MAEH Journal of Environmental Health eISSN 2637-1359
Jurnal Kesihatan Persekitaran MAEH
Published By Malaysian Association of Environmental Health
http://www.maeh4u.org.my/journal

RESEARCH ARTICLE

Water Quality of Water Vending Machines in Gombak, Selangor

Khaerun Nisaa Ansahrullah[a, b], Farah Ayuni Shafie*[a]

[a] *Centre of Environmental Health and Safety, Faculty of Health Sciences, Universiti Teknologi MARA Selangor*
[b] *Pejabat Kesihatan Daerah Gombak, Batu Caves Selangor*

**Corresponding author: farahayuni@uitm.edu.my*

Abstract

Water vending machines (WVMs) are commonly found in public areas and it is an alternative for public easier to buy drinking water with much cheaper price. However, majority of the WVM in Gombak, Selangor were not registered under Ministry of Health (MOH) and have raised a concern on the drinking water quality from these machines. The aim of this study was to assess the physical, chemical, microbiological parameters from the drinking WVMs, as well as to perform environmental assessments of 20 water vending machines (10registered, 10 non-registered water vending machines) in Gombak, and to compare the results between registered and non-registered WVMs. According to the results for water quality tests, one registered WVM violated pH and total coliform standard (10%). On the other hand, five non-registered WVMs (50%) were found not aligned with the MOH water quality standard. A number of four out of five of non-registered WVMs (80%) were found to violate pH standard and one non-registered WVM (10%) was violating total coliform standard. Environmental assessment also showed that registered WVMs have better machine conditions as well as cleaner surroundings compared to the nonregistered counterparts. The findings in this study showed that non-registered WVMs have higher tendencies to violate any water quality parameters as well as poorer WVM conditions and surroundings. These factors could pose health threats to the public who consume drinking water from these machines.

Keywords: *Water vending machines, water quality, environmental assessment, pH, total coliform*

INTRODUCTION

Water vending machine (WVM) is an automated self-service machine that dispenses water into a container in exchange for a mentioned price (Price et al., 2006). However, the quality of drinking water from WVMs are prone to contamination from the lack of hygienic practice and maintenance of the machines Thus, manufacturers of the vending machine need to obey and adhere to the procedure listed in Regulation 360C (Standard for Packaged, Drinking Water and Vended Water, 2012), the Malaysian Drinking Water Quality, Ministry of Health to ensure the safety and quality of water (Food Safety and Quality Ministry of Health, 2020). All WVMs in Malaysia must be registered to Health Offices of their respective districts so that these WVMs will be constantly inspected by Health Officers to ensure the quality of drinking water at all time. However, most WVMs are not registered and this could pose a health threats to all the public. As of November 2019, the licenses of 78 out of 88 registered vending machines (88.4%) have expired and not being renewed. Meanwhile, about 150 WVMs are suspected not registered in the Gombak district alone.

METHODOLOGY

Water sampling and analysis

Water samples were collected from selected 20 WMVs from Gombak's four mukims. Ten samples were from registered WVMs and another ten samples were from non-registered WVMs. All water samples were sent to an outsource laboratory and each samples undergone physical, chemical and microbiological test (Table 1).

Table 1 Test Parameters and techniques

Parameter	Techniques
Physical test	pH: APHA 4500-H^+ B(2005) turbidity: turbidity meter (APHA 2130 B) colour: APHA 2120 B (2005)
Chemical test	Aluminium - APHA 3500 Al Chloroform - USEPA 5021A Nitrite (NO_2^-) - APHA 4500 NO3 B
Microbiological test	Membrane Filtration (APHA 9222 B)

Environmental assessments

WVMs were evaluated on three aspects, which were the availability of dispensing nozzle cover, overall machine conditions, and surrounding's cleanliness. The surrounding area may also affect the water quality as the WVMs are normally situated in open spaces and can be contaminated with dust, droppings and others.

RESULTS AND DISCUSSION

Water sampling results

All water sampling results were depicted in Table 2. According to Table 2, chloroform content and nitrite (NO_2) content were observed to have little to none in all 20 samples tested. Besides that, colour parameter results showed that all samples obtained 5 (HU) which aligned with the standard by MOH.

Table 2 Water Sampling results

Registered Water Vending Machines	Parameters						
	pH @ 25°C	Aluminium	Chloroform	Nitrite as NO_2	Colour	Turbidity	Total Coliform
Unit		mg/l	mg/l	mg/l	Hazen Unit (HU)	NTU	CFU/100 ml
Limit	6.5 - 8.5	0.04	0.0006	0.04	5	0.1	<10
Sampling ID	RESULTS						
Registered WVMs							
A	7.32	0.024	ND<0.01	ND<0.01	5	0.04	ND<1
B	6.58	ND<0.014	ND<0.01	ND<0.01	5	ND<0.01	ND<1
C	6.97	ND<0.014	ND<0.01	ND<0.01	5	ND<0.01	4
D	6.37	ND<0.014	ND<0.01	ND<0.01	5	ND<0.01	10
E	6.75	ND<0.014	ND<0.01	ND<0.01	5	ND<0.01	ND<1
F	6.54	ND<0.014	ND<0.01	ND<0.01	5	ND<0.01	ND<1
G	6.71	ND<0.014	ND<0.01	ND<0.01	5	ND<0.01	ND<1
H	6.73	ND<0.014	ND<0.01	ND<0.01	5	ND<0.01	ND<1
I	6.88	ND<0.014	ND<0.01	ND<0.01	5	ND<0.01	ND<1
J	6.77	ND<0.014	ND<0.01	ND<0.01	5	ND<0.01	ND<1
Non-registered WVMs							
K	7	ND<0.014	ND<0.01	ND<0.01	5	ND<0.01	ND<1
L	6.23	0.022	ND<0.01	ND<0.01	5	ND<0.01	ND<1
M	6.82	ND<0.014	ND<0.01	ND<0.01	5	ND<0.01	ND<1
N	6.28	ND<0.014	ND<0.01	ND<0.01	5	ND<0.01	ND<1
O	6.29	ND<0.014	ND<0.01	ND<0.01	5	ND<0.01	ND<1
P	6.68	ND<0.014	ND<0.01	ND<0.01	5	ND<0.01	13
Q	6.31	0.031	ND<0.01	ND<0.01	5	ND<0.01	ND<1
R	6.49	ND<0.014	ND<0.01	ND<0.01	5	ND<0.01	ND<1
S	6.81	ND<0.014	ND<0.01	ND<0.01	5	ND<0.01	2
T	6.88	ND<0.014	ND<0.01	ND<0.01	5	ND<0.01	ND<1

Mean of pH value for water sample from registered machine was higher (mean: 6.76, SD: 0.26) than mean of pH value for water sample from non-registered machine (mean: 6.57, SD: 0.29). Nevertheless, independent t-test analysis shows that there is no significant difference in pH value between water samples from registered WVMs and non-registered WVMs ($t = 1.482$, $p>0.05$)(Table 3).

Table 3: Independent sample T-test for pH Value

Parameter	Mean / Std Division		t	P. Value
	Registered WVM	Non-Registered WVM		
pH value	6.76 ± 0.26	6.57 ± 0.29	1.482	> 0.05

The difference of pH for registered and non-registered WVMs were not significant due to small sample size. Where only 10 samples were taken from each registered and non-registered WVMs.

Despite that, these samples' results were still not aligned with pH standard of 6.5 – 8.5 set by Food Safety and Quality, Ministry of Health.

Oxides of sulphurs and nitrogen produced by either natural occurrences such as volcano eruptions or from human activities like fossil fuel consumption are the main factor of acid rain occurrences and acidifying water resources around the world (Baselga et al., 2011). The acidity of water also influenced by the formation of carbonic acid from the reaction of carbon dioxide, CO_2 in water (Eq. 1).

$$CO_2(g) + 3\,H_2O \rightleftharpoons CO_2(aq) + 3\,H_2O \rightleftharpoons H_2CO_3 + 2\,H_2O \quad \ldots(1)$$

And carbonic acid will undergoes further reaction resulting bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) as per (Eq. 2).

$$H_2CO_3 + 2\,H_2O \rightleftharpoons HCO_3^- + H_3O^+ + H_2O \rightleftharpoons CO_3^{2-} + 2H_3O^+ \quad \ldots(2)$$

The result has caused the decrease in pH (Adamczyk et al., 2009). Acidic pH condition could corrode the water piping system and possibly causing toxic metal such as copper, lead and iron

leached into the drinking water (Apera Instrument, 2017).
For example, the corrosion reaction is associated with oxidation of iron:

$$Fe \rightleftharpoons Fe^{2+} + 2e^{-} \dots\dots (3)$$

And the reduction process of free chlorine in water:

$$\frac{1}{2}O_2 + 2H^{+} + 2e^{-} \rightleftharpoons H_2O \dots\dots (4)$$
$$HOCl + H^{+} + 2e^{-} \rightleftharpoons Cl^{-} + H_2O \dots\dots (5)$$

(Eq.3) showed that the reduction of free chlorine in water has contributed to acidic pH.

$$2Fe^{2+} + HOCl + H^{+} + 2e^{-} \rightleftharpoons 2Fe^{3+} + Cl^{-} + H_2O \dots\dots (6)$$

Free chlorine resulted from reaction 3 could oxidized ferrous iron (Fe^{2+}) from (1) into ferric ions (Fe^{3+}) and causing iron corrosion. (Frateur et al., 1999). Prolong negligence on pipe maintenance of WVM could possessed threats on harmful side-effects due to consumption on water from rusted piping.
Besides that, violations of pH in drinking water could be from the absent or un-maintained neutralizing filters of the machines. Neutralizing filter is a part of the treatment device to increase the pH level of water and placed at intake point. This part consist of calcium carbonate (limestone) to reduce the pH and synthetic magnesium oxide to increase the pH of water (United State of Department of Agriculture, 2019). Moreover, neutralizing filters need to be backwashed periodically to remove solid particles in the water. Besides that, machines owners needs to periodically refilling the neutralizing material to ensure this filter is able to work efficiently (United States Environmental Protection Agency New England, 2007).

Although there was no certain correlation between consuming weak acidic water and health threat, pH of water are often related to the water quality aspects. This is because pH of water able to influence the level of metal corrosion, disinfection effectiveness, and heavy metal poisoning due to ingestion of dissolved metals. Besides that, low pH water could corrode piping system in the machine and could cause very serious faulty to the machine itself (World Health Organisation, 2007). Heavy metal exposure has been reported to pose more severe side effect to children such as developmental delays, mental retardation, heart disease, respiratory problems, and many more (Al Osman et al., 2019).

Total coliform results in water samples

Table 4 depicted the samples that recorded total coliform counts.

Table 4: Total coliform counts

Sampling ID	Sampling Point	Total coliform count (CFU/100 ml)
C	Bandar Country Homes	4
D	Taman Sri Batu Caves	10
P	Taman Melawati	13
S	Bukit Indah, Ampang	2

Four samples were detected to consist of total coliforms. Firstly, sample number C, which located at Bandar Country Homes in Rawang was recorded to have 4 CFU/100 ml of total coliforms. Secondly, sample number D in Taman Sri Batu Caves of Batu was reported to have 10 CFU/100 ml of total coliforms. Both of these machines are registered WVMs.

For non-registered WVMs, there were also two machines that were recorded to have the presence of total coliforms. Those were from samples number P and S which located in the mukim of Hulu Kelang. P were recorded to consist of 13 (CFU/100 ml) while S were 2 (CFU/100 ml) of total coliforms. From this result, only P was violating the standards by exceeding 10 (CFU/100 ml).

Table 5 shows the independent sample T-test for total coliform counts for both registered and non-registered WVMs.

Table 5 Independent t-test for total coliform

Parameter	Mean / Std Division		t	P-value
	Registered WVM	Non-Registered WVM		
Total Coliform	1.40 ± 3.27	1.50 ± 4.08	-0.06	> 0.05

Mean of total coliform value for water sample from registered machine was higher (mean: 1.40, SD: 1.50) than mean of total coliform value for water sample from non-registered machine (mean: 1.50, SD: 4.08). Nevertheless, independent t-test analysis shows that there is no significant difference in total coliform value between water samples from registered WVMs and non-registered WVMs (t= -0.06, p>0.05).

Similar to pH result, the difference of total coliform for registered and non-registered WVMs were not significant due to small sample size. Where only 10 samples were taken from each registered and non-registered WVMs. Despite that, these samples' results were still not aligned with total coliform standard <10 CFU/100ml set by Food Safety and Quality, Ministry of Health.

Two of the highest recorded total coliform counts were observed to have garbage placed nearby the WVMs and unsanitary machine and surrounding

conditions. There are high chances that water dispensed from both machines were contaminated by insects like flies that were present at the garbage piles nearby. These flies could also have been perched on the nozzle of these machines which may pollute the water came out from it.

According to Guidelines for Drinking-water Quality by WHO, total coliforms parameters were able to describe the cleanliness and integrity of distribution system and the presence of biofilms. Total coliforms should not be presence in well-sanitized machine and this parameters were giving the rough idea on maintenance sufficiency and machines' condition. Drinking water also may be contaminated during storage as biofilms reformations or cross-contaminations occurrences between stored drinking water with foreign contaminants (World Health Organisation, 2017).

Other possible factors might be the formation of biofilms inside the piping system and inside the nozzle due to lack of maintenance and improper sanitation of the WVMs. Water contaminations during storage could also be happened due to insufficient regulations, limited understanding and awareness among public (Zamberlan da Silva et al., 2008).

