Editor
Aida Bulucea

Recent Advances in Energy, Environment and Financial Science

- Proceedings of the 12th International Conference on Energy, Environment, Ecosystems and Sustainable Development (EEESD '16)
- Proceedings of the 4th International Conference on Management, Marketing, Tourism, Retail, Finance and Computer Applications (MATREFC '16)

Venice, Italy, January 29-31, 2016

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Plenary Lecture 1

Structuring Environmental Models by Means of Dimensional Analysis

Professor Fragiskos Batzias
Laboratory of Simulation of Industrial Processes
Department of Industrial Management and Technology
School of Maritime and Industry
University of Piraeus
Greece
E-mail: fbatzi@unipi.gr

Abstract: Dimensional Analysis (DA) is a method for describing the function of a physical system in terms of the necessary independent variables, parameters, and coefficients (VPCs), arranged in a form that remains basically unchanged when the magnitude of the system increases or decreases (scale up or down, respectively). The environmental models simulate the behavior of large systems met in Nature, and are complex, since they include VPCs at different phenomenological levels, from simple/empirical to advanced/scientific ones. In the present work DA is used for structuring such models by arranging the VPCs in dimensionless groups. For this purpose, a methodological framework under the form of an algorithmic procedure has been designed/developed and implemented in two waterbody pollution cases. The innovative technique used in that procedure is a combination of system decomposition/ recomposition and model based reasoning (MBR) derived through case based reasoning (CBR) by induction. The results of the implementation are (i) presented by means of ontological mapping and (ii) evaluated/discussed by means of sensitivity/robustness analysis.

Brief Biography of the Speaker: Prof. Fragiskos Batzias holds a 5years Diploma and a PhD degree in Chemical Engineering, and a BSc in Economics. He has also studied Mathematics and Philosophy. He designed/developed the Laboratory of Simulation of Industrial Processes and the Research Group on Systems Analysis at the Department of Industrial Management and Technology of the University of Piraeus, Greece. He is teaching at the postgraduate courses (i) Systems of Energy Management and Protection of the Environment, running by the University of Piraeus, and (ii) Techno-Economic Systems, running by the Electr. & Comp. Eng. Dept. of the Nat. Tech. Univ. of Athens in cooperation with the University of Athens and the University of Piraeus. His research interests are in chemical engineering systems analysis and knowledge based decision making. He has >100 publications in highly ranked journals and conference proceedings, including 29 research monographs in collective volumes, with 652 citations and an h-index of 13 (Scopus). He has participated (and chaired after invitation from the organizers) in prestigious international conferences, such as those organized periodically by the IEEE, the European Federation of Chemical Engineering (EFCE), the DECHEMA, CHISA, WSEAS Organizations. He organizes the annual Symposium on Industrial and Environmental Case Studies running successfully since 2004 within the International Conference of Computational Methods in Sciences and Engineering (ICCMSE).

Analysis of Ergonomic of Sulphur Miners by Rapid Upper Limb Assessment (RULA)

(A Case Study of Sulphur Miners of Mount Ijen, Licin Sub-district, Banyuwangi)

KHAIDAR ALI
Department of Environmental Health and Safety
University of Jember
Jl. Jawa VI No. 23 D, Jember, East Java, Indonesia
INDONESIA
Alikhaidar15@yahoo.co.id

KHAIRUL ANWAR
Department of Occupational Health and Safety
University of Jember
INDONESIA

FITRI NUR'AINI
Department of Occupational health and Safety
University of Jember
INDONESIA

ISA MA'RUFI
Department of Environmental Health and Occupational Health and Safety
University of Jember
INDONESIA

