, C4 and C5 where C1 is a risk are not significant while C2 is a risk that significant but in adequate controlled and C3 is a risk that significant but not in adequate controlled. From the analysis there is no assessment conclusion felled under the category C4 which is insufficient information about chemical and C5 was about uncertain information of chemical exposure.

Based on the result shown in Table.2, most of the total chemicals assessed in 13 quarry operators were adequate controlled with percentage of 35.1% followed with inadequate controlled with percentage of 32.7%. Risks are not significant recorded 32.2% of the total chemicals assessed while none for insufficient chemical information and uncertain chemicals exposure recoded. There are several points of discussion for the CHRA assessment conclusion analysis from the Table2 and the findings were well aligned with structured interview. Based on the interview findings, several control methods are found to be not adequate in mitigating the risks.

It was also observed that no written Safe System of Work (SSW) in place. Safe system of work is defined as a formal safety operation procedure which results from systematic examination of a task in order to identify all the hazards. In terms of chemical health risk management, SSW is important as a communication tool so that workers are aware of good work practices and steps on how to effectively protect themselves from chemical exposure. Currently, there is no formal written SSW such as safe operating procedure or work instructions devised for every job tasks involved with handling or exposure to chemicals.

Furthermore, no testing and examination of water sprayer system at crusher section was observed. Water spraying or sprinkling system is a common method used as dust suppression technique in stone quarries. While regular inspection of the water spraying pipes is carried out to ensure they are not clogged, examination and testing of the system had not been conducted before. Due to that, the effectiveness of this system to control dust emission cannot be determined adequately. In this case the water spraying system need to be examined and tested by a competent person at minimum of 12 months' interval as stated in USECHH Regulations 2000 – Regulation 17.1.b

Inappropriate of personal protective equipment (PPE) was also observed during the inspection. The PPE provided to the workers is not suitable because they did not match with the type of airborne contaminants such as surgical mask used in prevention of dust are unable to filter dry dust and cotton glove was used in handling oils.

Table 2 Assessment Conclusion and Percentage Based on Quarry Operator

Quarry Operator	Assessment Conclusions: No. of Chemical, (%)				
	C1 Risk Not significant	C2 Adequate Control	C3 Inadequate Control	C4 Insufficient Information	C5 Uncertain Exposure
Operator 1	5	0	7	0	0
	(41.7)	(0)	(58.3)	(0)	(0)
Operator 2	6	1	3	0	0
	(60)	(10)	(30)	(0)	(0)
Operator 3	5	0	4	0	0
	(55.6)	(0)	(44.4)	(v0)	(0)
Operator 4	2	8	0	0	0
	(20)	(80)	(0)	(0)	(0)
Operator 5	5	0	4	0	0
	(55.6)	(0)	(44.4)	(0)	(0)
Operator 6	7	7	0	0	0
	(50)	(50)	(0)	(0)	(0)
Operator 7	1	3	16	0	0
	(5)	(15)	(75)	(0)	(0)
Operator 8	1	2	12	0	0
	(6.7)	(13.3)	(80)	(0)	(0)
Operator 9	0	9	0	0	0
	(0)	(100)	(0)	(0)	(0)
Operator 10	6	1	8	0	0
	(40)	(6.7)	(53.3)	(0)	(0)
Operator 11	12	15	0	0	0
	(44.4)	(55.6)	(0)	(0)	(0)
Operator 12	1	10	1	0	0
	(8.3)	(83.3)	(8.3)	(0)	(0)
Operator 13	3	3	3	0	0
	(33.3)	(33.3)	(33.3)	(0)	(0)
Total	**55**	**60**	**56**	**0**	**0**
	(32.2)	**(35.1**	**(32.7)**	**(0)**	**(0)**

Table 3 shows the result of control banding method for each chemical used in quarry while Table4 outline four basic levels of control bands. There were eight (8) chemicals categorized under hazard band E which is the most hazardous chemical hence require special control approach to handle this group of chemicals. Seven (7) chemicals were assessed with hazard band D and categorized with control approach 3 and control approach 2. The different in control approach for chemical in same group of hazard band depends on the amount of chemical exposed at the workplace. Table3 also shows nine (9) chemicals were assessed with hazard band C, one (1) chemical assessed with band B and ten (10) chemicals were assessed with hazard band A. Global Harmonize System (GHS) codes are used to categorize the hazard band between those chemicals used in quarry from extreme chemical to those chemicals at lower level toxicity. The chemicals with no H code means the hazard is categorized as non-hazardous chemicals. Those are chemicals with the lowest hazard band as suggested in COSH Essentials.