Temperature is one of the major factor that affect the growth of total coliforms. One study shows that total coliform growth increases when temperature is higher than 15 °C (Moosa et al., 2015b). *E. coli* growth was reported to be increased when the temperature is between 12-30°C (Prest et al., 2016). With Malaysia experiencing humid weather and averaging daily temperature between 21 - 32°C, total coliform occurrences were expected to be high.

Total coliforms are made from few bacteria which in majority does not possess harm to human health. However, some of the bacteria in water such as *Escherichia coli* (*E. coli*) and *Klebsiella spp.* could possess health hazards to consumers. *E. coli* is the typical form of faecal bacteria, which not only found in human intestinal tract and other warmed-blooded animals, also in faecal-contaminated water supply (An et al., 2002). Despite most of the *E. coli* strains are harmless, but some strains causes' diarrhoea, pneumonia, respiratory disease and many more.

Aluminium content, contributing factors, and possible health effects

Table 6 listed 3 samples that recorded aluminium content reading and their pH value.

Table 6: Aluminium Content vs. pH and turbidity

Sampling ID	Aluminium content (mg/l)	pH @ 25 °C	Turbidity (NTU)
A	0.024	7.32	0.04
L	0.022	6.23	ND<0.01
Q	0.031	6.31	ND<0.01

According to the Water Vending Machine Guidelines from Ministry of Health, the standard for aluminium content is not more than 0.04 mg/l. In this case, all of the samples were within the permissible limit.

One of the samples from registered WVMs, A with 0.024 mg/l of aluminium content with pH of 7.32, but detected a slight reading of turbidity of 0.04 NTU (Turbidity Standard: 0.1 NTU). Interestingly, the other two samples from unregistered WVMs that were recorded aluminium content results; samples L and Q; were violating pH limit but no detectable turbidity were recorded.

Concentration of alum and pH determines the efficiency for turbidity removal (Jaeel & Zaalan, 2017). The most efficient concentration of alum are between 20-30 mg/l where the turbidity removal percentage were between 80-95%. However, when the concentration of alum are at 40 mg/l, a noticeable decrease of turbidity removal percentage were observed. In the same study, the highest turbidity removal were observed at pH 6.1 -6.2 (Jaeel & Zaalan, 2017). A study by Pernitsky and Edzwald also agreed that alum coagulant were very effective in eliminating turbidity at pH 6-7 (Pernitsky & Edzwald, 2006).

Besides that, exposure of high concentration of aluminium in dialysis fluid also could cause dementia among dialysis patients. Long period exposure of high level of aluminium also could impair cognitive function in human such as Alzheimer (Fawell, 2010). Aluminium originally added to dialysate in form of aluminium salts as phosphate binder. However, due to this patients were diagnosed with elevated aluminium concentration in brain tissue and plasma. Due to its high affinity towards proteins, the affected patient showed disorientation, and memory loss and could causing dementia when memory impairment at advance stages (Klotz et al., 2017). According to the safety data sheet of alum by thermo fisher, the lethal dosage, LD_{50} for alum is 2g/kg via ingestion route, but no data for LD_{50} of dermal and inhalation route (Thermo Fisher Scientific, 2012).

Environmental assessments and health impacts

All WVMs were evaluated on three aspects, which were the availability of dispensing nozzle cover, overall machine conditions, and surrounding cleanliness and the rating were depicted in Table 7.

According to the observations, out of ten registered WVMs, only six of them has cover for the dispensing nozzles and surprisingly all of the non-registered WVMs has cover for the dispensing nozzles.

Table 7: Environmental assessments results.

	Dispensing Nozzle Cover	
	Registered WVM	Non-registered WVM
Yes	6	10
No	4	0
	Overall machine conditions	
	Registered WVM	Non-registered WVM
Good	6	3
Satisfactory	3	4
Poor	1	3
	Surroundings cleanliness	
	Registered WVM	Non-registered WVM
Good	7	2
Satisfactory	2	5
Poor	1	3

For overall machine conditions, registered WVMs in general has better machine conditions where six units of WVMs were in good conditions and three units were in satisfactory conditions and only one unit in poor conditions. Meanwhile non-registered WVMs, only three units were in good conditions, four units in satisfactory conditions, and three units were in poor conditions. For machines' surrounding cleanliness criteria, in overall registered WVMs were in better surroundings compared to non-registered ones where seven machines had clean surroundings, two had satisfactory surroundings and only one machine were in dirty surroundings. In the other hand, only three non-registered WVMs had clean surroundings, five were satisfactory, and three were in very poor surroundings.

In general, all WVMs have their own dispending nozzle cover which functioned to protect the dispensing nozzles from cross contamination caused by dust, wild animals, and etc. Four units of registered WVMs which do not have the cover were because the cover doors were broken and yet to be fixed. These might compromised the water safety as the dispensing nozzles were opened to any contamination from the surroundings.

Overall machine conditions for registered WVMs, three registered WVMs were graded as satisfactory due to the missing nozzle cover but the machine conditions were clean. And one unit of registered WVMs was graded as poor because of missing nozzle cover and poor machine conditions where there were many dirty stains as well as rust stains were spotted all over the machine.

For non-registered WVMs, four of the machines were graded satisfactory were either because of dirty and rust stains or some food leftover were spotted on the machine. Meanwhile, three units were graded as poor were because of not only the machine were very dirty, some of the machines were observed to have algae grown inside the dispensing nozzles. These shown that those machines were had little to no maintenance at all. The final criteria is the surrounding conditions which the cleanliness of machines' circumambient were evaluated. Two of the registered and five non-registered WVMs were graded as satisfactory due to the discovery of some water puddles underneath the machines, some rubbish, and grass grown nearby. Whereas one registered and three registered WVMs were graded as poor were due to some machines were placed besides very dirty drains, huge amount of garbage, or wild animals like rats and flies were spotted nearby the machines.

In general, environmental assessment towards WVMs and its surroundings giving the rough ideas on whether the water came from the machines are safe to be consumed. Poorly maintained WVMs could pollute the water from the rust of the piping system and the inefficiency of badly maintained filtration system. An article from The Star in 2019 mentioned that, our treated water was reported had a hardness level below 100 mg due to the presence of dissolved heavy metals such as cadmium, copper and lead. These water has high tendency to corrode piping system (The Star, 2019).

Hardness in drinking water plays an important role for aesthetic acceptability as well as operational considerations (Sengupta, 2013). Besides that, locations of the WVMs also plays an important role in determining the safety of drinking water. In this study, four of 20 WVMs rates as poor for both machine conditions and surrounding cleanliness. They are B, D, P, and S. According to water sample results obtained, these 4 samples were reported to have total coliform reading from the respective samples. The Centre for Disease Control (CDC) of United States estimated that around 32 million cases of annual acute gastrointestinal illness were from public drinking water system (Wright et al., 2004).

CONCLUSION

The water quality assessment and environmental assessment were found to be effective in this study. The results acquired were able to indicate the overall water quality as well as its safety between water from registered and non-registered water vending machines from all over Gombak district.

For physical characteristic assessments which involving pH, colour, and turbidity level; only one samples from registered WVM was violating pH standard while four samples from non-registered WVM were under the pH standard. Out of 20 samples from both registered and non-registered WVM, only one sample from registered WVM recorded a turbidity level reading but it was still within the permissible level. Meanwhile, there were no samples neither from registered nor non-registered WVM were violating colour standard.

For chemical parameters, both chloroform and nitrite (NO_2^-) were not detected in any samples neither from registered nor non-registered WVM. In the meantime, aluminium concentration were detected in one samples from WVM (0.24 mg/l) and two samples (0.022 and 0.031 mg/l) from non-registered WVMs. However all three reading were still within standard of 0.04 mg/l.

For microorganism parameters, total coliform reading has been detected in four samples. Two samples from registered WVMs were recorded 4 and 10 CFU/100 ml, while two samples from non-registered WVMs were recorded 2 and 13 CFU/100 ml of total coliform. Finally for environmental assessment, registered WVMs collectively were in better conditions compared to non-registered water vending machines. Besides that, registered water vending machines also have cleaner surrounding compared to the non-registered ones.

In overall, only two registered WVMs were violating any of the parameters' standard. On the other hand, 6 out of 10 samples from non-registered WVMs were violating any other parameters. In conclusion, registered WVMs were better in both water quality analysis and environmental assessment compared to non-registered WVMs.

REFERENCES

Adamczyk, K., Prémont-Schwarz, M., Pines, D., Pines, E., & Nibbering, E. T. J. (2009). Real-time observation of carbonic acid formation in aqueous solution. *Science*, *326*(5960), 1690–1694.

Al osman, M., Yang, F., & Massey, I. Y. (2019). Exposure routes and health effects of heavy metals on children. *BioMetals*, *32*(4), 563–573.

An, Y. J., Kampbell, D. H., & Peter Breidenbach, G. (2002). Escherichia coli and total coliforms in water and sediments at lake marinas. *Environmental Pollution*, *120*(3), 771–778.

Apera Instrument. (2017). *The Importance of PH*. Apera Instrument. https://aperainst.com/blog/why-ph-is-important/

Fawell, M. J. K. (2010). Aluminium in drinking-water, Background document for development of WHO. *Journal of Guidelines for Drinking-Water Quality (GDWQ)*, 8–23.

Food Safety and Quality Ministry of Health. (2020). *License Application Guidelines for Operating Water Selling Machines for Trade and Business*.

Frateur, I., Deslouis, C., Kiene, L., Levi, Y., & Tribollet, B. (1999). Free chlorine consumption induced by cast iron corrosion in drinking water distribution systems. *Water Research*, *33*(8), 1781–1790.

Jaeel, A. J., & Zaalan, S. A. (2017). Calculation the Optimum Alum Dosages Used in Several Drinking Water Treatment Plants in WASIT Governorate (IRAQ) and Investigation the Effect of pH on Alum Optimum Dosages . *Icocee – Cappadocia 2017*, *January*, 1–10.

Klotz, K., Weistenhöfer, W., Neff, F., Hartwig, A., Van Thriel, C., & Drexler, H. (2017). The health effects of aluminum exposure. *Deutsches Arzteblatt International*, *114*(39), 653–659.

Moosa, M. E. Al, Khan, M. A., Alalami, U., & Hussain, A. (2015b). Microbiological Quality of Drinking Water from Water Dispenser Machines. *International Journal of Environmental Science and Development*, *6*(9), 710–713.

Pernitsky, D. J., & Edzwald, J. K. (2006). Selection of alum and polyaluminum coagulants: Principles and applications. *Journal of Water Supply: Research and Technology - AQUA*, *55*(2), 121–141.

Prest, E. I., Hammes, F., van Loosdrecht, M. C. M., & Vrouwenvelder, J. S. (2016). Biological stability of drinking water: Controlling factors, methods, and challenges. *Frontiers in Microbiology*, *7*(FEB), 1–24.

Price, J. H., Murnan, J., & Moore, B. (2006). Soft Drink Vending Machines in Schools: A clear and present danger. *American Journal of Health Education*, *37*(5), 306–314.

Sengupta, P. (2013). Potential health impacts of hard water. *International Journal of Preventive Medicine*, *4*(8), 866–875.

The Star. (2019). *4 reasons why your water purifier needs regular maintenance*.

Thermo Fisher Scientific. (2012). Safety Data Sheet Aluminum Potassium Sulfate Dodecahydrate. *The OSHA Hazard Communication Standard 29 CFR 1910.1200*, *4*(2), 1–6.

United State of Department of Agriculture. (2019). *Drinking Water Treatment*. United State of Department of Agriculture. https://drinking-water.extension.org/drinking-water-treatment-ph-adjustment/#:~:text=Soda ash%2Fsodium hydroxide injection,-How soda ash&text=This treatment method is used,hardness problems in treated water.)

United States Environemtal Protection Agency New England. (2007). pH-Acidity of Private Drinking Water Wells. In *Healthy Drinking Waters of MAssachusetts*.

World Health Organisation. (2007). pH in drinking-water. *Guidelines for Drinking Water Quality*, *2*(2), 1–7.

World Health Organisation. (2017). *Guideline fo Drinking Water Quality*.

Wright, J., Gundry, S., & Conroy, R. (2004). Household drinking water in developing countries: A systematic review of microbiological contamination between source and point-of-use. *Tropical Medicine and International Health*, *9*(1), 106–117.

Zamberlan da Silva, M. E., Santana, R. G., Guilhermetti, M., Filho, I. C., Endo, E. H., Ueda-Nakamura, T., Nakamura, C. V., & Dias Filho, B. P. (2008). Comparison of the bacteriological quality of tap water and bottled mineral water. *International Journal of Hygiene and Environmental Health*, *211*(5–6), 504–509.