Abstract: Mount Ijen is one of a volcanoes series in East Java. Mount Ijen is still active and located in three regencies, there are Situbondo regency, Bondowoso regency and Banyuwangi regency. The high sulfur content makes Mount Ijen became mining area which one the main problems of sulfur miners is related to the ergonomics level of miners due to excessive workload that could potentially affect the health level of the worker. The study is analytic observational. Design of this study using cross sectional. The ergonomic assessment of sulphur miner used Rapid Upper Limb Assessment (RULA). The analysis technic of this study is descriptive. The result of assessments is the total score of Sulphur Stone Taking Process is 7 with action level is 4, total score of Sulphur Stone Lifting Process is 7 with action level is 4 and total score of Sulphur Stone Transport Process is 6 with action level is 3. The conclusion of study is RULA score of Sulphur stone taking and lifting process is level 4, shown that the condition of work posture of Sulphur stone taking process is dangerous for miner then investigate and change the work posture or implementation (in the near future) is necessary. And then, RULA score of Sulphur stone transport process is level 3, shown that further investigate and change the work posture or implementation soon is necessary.

Key-Words: Ergonomic, Sulphur Miners Mining Process, RULA, Sulphur Miners Health Problem

1 Introduction

Mount Ijen is one of a volcanoes series in East Java. Mount Ijen is still active and located in three regencys, there are Situbondo regency, Bondowoso regency and Banyuwangi regency. Mount Ijen has been erupt amount 12 time [1]. The altitude of Mount Ijen is 2,386 masl. Geographically, Mount Ijen is in 8º03'30" LS and 114º14'30" BT, which the top of Mount Ijen had a crater or cauldron with length, width and depth of Ijen Crater is 800 meters, 700 meters, 180 meters[2]. Furthermore, Crater of Ijen has high sulfur content and well-known as tourism object. The high content of sulphur of Ijen Crater created that region become mining area.

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Generally, Sulphur miner carry out of mining activities as traditional manner. Thus, the health and safety of sulphur miners in Crater of Ijen at risk to disrupted because miners do not has maximal covered for mining activities.

Generally, informal worker has higher potential to get health problem than formal worker, which one that incident related with the lower information about safety and health in environmental occupational of worker. Based on research of Ulfah et al about work attitude and health problem risk of laundry worker or employment describes that laundry is informal work and musculoskeletal disorder of laundry worker occur in washery section[3]. Besides The Crater of Ijen expel H_2S that is harmful to humans, but the sulphur has a benefit of human beings and sulphur has been used in various industries, such as sugar, pesticides, and cosmetics [4]. Sulphur gas measurement carried out by central team of the Volcanology Hazard Mitigation and Geological (PVMBG) on seven points at Mount Ijen with the result that the highest sulphur contained known around the crater, amounted to 47 ppm (normal limit of 10 ppm) [5]. The water of crater of Mount Ijen could endanger for human safety, caused by the effect of CO_2, SO_2 and HCl. The concentration of CO_2 when exceeding by 10% of volume, while the sulfuric acid and bicarbonate due dissolution of CO_2 and SO_2 or HCl in the water of crater of Mount Ijen is corrosive for metal and endanger for skin [2].

The main problem of Ijen sulphur mining workers is a matter of occupational health and safety (K3) which one workers are not getting the maximum covered or protection, both from industrial or government. There are health and occupational safety issue of sulphur mining workers such as the workers or miners directly exposed to chemicals released like sulfatara gases (S, SO_2, SO_3, H_2S), fumarole fume (H_2O, and nitrogen), mofet, hydrogen chloride, and hydrogen fluoride is threaten for miner at any time [6]. Besides, the work environment condition is unencouraged caused the distance of miners walk way to mining area through Paltuding (weighing area) about 3 km with the declivity of track is 25-35 degrees as far as 250 meters and then the excessive workload of miners became a problem which associated with the ergonomics level, which every day miners must carried out the Sulphur stone about 40-50 kg twice from top to bottom with a bamboo basket [6].

The impact of ergonomics or poor in work attitude/posture among miners is potential to adverse for miners health. Therefore, the aim of this study is to analyze the level of ergonomics at the Sulphur miners in the Crater of Ijen of Mount Ijen, Banyuwangi and to determine the ergonomics level of mining activities of miners.

2 Material and Method

This study is analytic observational include in survey research without intervention to the research subject. Design of study is using cross sectional. The study was conduct in March 2015 – June 2015 at Mount Ijen area, Banyuwangi Regency. The technic of sample withdrawal is using non random sampling with accidental sampling approach. The ergonomic assessment of sulphur miner used Rapid Upper Limb Assessment (RULA). The analysis technic of this study is descriptive analysis, the researcher describes the result research or assessment of ergonomic of sulphur miners work body posture or position.