Table 3 Result of Hazard Banding for Chemicals Use in Quarry

Chemical	GHS Tier 1 Occupational Banding	Hazard Band	Control Band
	H Statement		
Granite	H372, H350, H319, H335	E	Control approach 4
Limestone	H350, H373, H315, H319	E	Control approach 4
Welding fume	H302, H317, H350, H314, H351, H319, H335, H372	E	Control approach 4
Waste oil	H302, H315, H319, H332, H317, H340, H350, H360, H335, H336, H304, H371	E	Control approach 4
Asphalt	H319, H350, H361, H372	E	Control approach 4
Zinc dust	H315, H319, H302, H336, H334	E	Control approach 4
Repumpable matrix	H319, H350, H361, H372	E	Control approach 4
Cement	H314, H317, H335, H350	E	Control approach 4
Gear oil	H304, H315, H400, H361, H413	D	Control approach 3
Diesel	H332, H315, H351, H373, H374	D	Control approach 3
Emulsion explosive	H351	D	Control approach 3
Cyanide	H300, H310, H314, H315, H319, H330	D	Control approach 3
Methylene chloride	H315, H319, H302, H370, H335, H336, H351	D	Control approach 2
Ethyl alchohol	H226, H315, H319, H361, H336, H370	D	Control approach 2
Thiourea	H302, H315, H317, H351, H361	D	Control approach 2
Kerosene	H304, H315, H336, H335	C	Control approach 2
TMB power coolant	H373	C	Control approach 2
Chemicide 75	H302, H315, H318, H335, H400	C	Control approach 2
Bakelite powder	H318, H317	C	Control approach 2
calcium hidroxide	H315 ,H318, H335	C	Control approach 2
Sulfuric acid	H303, H314, H412	C	Control approach 2
Sodium cyanide	H301, H311, H332, H315, H319, H402	C	Control approach 2
Hydrochloric acid	H314, H318, H335, H302	C	Control approach 2
Nitric acid	H314, H318	C	Control approach 2
Ammonium nitrate	H319, H303, H272	B	Control approach 2
Acetylene	H220, H280	A	Control approach 1
Engine oil	H315, H319	A	Control approach 1
Grease	NA	A	Control approach 1
Compress oxygen	H270, H280	A	Control approach 1
Welding electrode	NA	A	Control approach 1
Hydraulic oil	NA	A	Control approach 1
Engine oil treatment	NA	A	Control approach 1
Glyphosate isopropylamine	H315, H318, H411	A	Control approach 1
Metsulfuron methyl	NA	A	Control approach 1
Bitumen	NA	A	Control approach 1

Table 4 Control Bands

Amount of the chemical present in the workplace at any one time				Control band approach	Recommended control measure
A little (g or mg)	Some (kg or L)	A lot (hundred of kg or L up to a few metric tonnes or cubic meter)	Bulk (many metric tonnes or cubic meter		
C	B	A	A	1	General ventilation, basic hygiene
D	C	B	A/B	2	Local exhaust, engineering control
D	D	C	C	3	Enclosure, containment, strict engineering control
		E		4	Special cases that require a professional evaluation

4.0 CONCLUSION

This study evaluates the findings of CHRA report from various quarry organizations, aiming to standardize on control measure in conducting CHRA at quarry industries via control banding method. Thirteen CHRA reports were analyzed and found that there are inconsistencies in rating the hazards by competent assessors. Most of the quarries are operating in inadequate control measure that could have effect on the health of the workers. From the analysis, it was found that only 32.7% of the chemicals are in adequate control.

There were eight chemicals categorized as hazard band E, seven chemicals with hazard band D, nine chemicals with hazard band C, one chemical with band B and 10 chemicals with hazard band A and assigned control approach 4 to control approval 1 based on an amount of chemical concentration.

Overall, the findings from this study will help assessors to improve the assessment result of CHRA in achieving adequacy of control of risk among workers in quarry industries. This will also make it easier to the operators to understand the associated risk and reduce the number of health disorders contributed by the quarry industry.

REFERENCES

Cresswell, J. W. (2013). *Steps in conducting a scholarly mixed methods study.* (DBER Speaker Series. 48). Retrieved from https://www.researchgate.net

DOSH. (2000). *Manual of Recommended Practice, 2nd Edition of Assessment of The Health Risks Arising from the Use of Hazardous Chemicals in The Workplace*.

DOSH. (2017). *Data Tempat Kerja Berdaftar Mengikut Negeri dan Sektor*. Retrieved from https://mykkp.dosh.gov.my

HSE. (2018a). Controlling exposure to chemicals – a simple control banding approach. Retrieved from http://www.hse.gov.uk/pubns/guidance/coshh-technical-basis.pdf

HSE, U. 2017. (2018b). Quarry health and safety. Retrieved from http://www.hse.gov.uk/quarries/index.htm

ILO. (2013). ILO calls for urgent global action to fight occupational diseases. *International Labour Office*. Retrieved from http://www.ilo.org/global/about-the-ilo/newsroom/news/WCMS_211627/lang--en/index.htm

NIOSH. (2017). *The NIOSH Occupational Exposure Banding Process: 4 Guidance for the Evaluation of Chemical Hazards*. Retrieved from https://www.cdc.gov/niosh/docket/review/docket290/pdfs/clean-cib-niosh-oebprocess-guidancefortheevaluationofchemicalhazards_3.8.17.pdf

Okafor, F. C. (2006). *Rural Development and the Environmental Degradation versus Protection, Environmental Issues and Management in Nigerian Development*. (S. and T. O. (ed.), Ed.).

Smallwood J.J and Haupt T.C. (2000). *Safety and Health Team Building. Construction Safety and Health Management.* Coble, R; Hinze, J; Haupt, T. C. (editors). New Jersey: Prentice Hall.