MAEH Journal of Environmental Health eISSN 2637-1359
Jurnal Kesihatan Persekitaran MAEH
Published By Malaysian Association of Environmental Health
http://www.maeh4u.org.my/journal

RESEARCH ARTICLE

Exposure Concentration of Heavy Metals in Indoor Air of FELDA Bukit Goh's Residential Area

Ahmad Firdaus Shafie, Megat Azman Megat Mokhtar*

Centre of Environmental Health and Safety, Faculty of Health Sciences, Universiti Teknologi MARA Selangor, Puncak Alam Campus, Selangor, Malaysia

**Corresponding author: megat729@uitm.edu.my*

Abstract

Introduction: Bauxite mining activity emits Heavy Metals (HMs) to the ambient air and may subsequently implicate the indoor air of residential area in Felda Bukit Goh, Kuantan, thus raising concern of HMs poisoning from exposure through inhalation. **Objective:** Study was performed to measure the concentration of HMs Al, Cd, Fe, Pb and Zn in indoor air of 25 selected houses in proximity to bauxite mining sites (Sample Location 1) and another 25 selected houses farther from bauxite mining sites (Sample Location 2). Next is to compare between the two areas and lastly to assess the potential health risk effects from exposure through inhalation by estimating health risk assessment. **Methodology:** A total of fifty samples of indoor air inside residential houses in Felda Bukit Goh were collected by using air sampling pumps, were digested appropriately and analyzed by AAS for five elements. **Result:** All five elements were detected in the indoor air of the houses at both Sample Location 1 and 2 with the variation order Fe > Al > Zn > Pb > Cd and Fe > Pb > Al > Zn > Cd respectively, and with mean concentration ranging from 0.0043 to 0.0259 mg/m3 and from 0.0038 to 0.0149 mg/m3 respectively. The p-value for all HMs except for Cd are lesser than 0.05, signifying that there is significant difference of most HMs concentration between the two areas, and Sample Location 1 is generally higher in concentration. The non-carcinogenic health risk of HMs was estimated by hazard quotient (HQ) and hazard index (HI) and the results showed that the HI value for both areas exceed the safe limit (HI>1), indicating non-carcinogenic health effects exist in present condition. Whereas, the carcinogenic health risk of HMs was estimated by cancer risk (CR) and the result showed that Cd is also above the threshold value, thus the carcinogenic health effects exist and likely to be of threat. **Conclusion:** Both non-carcinogenic and carcinogenic negative health effects are currently present at both areas in Felda Bukit Goh and may pose health deterioration to the locals through chronic inhalation exposure.

***Keywords*:** Heavy metals, Health risk assessment, Indoor air, Air sampling pump

INTRODUCTION

Bauxite mining causes plethora of environmental and health impacts by generating pollutants like particulate matter (PM) and chemical compounds like heavy metals (HMs) to the ambient air thus causing air pollution (Abdullah, Mohamed, Sulaiman, Zakaria, & Abdul Rahim, 2016; Al-Khashman, 2004). Concentration of PM and HMs in the ambient air can influence the concentration of the same pollutants in the indoor air from the transfer of pollutants into buildings through various means (WHO, 2016). Järup (2003) and Kurt-Karakus (2012) found that HMs in the indoor air like cadmium and lead may pose negative health complications including carcinogenic and non-carcinogenic effects from exposure through inhalation.

Despite the stop work order and moratorium commencement in Kuantan, Pahang, there were still reports stating that illegal mining is secretly being done by private sectors from unknown agencies (Abdullah et al., 2016). Out of hundreds of bauxite miners, only 21 are licensed and only 7.6 hectare of lands were approved. Moratorium is for the recuperation of the state and for repairing of the infrastructures like roads, houses and more, yet illegal practices are still being done.

METHODOLOGY

This study that was mainly adapted from a research conducted by Yeboah (2008) and Liu et al. (2015) and was performed to measure the concentration of HMs Al, Cd, Fe, Pb and Zn in indoor air of 25 selected houses located in the area that is in proximity to bauxite mining sites, which is approximately 0.5 to 1.5 km away from the mining sites (regarded as Sample Location 1 henceforth) and another 25 selected houses located farther, which is approximately 1.5 km to 3.0 km away from the mining sites (regarded as Sample Location 2 hereafter). A total of fifty samples of indoor air inside residential houses in Felda Bukit Goh were collected by using air sampling pumps, were digested appropriately and analyzed by AAS for the stated five elements.

Air sampling

Air sampling is done by utilizing air sampling equipment Sensidyne's GilAir-3 and GilAir-5 Air Sampling System. To collect the suspended dusts in the air, the media used is Mixed Cellulose Ester (MCE) membrane filter with pore size of 0.8 µm, specific to sample HMs-carrying dusts. The air sampling pump is placed indoor of the selected houses, 130cm above floor, in the middle of an area like living room, at least 2m away from windows and doors and 1m away from wall, with flow rate of 1 to 3 L/min (Hassanvand et al., 2014). Sampling is adopted based on Method 7013 from NIOSH Manual of Analytical Methods (NMAM), Fourth Edition. The sampling time inside the house is 8 hours (typically from 8am to 4pm). The cassettes are labeled according to sampling points (selected houses) and stored in an airtight and re-sealable laboratory plastic bag to prevent contamination during storage and transport.

Acid digestion and Heavy Metals Analysis

The cassettes are brought back to Environmental Instrumentation Laboratory in Faculty of Health Sciences, UiTM Puncak Alam. Acid digestion is based on Method 7300 and 7013 of NIOSH Manual of Analytical Methods (NMAM) and adapted from the work by Latif, Abidin, & Praveena (2015). MCEs are weighed for final weight (MCE + HMs), digested on hot plate in mixture of concentrated nitric acid (HNO3 and H2O2 in a ratio of 4:1) and diluted with deionised water up to 100 mL, then filtered through a 0.45-lm Millipore filter paper (Whatman 41) to obtain a clear solution. Solution samples are labeled accordingly and stored in a chiller of temperature 0-4oC before HMs analysis. The samples are then tested for Al, Cd, Fe, Pb and Znc concentrations by using Atomic Absorption Spectrophotometer (AAS) Perkin-Elmer Model AAnalyst 900.

Estimation of Health Risk Assessment for Adults via Inhalation Route

The Estimation is accomplished by calculating the chemical daily intake via inhalation route (CDIinh) then calculating hazard quotient (HQ) for non-carcinogens (Al, Fe and Zn) and lastly calculating the hazard index (HI) to characterize the non-carcinogenic health effects of the non-carcinogens. Similar to HQ and HI, Cancer Risk (CR) is calculated for carcinogens (Cd and Pb) to characterize the carcinogenic health effects of the carcinogens. CDIinh (mg/kg/day) can be computed through a formula developed by USEPA:

$$\mathrm{CDI_{inh}(mg/kg/day)} = \mathrm{C} \times \frac{\mathrm{Rinh} \times \mathrm{Fexp} \times \mathrm{Texp}}{\mathrm{ABW} \times \mathrm{Tavrg}}$$

Equation (1)

Where C is the mean concentration of indoor air HMs (mg/m3); Rinh is the inhalation rate, that is 20m3 day-1 for adults (Van den Berg, 1994); Fexp is the exposure frequency, that is 350 day year-1 (Lina Thabethe, Engelbrecht, Wright, & Oosthuizen, 2014); Texp is the exposure duration, that is 24 years for adults (USEPA, 2001); ABW is the average body weight, that is 70 kg for adults (USEPA, 2001); Tavrg is the averaging time in days, that is 22,550 for carcinogenic elements and Texp x 365 for non-carcinogenic elements (Abbasi & Tufail, 2013; Kurt-Karakus, 2012).

Next, by substituting values from Table 1 into the following equations, HQ, HI and CR are quantified.

$$\textbf{Hazard Quotient (HQ)} = \frac{CDIinh}{RfD}$$ Equation (2)

$$\textbf{Cancer Risk (CR)} = CDIinh \times CSFinh$$ Equation (3)

$$\textbf{Hazard Index (HI)} = \sum_{1}^{n} HQal + HQcd + HQfe + HQpb + HQzn$$

Equation (4)

Table 1 Recommended values in equation according to appropriate references.

	RfD for CDI_{inh} (mg/kg/day)	Reference	CSF_{inh} for CR (mg/kg/day)	Reference
Al[a]	4.0E–4	IRIS USEPA (1987)	-	-
Cd	1.0E–3	Kurt-Karakus (2012) and USEPA (2010)	1.5E+1	OEHHA (2009)
Fe[b]	7.0E–1	Hu et al. (2011)	-	-
Pb	3.5E–3	Kurt-Karakus (2012) and USEPA (2010)	4.2E–2	OEHHA (2009)
Zn	3.0E–1	Kurt-Karakus (2012) and USEPA (2010)	-	-

[a] RfD value of Al is substituted with Aluminum phosphide due to unavailability.
[b] RfD value of Fe is adopted from a different literature as compared to other RfD values.

RESULTS AND DISCUSSION

Interpretation and Comparison of Heavy Metals Concentration in Indoor Air of Residential Houses between Sample Location 1 and Sample Location 2

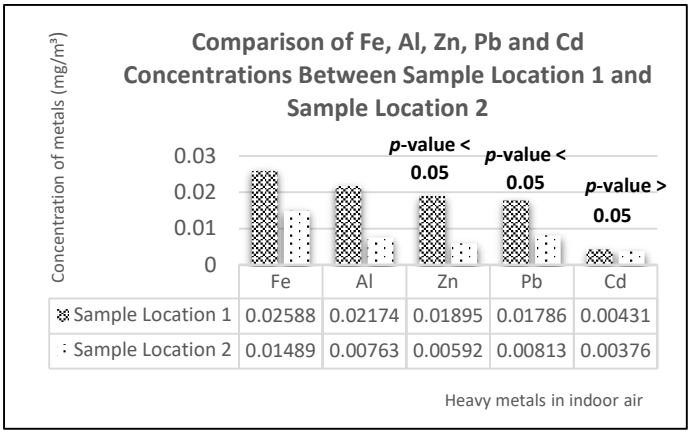


Fig.1 Mean Concentration in Sample Location 1 and Sample Location 2

Referring to Figure 1, all five elements were detected at both Sample Location 1 and Sample Location 2. At Sample Location 1, the order of elements detected according to concentration is Fe > Al > Zn > Pb > Cd. Sample Location 2 follows the variation order of Fe > Pb > Al > Zn > Cd. In general, the mean concentration of all the selected HMs in indoor air of Sample Location 1 is higher than Sample Location 2. Referring to Figure 1, The HM that dominates both sample locations is Iron (Fe), with the mean concentration of 0.0259 mg/m3 and 0.0149 mg/m3 respectively. A similar is result attained from Ntziachristos et al. (2007) and Shah & Shaheen (2007). The huge amount of Fe is hardly shocking because Fe is known for its abundance in the crust of the earth (Feng & Wang, 2012; Mohd Talib Latif et al., 2014). For Sample Location 1, second to Fe is Aluminum (Al) with the mean concentration of 0.0217 mg/m3 whereas for Sample Location 2, Fe is followed by Lead (Pb) with mean of 0.0081 mg/m3. Al-Khashman (2004) mentioned that contiguous to Fe, Al is also a naturally ample element in the soil and it can be float up into the air due natural or anthropogenic activities (Yap, Chew, & Tan, 2012). Due to the farther distance between Sample Location 2 and mining area, Aluminum that is copious in the bauxite mine only come in third after Pb. Pb which is second for Sample Location 2 and fourth for Sample Location 1 but still

higher in the latter (0.0179 mg/m3), may be due to anthropogenic sources in indoor and outdoor environment (Fergusson & Ryan, 1984). The fourth most concentrated HM at Sample Location 2 is Zinc (Zn), found to be 0.0059 mg/m3 and third at Sample Location 1, found to be 0.0189 mg/m3. Zn at the latter is higher because according to Nriagu (1988), Zn is also one of the HM emitted from anthropogenic mining like smelting and refining. Furthermore, Zn is also a widely known as a function of emission from indoor wall paints (Mohd Talib Latif et al., 2014). The most cancerous and fortunately the least highly concentrated HM is Cadmium (Cd) with 0.0043 mg/m3 and 0.0038 mg/m3 in Sample Location 1 and 2 respectively. According to the investigation by Fergusson & Ryan (1984), Cd, Pb and several other HM are extremely concentrated in households and are of anthropogenic origin from both indoor and outdoor atmosphere. Furthermore, Al-rajhl & Madany (1996) assert that Cd in particular could be due to vehicular emission and so forth.

It can be statistically described that the levels of Fe, Al, Zn and Pb contamination in indoor air in Sample Location 1 is proven to be greater than the level of contamination of the same elements in Sample Location 2 (p-value less than 0.05 for all the four HMs). Also, the difference in means of Cd between Sample Location 1 and Sample Location 2 is statistically not significant by p-values more than 0.05.

Results from this study is in agreement with Yeboah (2008), who once proved his similar hypothesis where the associated respiratory diseases, cold, cough and skin diseases from exposure to airborne particulate matters and chemical compounds among population is directly proportional to the distance from the active mine sites. Another research is also consistent where the associated respiratory diseases such as asthma and rhinoconjuctivitis are prevalent in children in a community that is 2.1 km apart from the gold and copper mining site compared to a population that is 2.0 km away from the site (Herrera et al., 2016). Although not quite the same source of air pollution, but both Jabeen et al. (2001) from Pakistan and Puett et al. (2014) from United States verified that the concentration of certain HM in indoor and the associated incidence of lung cancer is connected to the factor of proximity of the houses to sources of air pollutants arising from busy road occupied with traffic emissions and industrial activity releases. Findings by Al-rajhl & Madany (1996) demonstrated that the households nearby to industrial area and heavy motorcar traffic showed a considerably high concentration of toxic trace metals.

The overall higher concentration at Sample Location 1 could be due to indoor contributions like residents are practicing domestic fuel burning cooking, tobacco smoking and cleaning activities. Furthermore, Li et al. (2016) stressed that high levels of Cd, Pb and Zn can arise from wall paints. Indoor environment that contain carpet and clothing fibers, microbes and garden soil also give rise trace HMs (Fergusson & Ryan, 1984). Jabeen et al. (2001) also conclude that HM concentration inside houses they investigated depend on the natural or mechanical ventilation system of the house, which in turn is affected by loading of HMs into the house. Illegal mining operation is also a contributor to the concentration (Abdullah et al., 2016). Movement of illegal transportation trucks carrying bauxite ores heading out of the area is causing the roadways and ambient air to be tainted with red dust. Houses that are located along the streets are affected when wind carry the dusts into the indoor air (Holmes & Eisner, 2003; Lina Thabethe et al., 2014).