3 Result

Generally, Sulphur miners of Mount Ijen are traditional miners, which one the tools or equipment of mining activities used simple technology such as bamboo basket for lifting the Sulphur from crater to Paltuding. Beside, protection devices or equipment of Sulphur miners such as mask, goggle, helm, glove etc is not complete. So, the probability for miner to get accident is more higher than worker who use completed protection devices at work. Based on observation of Sulphur miners of Mount Ijen, there are 3 main step of Sulphur mining processes namely Sulphur stone taking process, Sulphur stone lifting process, and Sulphur stone transport process.

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3.1 Sulphur Stone Taking Process

Fig.1 The Angle of RULA Assessment of Sulphur Stone Taking Process

Sulphur stone taking process shown in figure 1. Based on that figure, right and left of miner side is bowed at sulphur stone taking process.

RULA assessment of body posture of Group A (Arm and Wrist Analysis):

1. Upper arm position: Angle of upper arm of worker is >200-450, score= +2
2. Lower arm position: Angle of lower arm of worker is <60º, score= + 2
3. Wrist position: Angle of wrist posture of worker is 0 - 15º, score= +2
4. Wrist twist: Wrist twist posture of worker occur in middle line or neutral, score= +1
5. Look-up posture score in Table A is 3, shown in fig. 2
6. Score of muscle used of miners is activity repeated occurs 4X per minutes, score +1
7. Score of Load > 2 kg = 1
8. Total score group A RULA assessments= 3 + 1+1= 5

SCORES

Table A: Wrist Posture Score

Upper Arm	Lower Arm	1 Wrist Twist 1	1 Wrist Twist 2	2 Wrist Twist 1	2 Wrist Twist 2	3 Wrist Twist 1	3 Wrist Twist 2	4 Wrist Twist 1	4 Wrist Twist 2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Fig.2 Score of Group A RULA measuring of Sulphur Stone Taking Process (Look-up Posture Score)

RULA measuring of group B (Neck, Trunk and Leg Analysis):

1. Neck position in sulphur stone taking process shaping >20º, score= +3
2. Trunk position in sulphur stone taking process shaping 20º- 60º, score= +3
3. The legs and feet of miners are supported, score= +1
4. Look-up posture score in table B is +4, shown in fig. 3
5. Score of muscle used of miners is activity repeated occurs 4X per minutes, score +1
6. Score of Load >2 kg = +1
7. Total score group B RULA assessments= 4 + 1+ 1 = 6

Table B: Trunk Posture Score

Neck Posture Score	1 Legs 1	1 Legs 2	2 Legs 1	2 Legs 2	3 Legs 1	3 Legs 2	4 Legs 1	4 Legs 2	5 Legs 1	5 Legs 2	6 Legs 1	6 Legs 2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

Fig.3 Score of Group B RULA measuring of Sulphur Stone Taking Process (Look-up Posture Score)

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Table C: Neck, trunk and leg score

Wrist and Arm Score	1	2	3	4	5	6	7+
1	1	2	3	3	4	5	5
2	2	2	3	4	4	5	5
3	3	3	3	4	4	5	6
4	3	3	3	4	5	6	6
5	4	4	4	5	6	7	7
6	4	4	5	6	6	7	7
7	5	5	6	6	7	7	7
8+	5	5	6	7	7	7	7

Fig.4 Total Score of Group A and Group B of Sulphur Stone Taking Process

According to figure 4 the total score of Group A and Group B of ergonomic level of work posture or position of miners is 7, it show that work posture of Sulphur taking process is not ergonomic.

Table 1 Ergonomic Level of Sulphur Stone Taking Process by RULA Assessment

Total Score of Group A and Group B	7
Action Level	4
Intervention	Investigate and implement change

3.2 Sulphur Stone Lifting Process

Fig.5 The angle of RULA assessment of Sulphur Stone Lifting Process

Sulphur stone lifting process of miners shown in Figure 5 shown the worker body posture when lifting of Sulphur stone with bowed position with the burden of sulphur stone more than 40 kg.