Indoor Air Heavy Metal Concentration in Comparison with Established International Air Quality Standards

The HMs concentration obtained were first compared with local occupational USECHH Regulations 2000 and all the HM concentrations are within the recommended permissible exposure limits range. The maximum allowed concentration (in mg/m3) according to USECHH is Al: 10; Fe: 5, Pb: 0.05; Zn: 10; Cd: 0.01. Since USECHH is an occupational standard and the study location is a community area, another comparison is made for element Cd and Pb with international two standards from 'Community Metals Concentration of Concern. Referring to Table 2, both elements at both Sample Locations are not within compliance of these two standards. The basis of EPA to making these standards as strict and low as they are now is because these HMs (Pb and Cd) in rural and urban zones are of exceptional concern due to the great number of citizens. However, the mean concentration alone does not infer that the same concentration is being exposed to the human population (USEPA, 2005). Hence, measurement is coupled with HRA to associate the mean concentration with the exposure towards human beings and ultimately characterize the human health status (Smolders & Degryse, 2002).

Table 2 Heavy Metals Mean Concentration at Sample Location 1 and Sample Location 2 vs Community Metals Concentration of Concern and Compliancy Status.

Metal	Concentration of Heavy Metals in Indoor Air of FELDA Bukit Goh ($\mu g/m^3$)		U.S National Ambient Air Concentrations for Rural Area[a] ($\mu g/m^3$)	European Union Air Quality Standard ($\mu g/m^3$)	Compliance
	Sample Location 1	Sample Location 2			
Cd	4.3	3.8	0.001	0.005	Not comply
Pb	17.9	8.1	0.02	0.5	Not comply

Health Risk Assessment (HRA) of Exposure to Heavy Metals via Inhalation

The HQ values for non-carcinogenic effects of non-carcinogens, Sample Location 1 was in the order of Al > Zn > Fe. Whereas for Sample Location 2, the order goes Al > Fe > Zn. HQ is calculated by applying Equation 2 and by using the recommended RfD values listed in Table 1. By referring to note from Table 1, usually, in the event of absence of RfD of a certain element, the HQ value is not calculated at all and is disregarded. Therefore, the peculiar order of HQ for both sample locations are due to this reason. If Al and Fe is neglected due to their absence of RfD, no HQ can be calculated since there is no non-carcinogenic HMs left that is applicable for estimation of HQ.

Table 3 HQ and HI for Non-Carcinogens Al, Fe and Zn and CDlinh and CR for carcinogens Cd and Pb

Element	Route of Exposure	Sample Location 1		Sample Location 2		Sample Location 1	Sample Location 2
		HQ	HI	HQ	HI	CR	CR
Al	Inhalation	5.095	14.89	1.785	5.22	N/A	
Fe		3.476×10^{-3}		1.999×10^{-3}			
Zn		5.917×10^{-3}		1.847×10^{-3}			
Cd		N/A				6.059×10^{-3}	5.355×10^{-3}
Pb						7.060×10^{-5}	3.196×10^{-5}

Referring to Table 3, HI values for both Sample Location 1 and Sample Location 2 showed to be greater than 1, that is 14.89 and 5.22 respectively, which indicates that there shall be concern

for potential non-carcinogenic chronic effects of the HMs to human health (Liu et al., 2015). The HI value that is less or equal to 1 is acknowledged as a safe limit of exposure in which there is zero adverse health effects due to the exposure concentration (USEPA, 2001). Similarly, Lemly (1996) and Lina Thabethe et al., (2014) have established a guideline for interpreting and characterizing HI. The following is the guideline: HI <0.1: no hazard exists; HI 0.1-1.0: low hazard; HI 1.1-10: moderate hazard; and HI >10: high hazard. The HI for Sample Location 1 which is 14.89 was above 10, which means the population there was at high risk of negative health effects from chronic exposure to the HMs. Meanwhile, the HI for Sample Location 2 is 5.22; above 1.1 yet below 10; which indicates that the residents were at low moderate risk and it is likely that they may have experienced some of the negative symptoms (Lina Thabethe et al., 2014).

The cancer risk (CR) for Pb and Cd were calculated using Equation 3. Table 3 depicts the CR value where the order is Cd > Pb for both sample locations. The upsetting result of 6.059 x 10-3 and 5.355 x 10-3 of Cd for Sample Location 1 and 2 respectively are worrying as they both exceed the range that has been deemed acceptable by corresponding regulatory authorities. This suggest that chronic carcinogenic risks of Cd from exposure to the indoor air are present and are of concern, thus cannot be neglected (Liu et al., 2015).

CONCLUSION

Indoor air of Felda Bukit Goh, Kuantan, Pahang were selected to determine the concentration of heavy elements and to assess the potential carcinogenic (only from Pb and Cd) and non-carcinogenic health risk effects. The health risk of HMs in indoor air was measured by calculating the HI and CR values of HMs which indicated the presence of both non-carcinogenic and carcinogenic negative health effects at both Sample Locations in Felda Bukit Goh and may pose health deterioration to the locals through chronic inhalation exposure. The limitations of this study are that should be understood that the estimated risk is affected by a substantial degree of uncertainties. Nonetheless, exposure health risk assessment has proved in hundreds of previous literary works to be a powerful tool to estimate the health risks from HMs exposure (Du et al., 2013). Furthermore, the absence of reference dose (RfD) or reference concentration (RfC) for certain heavy metals like Fe and Al forces the estimation to advance but by employing values from other references. These facts shall act as the prerequisite of using the results from this study. Instead, the results presented here should be regarded as preliminary, thus call for the need of further research.

ACKNOWLEDGEMENT

The authors would like to thank the residents of Felda Bukit Goh for their support to the study.

REFERENCES

Abbasi, M. N., & Tufail, M. (2013). Health Risks Assessment for Heavy Elements Suspended in Dusty Air along Murree Highway, Pakistan. *American-Eurasion J. Agric. & Environ. Sci*., 13(3), 372–377.

Abdullah, N. H., Mohamed, N., Sulaiman, L. H., Zakaria, T. A., & Abdul Rahim, D. (2016). Potential health impacts of bauxite mining in Kuantan. *Malaysian Journal of Medical Sciences*, 23(3), 1–8.

Al-rajhl, M. A., & Madany, W. C. (1996). Metal levels in indoor and outdoor dust in Riyadh, Saudi. *Environment International*, 22(3),315-324.

Du, Y., Gao, B., Zhou, H., Ju, X., Hao, H., & Yin, S. (2013). Health Risk Assessment of Heavy Metals in Road Dusts in Urban Parks of Beijing, China. *Procedia Environmental Sciences*, 18, 299–309.

Herrera, R., Radon, K., Von Ehrenstein, O. S., Cifuentes, S., Moraga Muñoz, D., & Berger, U. (2016). Proximity to mining industry and respiratory diseases in children in a community in Northern Chile: A cross- sectional study. *Environmental Health*, 1–10.

Jabeen, N., Ahmed, S., Hassan, S. T., & Alam, N. M. (2001). Levels and sources of heavy metals in house dust. *Journal of Radioanalytical and Nuclear Chemistry*, 247(1), 145–149.

Järup, L. (2003). Hazards of heavy metal contamination. *British Medical Bulletin*, 68, 167–182.

Kurt-Karakus, P. B. (2012). Determination of heavy metals in indoor dust from Istanbul, Turkey: Estimation of the health risk. *Environment International,* 50, 47–55.

Latif, M. T., Yong, S. M., Saad, A., Mohamad, N., Baharudin, N. H., Mokhtar, M. Bin, & Tahir, N. M. (2014). Composition of heavy metals in indoor dust and their possible exposure: A case study of preschool children in Malaysia. Air Quality, *Atmosphere and Health*, 7(2), 181–193.

Lemly, A. D. (1996). Evaluation of the hazard quotient method for risk assessment of selenium. *Ecotoxicology and Environmental Safety*, 35(2), 156–162.

Li, Y., Pi, L., Hu, W., Chen, M., Luo, Y., Li, Z., Ding, S. (2016). Concentrations and health risk assessment of metal(loid)s in indoor dust from two typical cities of China. *Environmental Science and Pollution Research,* 23(9), 9082–9092.

Lina Thabethe, N. D., Engelbrecht, J. C., Wright, C. Y., & Oosthuizen, M. A. (2014). Human health risks posed by exposure to PM10 for four life stages in a low socio-economic community in South Africa. *Pan African Medical Journal*, 18, 1–12.

Liu, X., Zhai, Y., Zhu, Y., Liu, Y., Chen, H., Li, P., Zeng, G. (2015). Mass concentration and health risk assessment of heavy metals in size-segregated airborne particulate matter in Changsha. *Science of the Total Environment*, 517, 215–221.

Nriagu, J. O. (1988). A silent epidemic of environmental metal poisoning? *Environmental Pollution*, 50(1–2), 139–161.

Ntziachristos, L., Ning, Z., Geller, M. D., Sheesley, R. J., Schauer, J. J., & Sioutas, C. (2007). Fine, ultrafine and nanoparticle trace element compositions near a major freeway with a high heavy-duty diesel fraction. *Atmospheric Environment*, 41(27), 5684–5696.

Puett, R. C., Hart, J. E., Yanosky, J. D., Spiegelman, D., Wang, M., Fisher, J. A., Laden, F. (2014). Particulate matter air pollution exposure, distance to road, and incident lung cancer in the nurses' health study cohort. *Environmental Health Perspectives*, 122(9), 926–932.

USEPA. (2005). Chapter 7 Characterizing Risk and Hazard. Human Health Risk Assessment Protocol, 1–15.

USEPA. (2001). Risk Assessment Guidance for Superfund (RAGS) Volume III - Part A: Process for Conducting Probabilistic Risk Assessment, Appendix B. Office of Emergency and Remedial Response U.S. Environmental Protection Agency, III (December), 1–385.

Yeboah, J. Y. (2008). Environmental and Health Impact of Mining on Surrounding Communities: A Case Study of Anglogold Ashanti in Obuasi, (August). Kwame Nkrumah University of Science and Technology.

MAEH Journal of Environmental Health eISSN 2637-1359
Jurnal Kesihatan Persekitaran MAEH
Published By Malaysian Association of Environmental Health
http://www.maeh4u.org.my/journal

RESEARCH ARTICLE

Assessment of Drinking Water Quality and Environmental Conditions of Vending Machine in Larut, Matang and Selama (LMS), Taiping, Perak, Malaysia

Muhamad Yusof Abdul Fuzi[a], Siti Rohana Mohd Yatim[b*], Nur Ain Mohd Zainuddin[c]

[a] Pejabat Kesihatan Daerah Larut, Matang, dan Selama, Taiping, Perak, Malaysia
[b] Centre for Environmental Health and Safety studies, Faculty of Health Sciences, Universiti Teknologi MARA Cawangan Selangor, Puncak Alam,Selangor, Malaysia
[c] Research Group (i-STRonG), School of Chemical Engineering, College of Engineering, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia

*Corresponding author: sitirohana@uitm.edu.my

Abstract

Water vending machines are widely used in public areas particularly in urban regions. Assessment of physico-chemical and microbiological parameters that can alter the quality of drinking water is essential for the prevention of waterborne diseases outbreak in the future. The aim of this study was to determine the performance and water quality of vending machines (WVMs) in the LMS district of Perak. In this study, out of 15 WVMs, only 2 machines were grading as satisfactory level based on observation survey. Analysis of physico-chemical parameter indicated all the water samples tested were found complied for pH value (6.40-7.40), while not complied for turbidity (0.22-1.47 NTU). There was only one WVM that incompliance for residual chlorine with 0.11 mg/L to the Food Regulations 1985 (25th Schedule). There were 5 vending machines detected total coliform (1.0-56.8MPN/100 mL) and none of *E.coli* detected for microbiological analysis. There was correlation found between the total coliform and pattern maintenance (r= -0.718; n= 15; p= 0.003). In overall, this study shows that each installed WVM must be maintained on a regular basis in order to ensure that drinking water is always safe for drinking purposes and to prevent the growth of harmful microorganisms.

Keywords: Vending machine, drinking water, coliform, *Escherichia coli*, public health

INTRODUCTION

Water is vital in people's daily lives as it is used for domestic, public and industrial, trade and agriculture purposes. Most percentage of the country's total water supply is for domestic use. Examples of domestic uses are including for drinking, food preparing and cooking, bathing, car washing, washing clothes and dishes and other purposes. Moreover, water is also recognized by all forms of life as one of essential basic elements to survive, including humankinds, flora, and fauna which frankly said, all may be died without water. It is continuing be an integral component for numerous processes of vital biochemical in human being [1]. For instance, water uses for cells, tissues and organs to help regulate temperature of body and maintain other bodily functions. It is encouraged that for every person is required to drink at least 8 glasses of plain water as equal as 2 L each day to maintain their good health [2]; the water need is increased to 3.3 L for man with modest physical activity and can be up to 4 till 5 L for active man [3].

In today's modern era, where time is equivalent to money, the rapidity of services becomes a significant factor affecting decision making which including water supplies [4]. In meeting such demand, the supply of filtered water like vending machine (VM) has been continue to gain encouraging response from consumers since it was first introduced. The number of water vending machine (WVM) vendors recently increasing in our country has made it easy for public to obtain filtered drinking water. The use of WVM is common among our Malaysian even though its safety for human consumption still remains unclear.

Basically, water vending machine (WVM) is defined as an automatic self-service machine that dispenses water into the container when sufficient coins, bills or tokens are inserted [5].