RULA assessment of body posture of Group A (Arm and Wrist Analysis):

1. Upper arm position: Angle of upper arm of worker is >200-450, score= +2
2. Lower arm position: Angle of lower arm of worker is 100º, score= +2
3. Wrist position of worker is neutral , score= +1
4. Wrist twist: Wrist twist posture of worker occur in middle line or neutral, score= +1
5. Look-up posture score in Table A is 3, shown in fig. 6
6. Score of muscle used of miners is activity did not occurs 4X per minutes, score +0
7. Score of Load > 10 kg = +3
8. Total score of Group A RULA assessments= 3 + 0+ 3= +6

SCORES

Table A: Wrist Posture Score

Upper Arm	Lower Arm	1 Wrist Twist 1	1 Wrist Twist 2	2 Wrist Twist 1	2 Wrist Twist 2	3 Wrist Twist 1	3 Wrist Twist 2	4 Wrist Twist 1	4 Wrist Twist 2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Fig.6 Score of Group A RULA measuring of Sulphur Stone Lifting Process (Look-up Posture Score)

RULA measuring of group B (Neck, Trunk and Leg Analysis):

1. Neck position in sulphur stone lifting process shaping >20º and the miners neck is side bending, score= +4
2. Trunk position in sulphur stone lifting process shaping >60º and the miners trunk is side bending, score= +5
3. The legs and feet of miners are supported or normal position, score= +1
4. Look-up posture score in table B is +7, shown

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fig. 7

5. Score of muscle used of miners is activity did not occurs 4X per minutes, score 0
6. Score of Load >10 kg = +3
7. Total score group B RULA assessments= 7 + 0+ 3= +10
8. RULA assessments = 7 + 0+ 3 = 10

Table B: Trunk Posture Score

Neck Posture Score	1		2		3		4		5		6	
	Legs		Legs		Legs		Legs		Legs		Legs	
	1	2	1	2	1	2	1	2	1	2	1	2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

Fig. 7 Score of Group B RULA measuring of Sulphur Stone Lifting Process (Look-up Posture Score)

Table C: Neck, trunk and leg score

Wrist and Arm Score	1	2	3	4	5	6	7+
1	1	2	3	3	4	5	5
2	2	2	3	4	4	5	5
3	3	3	3	4	4	5	6
4	3	3	3	4	5	6	6
5	4	4	4	5	6	7	7
6	4	4	5	6	6	7	7
7	5	5	6	6	7	7	7
8+	5	5	6	7	7	7	7

Fig. 8 Total Score of Group A and Group B of Sulphur Stone Lifting Process

According to figure 4 the total score of Group A and Group B of ergonomic level of work posture or position of miners is 7, it show that work posture of Sulphur lifting process is not ergonomic.

Table 2 Ergonomic Level of Sulphur Stone Lifting Process by RULA Assessment

Total Score of Group A and Group B	**7**
Action Level	4
Intervention	Investigate and implement change

3.3 Sulphur Stone Transport Process

Fig. 9 The angle of RULA assessment of Sulphur Stone Transport Process

Figure 9 shown the angle of RULA assessment of Sulphur Transport Process such as angle of upper and lower arm, neck, legs and feet etc. The load of Sulphur stone is about > 40 Kg.

RULA assessment of body posture of Group A (Arm and Wrist Analysis):

1. Upper arm position: Angle of upper arm of worker is >200-450, score= +2
2. Lower arm position: Angle of lower arm of worker is 100º, score= +2
3. Wrist position: Angle of wrist posture of worker is neutral, score= +1
4. Wrist twist: Wrist twist posture of worker occur in middle line or neutral, score= +1
5. Look-up posture score in Table A is 3, shown fig. 10
6. Score of muscle used of miners is activity did not occurs 4X per minutes, score +0
7. Score of Load > 10 kg = 3
8. Total score group A RULA assessments= 3 + 0+3= 6