One of the great reasons may because they are readily available and sold at a low price, which be considered as a great choice for families or individuals without home water filter machine. Malaysian citizen thought on vending machine (VM) is the water produced by it safe to drink because they rely on the advertisement by the company provider not from the public health perspective [6]. But at the same time there is a lot of news that gone viral about this water quality from various sources and this has caused some users to doubt the content of drinking water on the VM.

Notwithstanding well-designed WVMs are established and provided water treatments via reverse osmosis (RO), which believed can retain 99 percent of bacterial cell on the membrane, leaving less than 50 cell/mL in drinking water [7-8]; there are still possibilities for microbe to be transmitted to WVM. The sanitation conditions and drinking water quality related to health would be potentially influenced by numerous microbes due to the low hygienic conditions of WVMs and improper environments [9]. Coliform bacteria can colonize the carbon filters of WVM resulting in high concentration of coliform bacteria in the final vended water. A researcher from Philippines was revealed that 8 water samples taken from 8 public schools in Cebu City registered a total coliform count of 2.6 CFU/mL, while specific *E.coli* testing posted (<1.1 to 2.6 CFU/mL) [10]. These data are higher than the national standard for permissible value for clean water (<1.1/100 ml) and international standard of 0.00 CFU/100ml except in 2 schools that fall within the normal level (<1.1 CFU/mL).

Another researcher also highlighted that 6 out of 14 samples randomly picked from some locations in Kuala Lumpur were found to have either coliform or *Escherichia coli* (*E. coli*) and did not contained enough free chlorine for disinfection purpose [11]. The similar cases were also reported by some researchers in Los Angeles and Dubai. All incidents were concluded to be related to the poor maintenance and improper hygienic conditions of WVM [12-13]. Maintenance and water quality are inseparable. Inadequate maintenance and low sanitation service is a part of man-made factor that usually related to the growth of heterotrophic organisms in water. For example, the physicochemical parameters (such as temperature, pH and dissolved organic compounds) can influence the growth of bacteria in surfaces of water dispensers [14].

Hence, the aim of this study is to assess and evaluate whether the quality of water supplied from VMs comply with physical and microbiological parameters set by the National Standard for Drinking Water Quality 2004 [15].

MATERIALS AND METHODS

Study location

This study was conducted in Larut, Matang, and Selama (LMS) district, Taiping Perak (Fig. 1). LMS is bordered on the north by the state of Kedah, on the south by the Manjung District, on the northwest by the Kerian District and on the east by the Hulu Perak and Kuala Kangsar Districts.

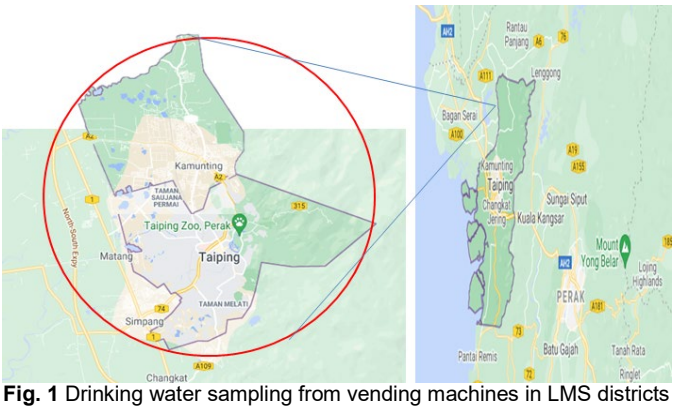


Fig. 1 Drinking water sampling from vending machines in LMS districts area.

Maintenance review and observation

Surrounding environment of where the water vending machine (WVM) located were observed in order to identify any potential risk that may affects the quality of water from vending machine (VM). A certified checklist was used to examine and observe for each WVM that involved in the study such as environmental surroundings, machine condition, hygiene status, and quality of filtered drinkable water, and most recent maintenance date. The checklist was used for score marking, which consists of 16 items. Each item that considered performed and done, had been given '1', whereas, if any not done or not known was scoring '0'. Total marks for every WVM had been categorized under low or moderate or high level (Table 2).

Table 2 Grading of observation score.

	Total possible score	Low/Poor <80%	Moderate/Satisfy 80-90%	High/Good >90%
Observation	0-16	0-12	13-14	15-16

Water sampling and analysis

A total of 15 samples of water drinking were collected randomly from water vending machines (WVMs) placed in 11 areas (Kampung Jambu, Medan Kamunting, Taman Jana, Taman Lela, Taman Jana Setia, Taman Saujana 2, Taman Jana Mulia, Medan Kamunting Jaya, Kampung Expo, Taman Mewah, and Perindustrian Kamunting) in Larut, Matang, and Selama (LMS) districts, Perak (Malaysia) that generally located at 4°55′N 100°45′E such in Fig. 1. A sampling form was created for the purpose of recording of sampling time, date, location, and physico-chemical test readings. While in field, physico-chemical test for turbidity, pH, and chlorine residue at the sampling station 'triplicate samples' were performed at first. All results physico-chemical analyses were recorded into dummy sampling forms.

For microbiological parameter test, nozzle and bottle sampler must be sterilized before water sampling process. The vessel cap need to be opened carefully and water sample was filled with 100 ml of 'FILL LINE' without rinsing first. Each vessel was required to be labeled with information such as station number, time, and date. Finally, all the collected samples must be kept inside cool box with ice packs and maintain temperature (1-4 °C) and analysed within 24 hours after collection. The collected water samples were analysed in laboratory according to the set procedure, which samples were filled into Quanti-Tray/2000 and incubated for 24 hours with temperature around 35 $\pm$0.5 ºC. After incubation, large and small positive wells were counted and recorded with referred to the Quanti-Tray/2000 MPN table to find the exact MPN.

RESULTS AND DISCUSSION

Environmental assessment

Data presented in Table 3 with regards to the first item of checklist, most of water vending machines (WVMs) (93.3%) were not labeled with registered name or address, which considered unknown status or not registered under Ministry of Health (MOH). Only 1 (6.7%) machine complied and proved with MOH sticker of registered name and address. The item no.2 was in a closely equal ratio between complied and non-complied machines that differs only 6.6%. 8 (53.3%) machines were not being placed suitably, which possibly can cause contamination and another 7 machines complied.

The third item from the checklist shown 40% of environment and surroundings of WVMs being located were not clean and sanitary. 7 out of 15 machines were not complied when their surrounding spaces and under the WVMs were quite inaccessible and seems potentially can become a nesting place for pests (item no.4). Regarding to the item no.5, floor condition and type, all were made of waterproof flat material and easy to clean. Approximately, 80% of WVMs for item no.6 were designed and built to facilitate cleaning and maintenance for all exterior and interior surfaces, whereas another 20% machines were incompliance. In item no. 7, 10 (66.7%) machines were observed to have all parts and surfaces of WVMs that come in contact with water were made of approved, corrosion-resistant, and impermeable materials that can withstand repeated cleaning and sanitation treatments. In addition, there were only 3 WVMs did not used corrosion-resistant or inflamed dispenser nozzle (item no.8), instead using flexible PVC pipe.

For item no.9, each WVM (15) have been observed built with treatment process that can be done effectively for the water sold through distillation, ion exchange, filtration, UV light, RO, or any other acceptable system. More than 50% WVMs have an effective system for handling water droplets, spills or overflows with regards to item no.10. Furthermore, there was only 1 (6.7%) machine that has a backwash system for all connections with water supply, while the other 93.3% WVMs were not being provided (item no.11). All WVMs complied on item no.12, which every machine dispenses water was disinfected through ozonisation or any other methods that approved by Director. For item no.13, more than 50% of WVMs involved were not equipped with self-closing door and not fitted neatly to the dispenser section or dispenser nozzle cover when it is not in use. Moreover, based on item no.14 shown less than 30% of machines that have been observed were clean and sanitary, free from dirt or pests.

Each vending machine (VM) was considered complied to item no.15 with using an approved public water supply. Last item in the checklist with regards to maintenance of machine, almost 75% of WVMs that have been observed did not displayed a sticker to certify their maintenance records, whereas only 4 (26.7%) machines were considered complied. If compared to Rapeepan's study, all 55 WVMs (100%) involved in the study did not record any date of maintenance, which means users will difficult to access and gain the maintenance information that should be displayed on the machines [16].

Table 3 Environment, conditions and maintenance of machine.

Item	Compliance	Frequency, N	Percentage, %
I. Registered name and address are labeled on WVM	No	14	93.3
	Yes	1	6.7
2. Protected from any contamination	No	8	53.3
	Yes	7	46.7
3. Clean and sanitary	No	6	40.0
	Yes	9	60.0
4. Spaces at surroundings and under the WVM are easily accessible and does not become a nesting place for pests	No	7	46.7
	Yes	8	53.3
5. Floor is made of waterproof flat material, easy to clean	No	0	0.0
	Yes	15	100.0
6. WVM is designed and built to facilitate cleaning and maintenance for all exterior and interior surfaces	No	3	20.0
	Yes	12	80.0
7. All parts and surfaces of WVM that come in contact with water are made of approved, corrosion-resistant, and impermeable materials that can withstand repeated cleaning and sanitation treatments	No	5	33.3
	Yes	10	66.7
8. WVM has corrosion-resistant or inflamed dispenser nozzle	No	3	20.0
	Yes	12	80.0
9. WVM is designed in such a way that all treatments for the water sold through distillation, ion exchange, filtration, ultraviolet light, reverse osmosis, mineral addition, or any other accepted process can be done effectively	No	0	0.0
	Yes	15	100.0
10. WVM has an effective system for handling water droplets, spills or overflows	No	7	46.7
	Yes	8	53.3
11. WVM has a backwash prevention device for all connections with water supply	No	14	93.3
	Yes	1	6.7
12. WVM that dispenses water is disinfected through ozonisation or other methods approved by Director	No	0	0.0
	Yes	15	100.0
13. WVM is equipped	No	8	53.3

with self-closing door and is fitted neatly to the dispenser section or dispenser nozzle cover when it is not in use	Yes	7	46.7
14. WVM is kept clean and sanitary, free from dirt or pests	No	11	73.3
	Yes	4	26.7
15. WVM uses an approved public water supply	No	0	0.0
	Yes	15	100.0
16. Maintenance and servicing record	No	11	73.3
	Yes	4	26.7

Physico-chemical analysis

The water samples from 15 machines that have been tested for physico-chemical analysis in this study are shown in the Table 4. On average, pH values were at 7.00, which indicated that most of water samples taken were in neutral category. The minimum and maximum readings (mean) data of pH parameter were between values 6.90 to 7.40. This shown that the pH value for each sample still ranging between values 6.5 to 8.5, which indicated that 100% has complied to set standard of 25th Schedule of Food Regulations 1985 [17]. Water research conducted in Parit Raja, Johor also obtained complied pH results for all VMs involved between values 6.2 to 6.62 [6]. These results were a bit different to the Tan's water study, when the pH value of water samples ranged between pH 6.23 and 8.75, which one out of 17 water samples taken was not complied when exceeded the permissible limit of WHO and EPA with a pH value of 8.75 [18].

However, there also some non-compliance to the drinking water quality standards of WVM for turbidity and chlorine residue parameters. All turbidity readings of water samples were over the acceptable maximum value and totally (100%) did not complied with the standard, which should be 0.1 NTU and below. The highest mean value recorded was 1.47 NTU from WVM 5 in Taman Lela, while the lowest mean value was 0.22 NTU (WVM 13) in Taman Mewah but still above the standard limit. Results similar to the study done in Johor, when the turbidity values for all water samples collected in Batu Pahat were in the range of 4.5 to 9.5 NTU that shown non-compliance [19]. Nonetheless, these values were 45 to 95 times higher than the set standard and also much different than the results that have been obtained in LMS district. It was emphasized that there is high chance for microorganisms might be presented in the drinking water due to increased protection from disinfectant, when turbidity level exceeded the acceptable NTU [18]. Normally, high turbidity value indicates lower quality of drinking water.

Furthermore, for chlorine residue readings (mean), one out 15 machines was considered non-compliance to the standard, which should be 0.04 mg/L and below. The eighth WVM point located in Taman Jana Mulia was the one that exceeded the limit of acceptance of Malaysian Food Regulations 1985 [17], which at value 0.11 mg/L as the highest mean value, whereas another 4 machines from different locations recorded the lowest readings at 0.01 mg/L (mean). On average, majority of machines were at 0.03 mg/L that shown the compliance of chlorine residue. Maximum residual chlorine from 30 WVMs found in Chaidez's study was 0.07 mg/L, which only difference 0.04 [20]. There was only little number among researchers monitored on chlorine residue with regards to VM drinking water, thus, caused lack of data that can be referred and compared.

Table 4 Physico-chemical results of water from VMs (n=15).