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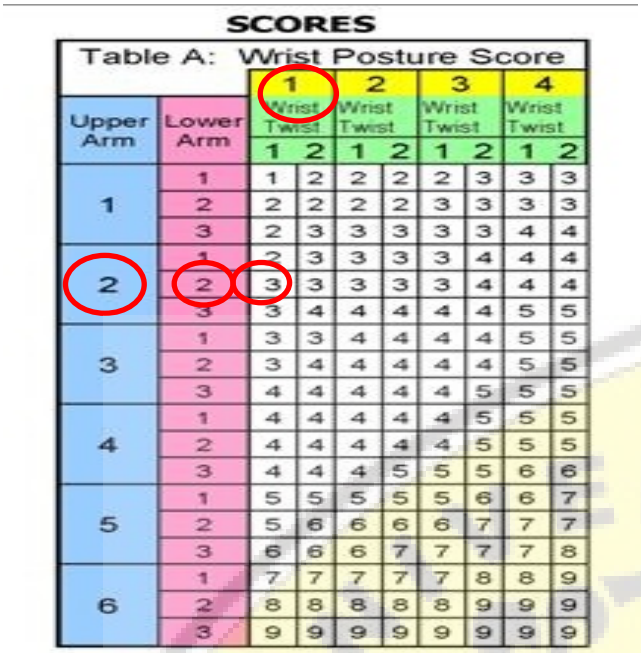
SCORES

Table A: Wrist Posture Score

Upper Arm	Lower Arm	1 Wrist Twist 1	1 Wrist Twist 2	2 Wrist Twist 1	2 Wrist Twist 2	3 Wrist Twist 1	3 Wrist Twist 2	4 Wrist Twist 1	4 Wrist Twist 2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Fig.10 Score of Group A RULA measuring of Sulphur Stone Transport Process (Look-up Posture Score)

RULA measuring of group B (Neck, Trunk and Leg Analysis):

1. Neck position in sulphur stone transport process shaping 0º-100, score= +1
2. Trunk position in sulphur stone transport process shaping 0º or normal, score= +1
3. The legs and feet of miners are supported, score= +1
4. Look-up posture score in table B is +1, shown fig. 11
5. Score of muscle used of miners is activity did not occurs 4X per minutes, score +0
6. Score of Load >10 kg = +3
7. Total score group B RULA assessments = 1 + 0+ 3 = 4

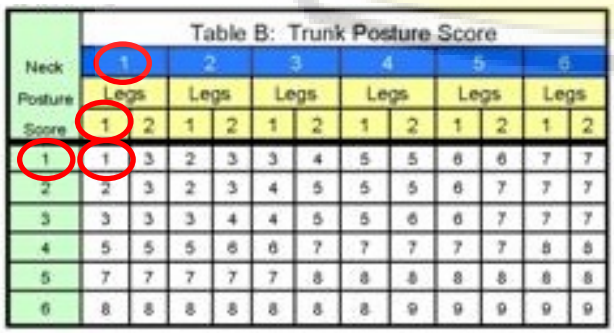
Table B: Trunk Posture Score

Neck Posture Score	1 Legs 1	1 Legs 2	2 Legs 1	2 Legs 2	3 Legs 1	3 Legs 2	4 Legs 1	4 Legs 2	5 Legs 1	5 Legs 2	6 Legs 1	6 Legs 2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

Fig.11 Score of Group B RULA measuring of Sulphur Stone Transport Process (Look-up Posture Score)

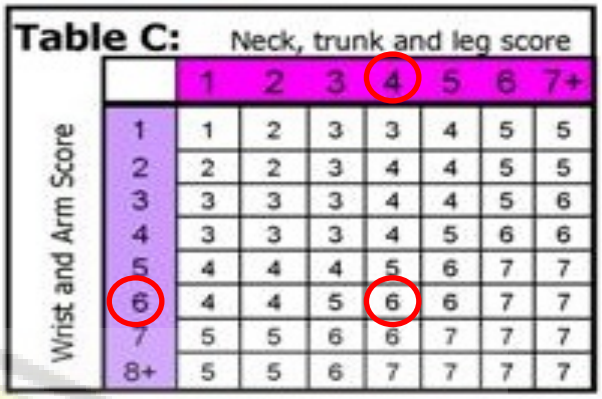
Table C: Neck, trunk and leg score

Wrist and Arm Score	1	2	3	4	5	6	7+
1	1	2	3	3	4	5	5
2	2	2	3	4	4	5	5
3	3	3	3	4	4	5	6
4	3	3	3	4	5	6	6
5	4	4	4	5	6	7	7
6	4	4	5	6	6	7	7
7	5	5	6	6	7	7	7
8+	5	5	6	7	7	7	7