Vending machine	Location	Mean turbidity (NTU)	Mean pH	Mean chlorine residue
1	Kampung Jambu-Pt.1	1.31±0.03	7.00±0.04	0.02±0.00
2	Kampung Jambu-Pt.2	1.42±0.00	7.20±0.02	0.01±0.00
3	Medan Kamunting	0.53±0.01	6.90±0.03	0.01±0.00
4	Taman Jana	0.44±0.01	7.00±0.03	0.01±0.00
5	Taman Lela	1.47±0.05	7.00±0.05	0.01±0.00
6	Taman Jana Setia	0.29±0.01	7.00±0.00	0.03±0.02
7	Taman Saujana 2	0.28±0.03	6.90±0.04	0.04±0.01
8	Taman Jana Mulia	0.34±0.02	6.90±0.06	0.11±0.04
9	Medan Kamunting Jaya	0.36±0.02	7.20±0.06	0.03±0.02
10	Kampung Expo	0.32±0.06	7.20±0.05	0.02±0.01
11	Taman Mewah-Pt.1	1.21±0.03	7.20±0.02	0.04±0.00
12	Taman Mewah-Pt.2	0.44±0.01	6.90±0.01	0.03±0.01
13	Taman Mewah-Pt.3	0.22±0.03	7.00±0.00	0.03±0.01
14	Taman Mewah-Pt.4	0.63±0.04	7.40±0.02	0.02±0.00
15	Perindustrian Kamunting	0.49±0.05	6.90±0.02	0.02±0.01
Average		0.65	7.00	0.03

Total coliform and *E.coli* test

Fortunately, data shown in Table 5, there was no incompliance indicated for parameter of *E.coli*. The *E.coli* was absent and not detected in each 100mL water sample taken. Hence, water consumption from tested WVMs in LMS district might be considered safe. In comparison, there were found *E.coli* in Seri Serdang with 45-68 CFU and Taman Pinggiran Putra 45-62 CFU from 100mL WVM samples. *E. coli* levels in drinking water samples from these WVMs were definitely exceeded the standard guidelines [21]. Additionally, all water samples taken by a researcher from several selected public schools in Cebu City, Philippines were positive *E.coli*, which 2 schools (<1.1/100mL) and 6 schools (2.6/100mL). It was considered that the results were non-compliance to the strict international standard of US EPA [10]. Therefore, findings of *E.coli* from both researchers respectively indicated that the filtered drinking water from those machines were absolutely not safe for consumers that potentially might cause diarrhoea or even worse effects.

Nevertheless, there were total coliform found positive in 5 tested water samples from WVMs in Perindustrian Kamunting (1), Taman Mewah (2), Taman Jana Mulia (1) and Kampung Jambu (1) within LMS district. Analyzed results obviously have shown that WVM 8 was the highest MPN value (56.8) if compared to other WVMs, which less than 10 MPN/100 mL detected. The detection was followed by 5.2 (WVM 13), 2.0 (WVM 1), 1.0 (WVM 15), and 1.0 (WVM 12). That means more

than 30% of the WVMs involved were positive detected of total coliform. If referred to drinking water quality standards of WVM, only one (WVM 8) located in Taman Jana Mulia was considered non-compliance and the rest were acceptable and complied the standard. In comparison, results from 3 locations obtained in Kelantan was obviously higher in detection of coliform bacteria, which 16 (94%) out of 17 samples tested were positive with total coliform [18]. Findings in Chiang Khruea Sub-district, Thailand indicated was even worse results when total coliform contained in tested samples reached over 2000 MPN/100mL due to improper maintenance and low hygienic condition of machines [16]. As a microbe indicator in drinking water, high coliform bacteria present normally indicate that the water treatment system in VMs were not being sanitized and maintained on a regular basis.

Table 5 Microbiological results of water from VMs (n=15).

Vending machine	Location	Total coliform (MPN/100mL)	*E.coli* (MPN/100mL)
1	Kampung Jambu-Pt.1	2.0	<1
2	Kampung Jambu-Pt.2	<1	<1
3	Medan Kamunting	<1	<1
4	Taman Jana	<1	<1
5	Taman Lela	<1	<1
6	Taman Jana Setia	<1	<1
7	Taman Saujana 2	<1	<1
8	Taman Jana Mulia	56.8	<1
9	Medan Kamunting Jaya	<1	<1
10	Kampung Expo	<1	<1
11	Taman Mewah-Pt.1	<1	<1
12	Taman Mewah-Pt.2	1.0	<1
13	Taman Mewah-Pt.3	5.2	<1
14	Taman Mewah-Pt.4	<1	<1
15	Perindustrian Kamunting	1.0	<1
Average		4.4	<1

Based on Table 6, the relationship between turbidity and pattern maintenance has a significant value (2-tailed) at 0.351>0.05; the relationship between pH and pattern maintenance has a significant value (2-tailed) at 0.122>0.05; and the significant value (2-tailed) for the relationship between chlorine residue and pattern maintenance at 0.799>0.05. All physico-chemical parameters have larger significant value (2-tailed) than the set alpha value (0.05) in this study. That means there is no any association for all three physico-chemical parameters with pattern maintenance, when failed to reject the H null.

Whereas, the significant value (2-tailed) for the relationship between total coliform and pattern maintenance has been 0.003, which is smaller than 0.05. Hence, there is an association between total coliform and pattern maintenance, when the H null was successfully rejected. It was also indicated that there was a strong negative correlation between the total coliform and pattern maintenance, r(13)= -0.718, p<0.05, with low level of pattern maintenance (survey marks) associated with high level of total coliform. Based on evaluation marks, all 5 machines that detected positive total coliform were categorized under low grade. Poor cleaning and sanitation of the WVMs might be the biggest factor to the growth of the coliform bacteria. In facts, with low quality of membrane filtration and lack of disinfection may contribute to bacteria re-growth after water treatment stages in machine [18]. This is supported by other researchers found that contamination of drinking water were contributed by bad condition and inadequate maintenance services of machines provided by the vendors [12-13]. As well, for safe water provision, it crucial to ensure that the drinkable water resources remain uncontaminated and clean [1, 22-23]. Unfortunately, the relationship between *E.coli* and pattern maintenance could not be proven when the data has been omitted due to constant trend.

Table 6 Correlations (Spearman's rho).

		Marks	Turbidity (<0.1)	pH (6.5-8.5)	Chlorine residue (<0.04)	Total coliform (<10mpn/100ml)
Marks	Correlation Coefficient	1.000	.259	.417	-.072	-.718**
	Sig. (2-tailed)	.	.351	.122	.799	.003
	N	15	15	15	15	15

**. Correlation is significant at the 0.01 level (2-tailed).

CONCLUSION

Through the water quality parameter tests, there were some non-compliances in filtered drinking water in LMS district such as for total coliform, turbidity, and followed by residual chlorine, which might be contaminant in drinkable water content. The highest MPN value of total coliform was found in water sample for vending machine (VM) located in Taman Jana Mulia ought to be prioritized by vendor. This indicated that many owners were not really aware of having the water inspections and test in terms of microbiological, physical, and chemical conditions. Most water vending machines (WVMs) found not being cared and maintained properly, which is believed might cause negative impacts to the consumers in the future if no remedial action be taken by the related vendors. This research concern towards the environmental conditions and machine maintenance, which the results showed these factors related to the quality of drinking water. However, further research for the study is recommended to obtain more solid answer.

ACKNOWLEDGEMENT

The authors would like to thank Faculty of Health Sciences, Universiti Teknologi MARA (UiTM) Puncak Alam and staff from Water Quality and Food Safety Units at LMS district for their full cooperation and assistance.

REFERENCES

[1] Cabral, J. P. S. Water Microbiology. Bacterial Pathogens and Water. International Journal of Environmental Research and Public Health, 2010, 3658-3703.

[2] Heinz, V. & Sheila, A. G. “Drink at least eight glasses of water a day.” Really? Is there scientific evidence for “8 x 8”? . Department of Physiology, Dartmouth Medical School, Lebanon, New Hampshire. Am J Physiol Regul Integr Comp Physiol, 2002, 283: R993–R1004.

[3] Sawka, M. N., Cheuvront, S. N., & Robert, C. Human Water Needs. PubMed: Nutrition Reviews, 2005, Vol. 63, No. 6.

[4] Allard, C. R. V. R., Jos, L., & Hans, O. High-Technology Service Innovation Success: A Decision-Making Perspective. J Prod Innov Manag, 2004, 21: 348-359.

[5] Price, J. H., Murnan, J., & Moore, B. Soft drink vending machines in schools: a clear and present danger. Am J Health Edu, 2006,37:306–314.

[6] Suhaila, S., Nadia, K., Masiri, K., Norbaizura, H., & Nor, F. A. A. A Case Study: Water Quality Content between Water Supply and Water Vending Machine at Parit Raja, Johor. IOP Conf. Series: Materials Science and Engineering, 2019, 601, 012009.

[7] Environmental Protection Agency (EPA) (2011). *Water treatment manual: Disinfection.* Retrieved from https://www.epa.ie/pubs/advice/drinking water/ Disinfection2 _web.pdf.

[8] Ladner, D. A. Effects of bloom-forming algae on fouling integrated membrane systems in seawater desalination. University of Illinois, U.S. 2009.

[9] Jindawan, W., Pornpilai, T., Kannika, B., & Udomsak, M. Microbial risk assessment of drinking water filtration dispenser toll machines (DFTMs) in Mahasarakham province of Thailand. Faculty of Public Health, 2019.

[10] Picardal, M. T., Rapirap, E. M. G., Micame, L. I., Tura, M. J. B., Barrientos, O. N., Kimilat, R. A., ... & Porol, A. L. Drinking Water Quality from Water Vending Machines in Selected Public Schools in Cebu City, Philippines. International Journal of Environmental Science & Sustainable Development, 2018, 3(1), 1-9.

[11] Aruna, P. and Camoens, A. (2014, August 19). Bacteria in your drinking water. TheStar. Retrieved from https://www.thestar. com.my/news/ nation/2014/08/19/bacteria-in-your-drinking-water-germs-in-human-and-animal-faeces-found-in-vending-machines.

[12] John, A. S. & Suzanne, D. V. K. Drinking-water quality and issues associated with water vending machines in the city of Los Angeles. Journal of Environmental Health, 2004, 66 (6), 25–31, 43-46.

[13] Merfat, E. A. M., Munawwar, A. K., Usama, A., & Arif, H. Microbiological Quality of Drinking Water from Water Dispenser Machines. International Journal of Environmental Science and Development, 2015, Vol. 6, No. 9.

[14] Gibert, O., Lefèvre, B., Fernández, M., Bernat, X., Paraira, M., Calderer, M. & Martínez-Lladó, X. Characterising biofilm development on granular activated carbon used for drinking water production. *Water Res*, 2013, 47(3), 1101–10.

[15] National Standard for Drinking Water Quality (2004). *Engineering Sevices Division,* Ministry of Health Malaysia.

[16] Yongyod, R. Drinking water quality and evaluation of environmental conditions of water vending machines. Asia-Pacific Journal of Science and Technology, 2018, 23 (1).

[17] Food Act 1983 (Act 281) & Regulations. Twenty-fifth schedule: Standard for Water and Packaged Drinking Water and Packaged Drinking Water. Malaysia: International Law Book Series, 2013, 298-300.

[18] Tan, E.Y., Arifullah, M. & Soon, J.M. (2016). Identification of Escherichia coli Strains from Water Vending Machines of Kelantan, Malaysia Using 16S rRNA Gene Sequence Analysis. Expo Health, 2016, 8, 211–216.

[19] Hashim, N. H. & Yusop, H. M. Drinking Water Quality of Water Vending Machines in Parit Raja, Batu Pahat, Johor. Soft Soil Engineering International Conference (SEIC2015) IOP Conf. Series: Materials Science and Engineering, 2015, 136, 012053.

[20] Chaidez, C., Rusin, P., Naranjo, J., & P. Gerba, C. Microbiological quality of water vending machines, International Journal of Environmental Health Research, 1999, 3, 197-206.

[21] Praveena, S. M., Nurul, F. K. H., & Claire, D. B. Public health risk assessment from drinking water from vending machines in Seri Kembangan (Malaysia). Food Control, 2018, 91, 40-46.

[22] Suthar, S. Contaminated Drinking Water and Rural Health Perspective in Rajasthan, India; an Overview of Recent Case Studies. Environ Monit Assess, 2010, 173,837 – 849.

[23] Pirsaheb, M., Khosravi, T., Sharafi, K., Babajani, L., & Rezaei, M. Measurement of heavy metals concentration in drinking water from source to consumption site in Kermanshah-Iran. World Applied Sciences Journal, 2013, 21(3), 416-423.

MAEH Journal of Environmental Health eISSN 2637-1359
Jurnal Kesihatan Persekitaran MAEH
Published By Malaysian Association of Environmental Health
http://www.maeh4u.org.my/journal

RESEARCH ARTICLE

Spatio-temporal Patterns of Dengue in Maran District from 2014-2018

Najihah Afifah Manah[a,b], Farah Ayuni Shafie*[a]

[a] *Centre of Environmental Health and Safety, Faculty of Health Sciences, Universiti Teknologi MARA, Selangor*
[b] *Pejabat Kesihatan Daerah Maran, Aras 3, Bangunan Persekutuan Maran, Maran, Pahang*

**Corresponding author: farahayuni@uitm.edu.my*

Abstract

Dengue fever is a systemic viral infection transmitted by the *Aedes aegypti* and *Aedes albopictus* mosquitoes to human and become endemic in more than 100 countries of Southeast Asia, America, Western Pacific, Africa and Mediterranean regions. Many studies are discussing on how to control public health issues including Dengue using temporal and spatial analysis. This study was conducted to assess the distribution of dengue cases in Maran District, Pahang from 2014 to 2018. A retrospective study was carried out in Maran by using data from e-notification system from the year 2014 until 2018 in which 634 cases of Dengue in the analysis to see patterns of Dengue in Maran. All the data regarding the cases of longitude and latitude were based on "mukim" and locality by using ArcGIS. Female and aged group (15-29 years old) were more likely to be infected by Dengue (51% and 32.2%%, respectively). Descriptive spatial analysis indicated the DF infection was normally distributed in all zones. Descriptive analyzes show a spatial Dengue infection has spread sporadically in all "mukim" with mukim Chenor was the most affected. All the pattern analysis showed clustered pattern. The factors that cause the occurrence of Dengue identified should be considered to ensure that control measures can approach to be more drastic and carried out to prevent the spread of Dengue in the Maran District.