Fig.12 Total Score of Group A and Group B of Sulphur Stone Transport Process

According to figure 4 the total score of Group A and Group B of ergonomic level of work posture or position of miners is 6, it show that work posture of Sulphur transport process is not ergonomic.

Table 3 Ergonomic Level of Sulphur Stone Transport Process by RULA Assessment

Total Score of Group A and Group B	7
Action Level	4
Intervention	Investigate and implement change

4 Discussion

4.1 The Comparison Between Taking Process, Lifting Process, Transport Process and Health Problem of Miners

The result of ergonomic assessment of work process of sulphur miner by Rapid Upper Limb Assessment (RULA) shown in table 4, which the mining process of sulphur miners are sulphur stone taking process, sulphur stone lifting process and sulphur stone transport process.

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Table 4 The Comparison of Ergonomic Level of Sulphur Mining Process by RULA Assessment

Work Process	Total Score	Action Level	Intervention
Taking Process	7	4	Investigate and implement change
Lifting Process	7	4	Investigate and implement change
Transport Process	6	3	Further investigation and change soon

Generally, based on table 4 total score and action level of taking, lifting and transport process include in high categories which related with not ergonomic work posture or position of sulphur miner. So, the risk of sulphur miners of Mount Ijen to get negative impact such as health problems and accident caused by work is high with not ergonomic work posture or position.

There are many health problem occuring among sulphur miner, such as respiratory problem, vision problem, skin problem and gingivitis [6]. Most literature noted that gingivitis of sulphur miners has relation with sulphur gas exposure [8-10] and Sulphur exposure duration has significant correlation with gingivitis incident to Sulphur miners [11-12]. Rall [13] describes that concentration of SO_2 in the ambient air twice the current standard are associated with adverse effect. Such as, Acute inflamatory obstruction sequel obstructive impairment ventilator function and permanent bronchial hyperactivity [14]. Furthermore, Amin et al [15] noted that exposure to acid in the workplace has significant associated with dental erosion and deteriorate oral health status. It has been shown that gases which produce by Crater of Mount Ijen like sulfatara gases, fumarole fume, mofet, hydrogen chloride, and hydrogen fluoride have negative effect for miners. Moreover, Love et al [16] in respiratory health effect of opencast coalmining noted that frequency of chest radiographic abnormalities is associated with working in duster and preproduction jobs in the industry. Besides, biological hazards is one of risk factor led various health problem among miners. Donoghue [17] shown that biological hazards of mining is the risk of tropical disease such as malaria and dengue fever is substantial at some remote mining location. Moreover, Oliver [18] noted that all the risk of Sulphur miners is working in high temperatures; there occurs chilling of the body when perspiring also bronchial irritation form exposure to cold and from inhalation of Sulphur vapor, and then they are also liable to a form of fibrosis of the lungs. Based on various study, have been known that environment of workplace has association of occurring of health problem among miners.

Musculoskeletal Disorder is one of health problem among Sulphur miners, it caused by excessive workload who miners carried out from Crater of Mount Ijen to Paltuding and not ergonomic work posture such as Sulphur taking process posture until Sulphur transport process. Based on interview, most of miners suffering pain around neck, shoulder, and legs. Winn Jr. et al [19] in exposure probabilities to ergonomic hazards among miners describe major ergonomic hazards among miners include movement of the forearms, arms and shoulder and finger movement. Kunda et al [20] noted that ergonomic risk factors consistency reported by worker included poor posture and heavy lifting and back bent has association of back injury.

Bandyopadhyay et al [21] in prevalence of musculoskeletal disorder among coalminers of eastern coal field of India describes that 65,45% miners complained about the development of musculoskeletal disorder at different body part which one the maximum pain was identified at lower back. That study is relevant with study of Sarikaya et al [22] which noted that low back pain occurred in 78.0% of Turkish coal miners. Seragi et al [23] describes that back pain absence has relation with manual handling beyond forearm length among coal miners. Moreovers, the research result of gold miners in Cilograng sub-district, Banten has been shown that 79,2% of miners complaining MSDs [24]. And then, related with Sulphur transport process which standing posture or position is most used, Santoso et al [25] noted that standing position among gasoline station (SPBU) officers caused pain at back, right calf and left calf. Beside, according to Erdiansyah [26] work posture risk of manual handling worker at PT.Sumber Tirta Surakarta has significant correlation with musculoskeletal (NBM). Moreover, age and work period more related with MSDs incident compared with work posture, smoking behavior, physical activities, work time, and workload among manual handling worker of mail processing center [27]. Based on interview among Sulphur miners and various study, have been known that injury of

miners has association with poor posture or not ergonomic posture of miners.

4.2 Sulphur Stone Taking Process

According to table 1, the final score of Sulphur stone taking process on the Crater of Mount Ijen is 7. Based on these scores, the action levels to prevent the negative impact of not ergonomic work posture of Sulphur stone taking process is 4, which the score show that the condition of work posture of Sulphur stone taking process is dangerous for miner then investigate and change the work posture or implementation (in the near future) is necessary.

The Sulphur stone taking process performed with bent posture, it caused the location of the Sulphur stone which came out of the slopes of Mount Ijen is lower than the miners standing position. Bent work posture is not ergonomic for worker which caused occupational diseases such as gout and MSDs. Besides, there are a lot of miners did not used Personal Protection Equipment (PPE) such as respirator, eye protection, etc. which related with health problem for miners.

4.3 Sulphur Stone Lifting Process

According to table 2, the final score of Sulphur stone lifting process on the Crater of Mount Ijen is 7. Based on these scores, the action levels to prevent the negative impact of not ergonomic work posture of Sulphur stone lifting process is 4, has been shown that the condition of work posture of Sulphur stone lifting process is dangerous for miners then investigate and change the work posture or implementation (in the near future) is necessary. Pangaribuan [7] describes that squat work posture and stand on tiptoes has higher score of RULA assessment, which these work posture has high level risk.

The Sulphur stone lifting process performed by miners with a bent posture, it caused the load of Sulphur stone is about > 40 Kg. Furthermore, miners should be crouched to bamboo basket contain Sulphur stone and lay above his shoulders. Excessive load and bent work posture is not ergonomic for worker which may cause injury in shoulder. With the result that alteration of work means or miner equipment is necessary to prevent the negative impact of Sulphur mining activities.

4.4 Sulphur Stone Transport Process

Based on Table 3, the final score of Sulphur stone transport process on the Crater of Mount Ijen is 6. Based on these scores, the action levels to prevent the negative impact of not ergonomic work posture of Sulphur stone transport process is 3, shown that further investigate and change the work posture or implementation soon is necessary.

Sulphur stone transport process is related with miners is receiving physical workload greater than the ability of the body about > 40 Kg. With the result, the stand of miner work posture is not ergonomic. Besides, pain through legs and shoulders is higher complaint of Sulphur miners. Slip is hazard risk for miners at Sulphur transport process, caused by the declivity of track is about 25-35 degrees.

5 Conclusion

Based on the assessment of ergonomic level of Sulphur miners in the Mount Ijen is:

1. RULA score of Sulphur stone taking process is level 4, shown that the condition of work posture of Sulphur stone taking process is dangerous for miner then investigate and change the work posture or implementation (in the near future) is necessary.
2. RULA score of Sulphur stone lifting process is level 4, shown that the condition of work posture of Sulphur stone taking process is dangerous for miner then investigate and change the work posture or implementation (in the near future) is necessary.
3. RULA score of Sulphur stone transport process is level 3, shown that further investigate and change the work posture or implementation soon is necessary.

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