***Keywords*:** Dengue, temporal index, socio-demographic, epidemiological, ArcGIS

INTRODUCTION

Dengue fever is a systemic viral infection transmitted by the Aedes aegypti and Aedes albopictus mosquitoes to human (Simmons et al., 2012) and becomes endemic in more than 100 countries of Southeast Asia, America, Western Pacific, Africa and Mediterranean regions (Guzman and Harris, 2015). The weather condition in the Asian countries such as Malaysia, Thailand, Indonesia and Singapore consider as a suitable country for the dengue outbreaks. Dengue has been spreading from a sporadic disease to a major public problem due to the increase in geographical extension, the number of cases and disease severity with substantial social and economic impacts.
Malaysia has record dramatically risen annual cases of dengue infection since 1980 (Azami et al, 2011). According to the 2019 Health Facts by the Malaysian Ministry of Health, the incidence rate of dengue is 61.4 per 100,000 population with a mortality rate of 23.8. Selangor reported the largest number of cases of dengue fever among other states in Malaysia with 72,543 cases while in Pahang, the number of cases of dengue fever is 2873 (MOH, 2019).

The study of temporal and spatial analysis is the best method to create a model or picture on how to manage the disease. The Geographic Information System (GIS) is also known as another methodology in mapping cases thus helping the information of the cases to read easily. GIS is information bases that can catch, store, analyse and show information that is connected by a typical spatial organize framework and can incorporate different spatial and non-spatial information to analyse the risk of dengue cases. Dengue fever is randomly spread or will, in general, happen as a bunch over the long haul or space and thus it is very important to assess the trend of the cases. Vector-borne disease incidences and geographical are the factors influencing the disease that may include meteorological, land use, demographic and socio-economic factor (Mala et al, 2019).

METHODOLOGY

Study Design

The study is a retrospective study. The collection of data included demographic data and analysis on the number of dengue cases started from January 2014 until December 2018. In this study, secondary data related to dengue cases between year 2014 to

2018 was collected from Maran Health District Office. All the data regarding the cases of longitude and latitude data based on 'mukim' and locality has been filled into the *e-notifikasi* and *eDengue* system.

Study Location

The declaration of Maran District was made through a credential that was published in number 14 of Warta Government Pahang Darul Makmur, volume 34, on 13th May 1981. Before the declaration, Maran is a part of Temerloh District and Pekan District. Maran is the tenth district out of eleven in Pahang State with its geographical coordinates at 3° 35' North 102° 46' East. It is a small town which is surrounded by isolated forest and oil palm plantations. Figure 1 shows the map of Pahang which indicates where Maran is located.

Figure 1 Map of Pahang

The Maran district which is the tenth district in the state of Pahang comprised of four areas ("Mukim") namely "Mukim" Luit (587.93 km^2), "Mukim" Chenor (1,169.38 km^2), "Mukim" Kertau (147.63 km^2) and "Mukim" Bukit Segumpal (90.65 km^2) which covers 1,995.59 km2 of land area. The total population of the Maran district is 180,000 people.

Data Analysis

The secondary data of dengue cases was collected through e-notifikasi and eDengue to get the number of population and data about dengue cases. This study has been using GIS spatial analysis and modelling functions to achieve the objective which is to come out with a model of GIS to map the risk of dengue cases. The plotting of cases was a need to deal with the pattern of the dengue cases. The transmission of dengue cases by month is investigated and the findings were analysed into maps and charts.

The temporal analysis was used to assess the management and prevention of dengue cases. The temporal analysis was used to analyse the pattern and gap of the disease. ArcGIS 10.2 software was used to determine the analysis of Kernel Density Estimation (KDE) and the Average Nearest Neighbour (ANN). ANN analysis measures the distance between each feature and its nearest neighbour's centroid location for every year of the cases. It then averages all these nearest neighbours' distances. The average nearest neighbour ratio was calculated as the observed dengue cases in Maran District. KDE has calculated the density of Dengue infection in this study area and determined the hotspots area.

RESULTS AND DISCUSSION

Distribution of Dengue Cases in Maran, Pahang from 2014 to 2018

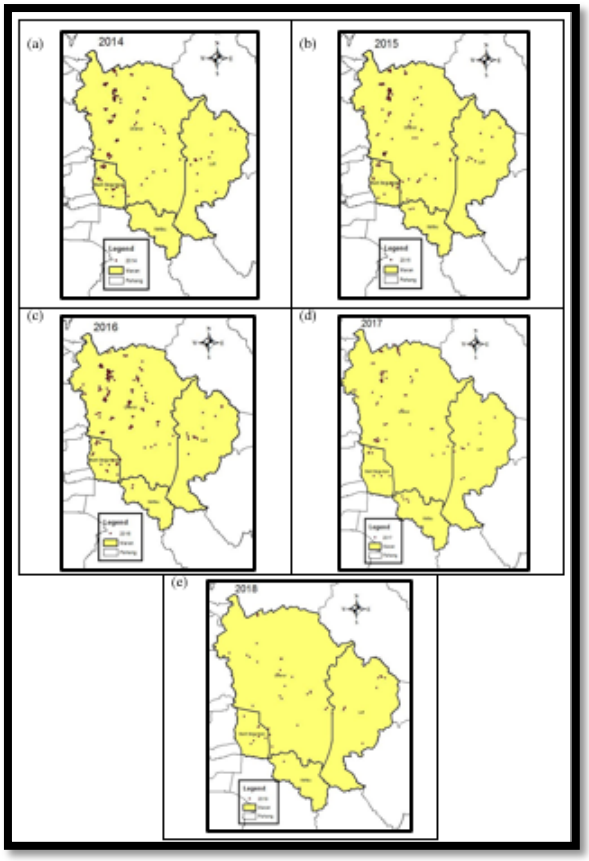


Figure 2 Distribution of Dengue Cases in Maran, Pahang between 2014 to 2018 by year (a) 2014, (b) 2015, (c) 2016, (d) 2017 and (e) 2018

Generally, a sum of 635 dengue cases were recorded between the years 2014 to 2018 in Maran District, Pahang where Chenor recorded the highest number of cases every year compared with the Bukit Segumpal, Luit and Kertau. Kertau has the least number of dengue cases every year. Figure 2 shows the distribution of dengue cases in Maran, Pahang between 2014 to 2018 by year.

Dengue cases in Maran District demonstrated a rising pattern from 2014 to 2016, however, from 2017 to 2018, the data shows a declining number of 100 cases. The reported cases of Dengue in 2016 were higher throughout the four years which are 197 cases. The increasing cases from 2016 are because of the socioeconomic factors and weather conditions. But from 2017 to 2018, it shows a decreasing pattern of Dengue cases. This map would provide the useful information to health authorities that in focusing the implementation of the control measures and prevention activities of Dengue cases from spread to the community and need to control the incidence of dengue effectively, especially when no cases are reported in any locality (Aziz et al, 2011).

Temporal Analysis of Dengue Distribution in Maran, Pahang between 2014 to 2018

Figure 3 shows that Chenor has higher dengue cases every year compared to the other "mukim" in Maran District while Kertau has the least number of dengue cases.

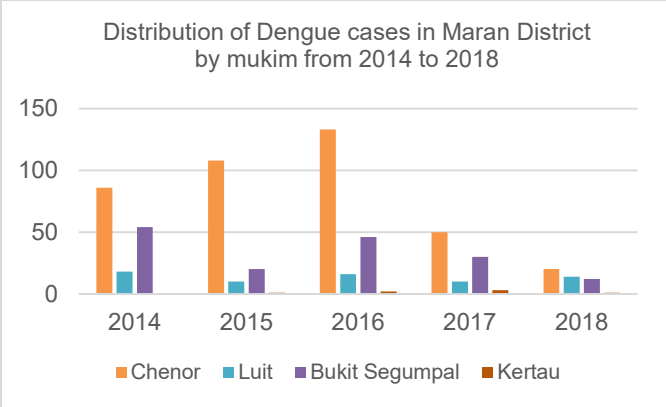
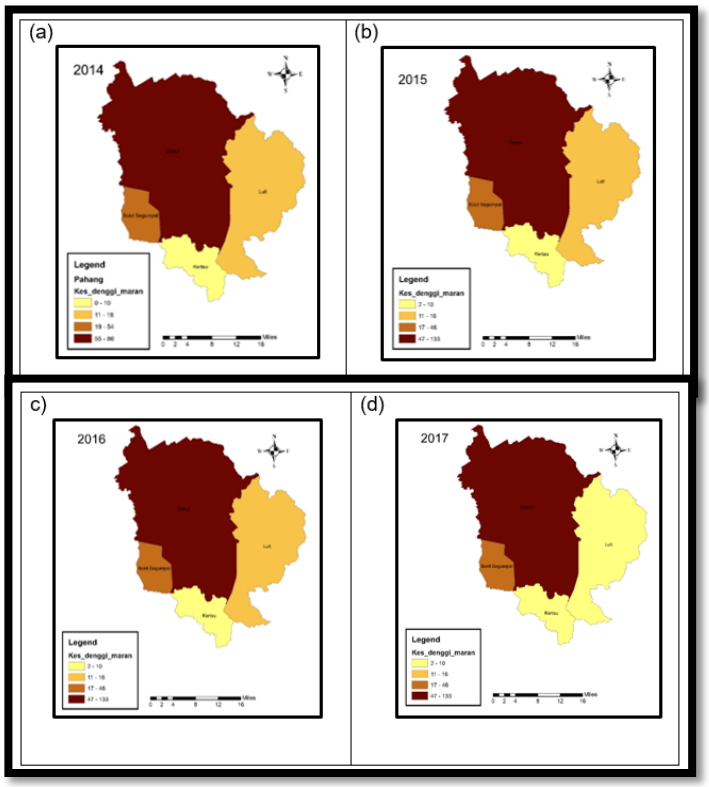


Figure 3 Distribution of Dengue cases for Maran District from 2014 to 2018 by "mukim"

The most noticeable warning of Dengue cases between 2014 to 2018 was accounted in September 2014. 32 cases of Dengue were reported to Maran Health Office during September 2014. The trend of Dengue cases shows an increasing number from June until September every year. In 2018, the Dengue cases show the lowest cases with an average number of two to four cases in each month. Figure 4 shows the distribution of Dengue cases in Maran District by month from 2014 to 2018.



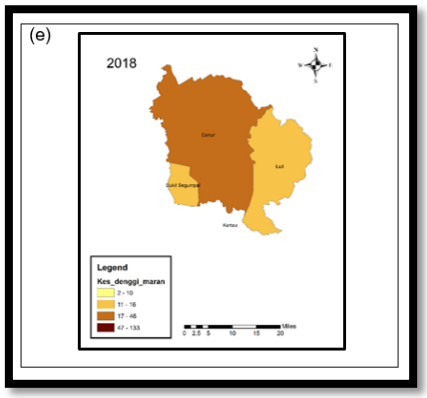


Figure 4 Distribution of Dengue Cases in Maran District by month from 2014 to 2018

Spatial Analysis of Dengue Cases in Maran, Pahang from 2014 to 2018

Based on the Dengue cases, the "mukims" of Maran are categorized into four classes as shown in Figure 1.4. For class 1, the indicator number of cases start from two cases until ten cases. Meanwhile, for class 2, data includes 11 cases to 16 cases. Class 3 includes 17 cases to 46 cases and Class 4 is where more than 47 cases are reported in that area. Chenor showed as Class 4 locality as they recorded the highest cases every year. Figure 5 shows the spatial distribution of Dengue cases in Maran District, Pahang by year.

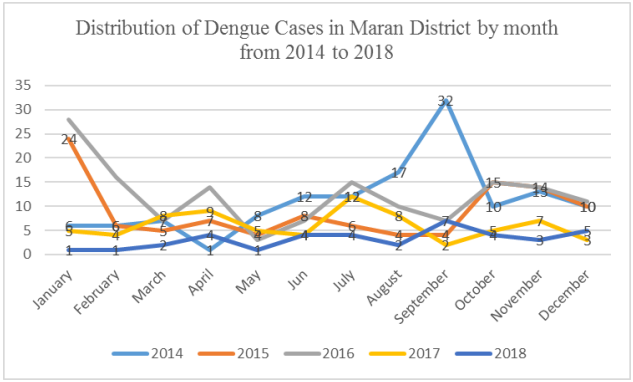


Figure 5 Spatial distribution of Dengue cases in Maran District, Pahang by year (a) 2014, (b) 2015, (c) 2016, (d) 2017 and (e) 2018

Kertau "mukim" was categorized as Class 1 locality because it recorded the least number of Dengue Cases every year which is less than ten cases. In 2018, Kertau "mukim" recorded zero cases. Bukit Segumpal "mukim" was put as Class locality as it recorded 17 cases until 46 cases every year. In 2014 and 2015, Luit "mukim" recorded 18 cases and 11 cases respectively and it was classified as Class 2 locality. In 2018, there was a sudden decrease of Dengue cases involving all the "mukims". Chenor "mukim" was the most affected locality with 20 cases recorded in 2018.

Distance Analysis of Dengue Distribution in Maran, Pahang from 2014 to 2018

Average Nearest Neighbour (ANN)

The ANN analysis was used to measure the distance between each feature and its nearest neighbour's centroid location for every year of the cases. It then averaged all these nearest neighbours' distances. The average nearest neighbour ratio was calculated as the observed dengue cases in Maran District and the target area of Dengue case is then determined as clustered, random or dispersed. Nearest Neighbour Ratio (R), z-scores and p-value are the three values that were determined for this study as shown in Table 1.

Table 1 Average Nearest Neighbour of Dengue Cases in Maran District from 2014 to 2018

ANN Value	Year Observation (2014-2018)				
	2014	2015	2016	2017	2018
Nearest Neighbour Ratio	0.395436	0.395436	0.359202	0.435398	0.512201
z-score	-14.5379	-14.5379	-17.2062	-10.2469	-6.39765
p-value	0.0000	0.0000	0.0000	0.0000	0.0000

From the outcome of ANN analysis, it can be said that the average ratio was less than one. All the z-score and p-value were statistically significant in every one of five years where the ANN outline shows p-value less than 0.05. The pattern of Dengue cases from 2014 to 2018 could be determined as clustered. Dengue incidence from 2014 to 2018 was within the z-score of -11.33 ($p<0.001$) and spatial of Dengue incidence occurred at an average distance of 522.77 meters. Figure 6 shows the average nearest neighbour summary of dengue distribution at Maran, Pahang.

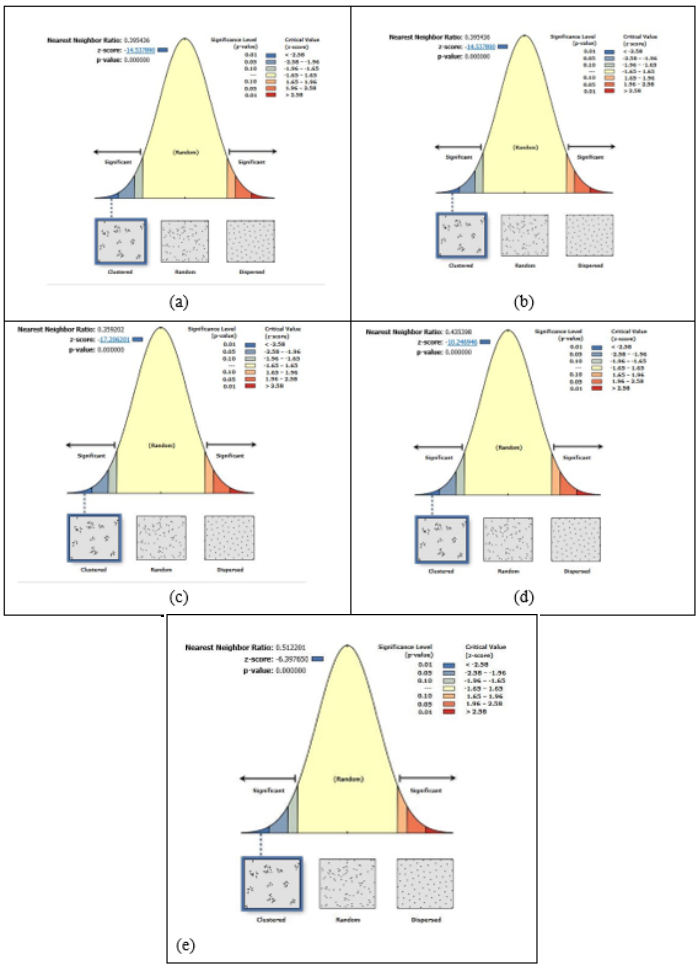


Figure 6 Dengue Distribution at Maran District, Pahang by year (a) 2014, (b) 2015, (c) 2016, (d) 2017 and (e) 2018

Dengue Distribution Hotspot Analysis in Maran District from 2014 to 2018

The distribution of Dengue cases recorded from 2014 to 2018 was evaluated further by analysing the Kernel Density as shown in Figure 7.

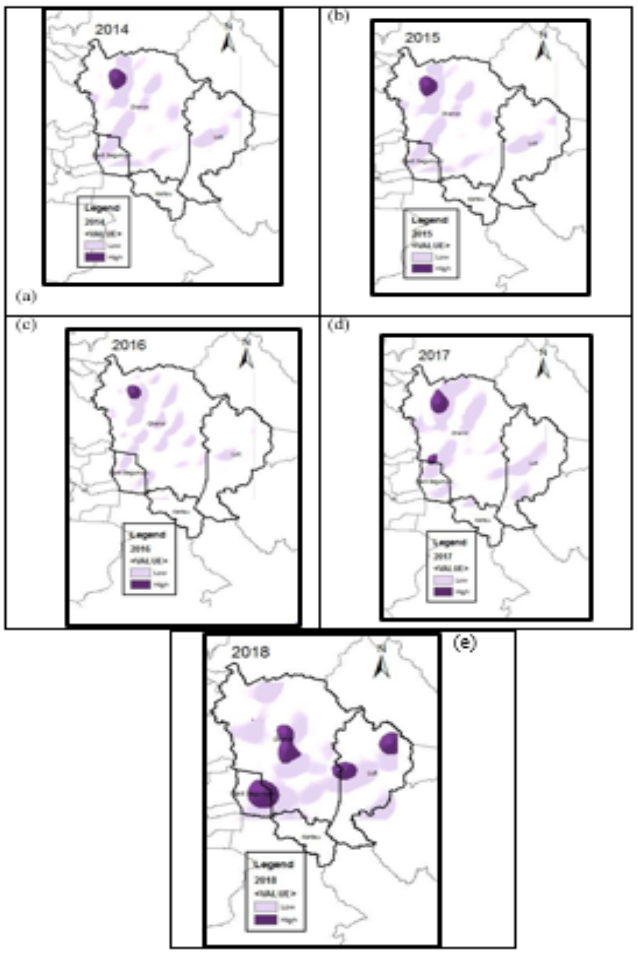


Figure 7 Kernell Density Estimation at Maran District, Pahang by year (a) 2014, (b) 2015, (c) 2016, (d) 2017 and (e) 2018

With this analysis, the location in Maran district with the highest risk of Dengue cases was identified. This analysis provided the location of the most affected area with Dengue cases. The hotspot area with a higher case of Dengue were spreading in all township especially in Chenor. It indicated the high risk of Dengue cases every year. This analysis outcome is demonstrated by using purple colour as the hotspot with a high number of Dengue cases while light purple as the hotspot area but with a low density of population and low infection of Dengue virus. In this analysis, the most density of Dengue cases was situated at Taman Desa Jaya and Taman Rantau Perintis for each year. It was the main hotspot area for every year in Maran District and therefore more effort need to be put in order to effectively control the cases from continuing to rise. From the result, the area most affected by dengue infection will identify and able to target specific area which highest incidence of dengue cases (Hazrin et al, 2016).

Descriptive Analysis on Factors Associated With HFMD Infection Based On Socio-Demographic

Socio-demographic characteristics of dengue cases from 2014 to 2018 divided into five categories: age, gender, race,

occupation and “mukim” are shown on Table 1.2. The age group from 15-29 years old are the most highly infected with dengue, namely with 32.2%.

Table 2 Socio-demographic of dengue cases in Maran District from 2014 to 2018

Socio-demographic	Variables	Frequency (n)	Prevalence%
Age Groups	1-14	109	17.2
	15-29	204	32.2
	30-44	173	27.3
	45-59	63	10
	60-74	76	12
	75-89	9	1.4
Gender	Male	309	49
	Female	325	51
Race	Malay	601	95
	Chinese	16	2.5
	India	6	0.9
	Orang Asal	1	0.2
	Indonesia	9	1.4
	Thailand	1	0.2
Occupation	Government	74	11.7
	Farm Labour	241	38
	Own Work	112	17.7
	Student	24	3.8
	Unemployed	102	16
	House wife	72	11.4
	Infant	9	1.4
Mukim	Luit	68	10.7
	Chenor	397	62.6
	Bukit Segumpal	162	25.6
	Kertau	7	1.1

CONCLUSION

From this study, the finding on the execution of GIS for Dengue was proven effective. It was confirmed that by using GIS and spatial statistic mechanism, the spatial-temporal density of Dengue infection can be determined. Spatial mapping of Dengue cases distribution likewise may assist health agencies, epidemiologist, public health officer and authorities to encounter the dengue fever. It provides a more effective way to help the health authorities to monitor the next potential Dengue clusters systematically and through with good management without any mistake.

Although GIS cannot fix the disease from spreading to the community, it provided useful information as well as the skill to determine spatial relationship among Dengue cases location through spatial analysis. Vector control with source reduction as the main environmental control measure can suppress vector populations to very low levels, and if maintained, can prevent Dengue outbreaks every year. Other than that, the role of the community in the prevention of dengue fever is very important to ensure Aedes breeding places destroyed. Apart from that, residents can take just 10 minutes a week to find and destroy the breeding places outside the home. They can educate their children how to prevent this disease start from childhood. Health education via social media such as television, newspapers, internet, radio and through distribution flyer, banner and constructed to be intensified to tell people how dangerous this disease and the importance of dengue control and elimination in dengue disease.

REFERENCES

Azami, N. A. M., Salleh, S. A., Neoh, H. M., Zakaria, S. Z. S., & Jamal, R. (2011). Dengue epidemic in Malaysia: Not a predominantly urban disease anymore. *BMC research notes*, *4*(1), 216-218.

Dom, N. C., Ahmad, A. H., Ishak, A. R., & Ismail, R. (2013). Assessing the risk of dengue fever based on the epidemiological, environmental and entomological variables. *Procedia-Social and Behavioral Sciences*, *105*, 183-194.

Dom, N. C., Ahmad, A. H., Latif, Z. A., Ismail, R., & Pradhan, B. (2013). Coupling of remote sensing data and environmental related parameters for dengue transmission risk assessment in Subang Jaya, Malaysia. *Geocarto International*, 28(3), 258-272.

Guzman, M. G., & Harris, E. (2005). Dengue. *The Lancet*, *385*(9966), 453-465.

Hazrin, M., Hiong, H. G., Jai, N., Yeop, N., Hatta, M., Paiwai, F & Othman, W. (2016). Spatial distribution of dengue incidence: A case study in Putrajaya. *Journal of Geographic Information System*, *8*(1), 89-97.

Mala, Suchi., & Jat, M. K. (2019). Geographic information system based spatio-temporal dengue fever cluster analysis and mapping. *The Egyptian Journal of Remote Sensing and Space Science*, 22(3), 297-304.

Mia, M. S., Begum, R. A., Er, A. C., Abidin, R. D. Z. R. Z., & Pereira, J. J. (2013). Trends of dengue infections in Malaysia, 2000-2010. *Asian Pacific journal of tropical medicine*, *6*(6), 462-466.

Simmons, C. P., Farrar, J. J., van Vinh Chau, N., & Wills, B. (2012). Dengue. *New England Journal of Medicine*, *366*(15), 1423-1432.

MAEH Journal of Environmental Health eISSN 2637-1359
Jurnal Kesihatan Persekitaran MAEH
Published By Malaysian Association of Environmental Health
http://www.maeh4u.org.my/journal

RESEARCH ARTICLE

Larvicidal Activity of *Piper nigrum*, *Pandanus amaryllifolius*, *Cymbopogon nardus*, *Cinnamomum burmanii* and *Azadirachta indica* Herbs Extracts on *Aedes aegypti* Larvae

Nur Nabilah Mohamad, Muniandy M Nathan*, Muhammad Ashraf Amzah

Institut Latihan Kementerian Kesihatan Malaysia Sungai Buloh

**Corresponding author: nmun61@yahoo.com*

Abstract

Dengue fever is an endemic disease in Malaysia. Existing control measures are aimed at important species of mosquitoes that are focused on adult mosquitoes or mosquito larvae. Mosquito control is difficult when there are many factors such as resistance to insecticides used in mosquito control and causing health effects to non-target organisms. One way to combat dengue fever is to eliminate *Aedes aegypti* mosquitoes. One way is to use plant extracts as an additional insecticide as it has larvacidal potentials that contain different phytochemicals, especially in killing mosquito larvae without affecting other organisms and the environment. This study aimed to study the use of herbs in the control and prevention of the breeding of *Aedes aegypti* mosquito larvae. The study was conducted in the form of an experimental quasi study. The sample for this study was instar IV larvae of 10 larvae with 4 readings with a sample size of 240 larvae. Results of larval mortality analysis using herbal species using the Kruskal Wallis test showed that this value was smaller than the alpha value of 0.05. It can be concluded that there are related herbicides (*Piper nigrum*, *Pandanus amaryllifolius*, *Cymbopogon nardus*, *Cinnamomum burmanii* and *Azadirachta indica*) in the control and reproduction of *Aedes aegypti* mosquito larvae.

***Keywords*:** *Mosquito Aedes Aegypti, Piper nigrum, Pandanus amaryllifolius, Cymbopogon nardus, Cinnamomum burmanii, Azadirachta indica*

INTRODUCTION

In Malaysia Dengue fever regarded as predominantly as an urban disease due to high densities susceptible hosts. High population growth in urban areas, improper disposal of waste, lack of efficient solid waste management and increased movement of dengue virus in infected human through current modern transportation contribute to a marked increase in dengue cases in Malaysia. Mosquitoes are a significant general wellbeing danger as a typical vector that can make genuine sickness people for particular kinds of dangerous ailments, for example, intestinal sickness, filariasis, chikungunya, yellow fever, dengue fever and encephalitis that add to significant mortality (World Health Organization) WHO) 2015). The use of synthetic insecticides, organophosphates and pyrethroids, is the most commonly used approach worldwide. An important issue in this regard is the occurrence of resistance against mosquitoes especially *Aedes aegypti* and *Aedes albopictus* after widespread use of chemical insecticides (Rohani et al. 2001). According to (Benelli et al. 2015) environmental friendly devices have been implemented to improve mosquito control. Significant efforts have been made to investigate the effectiveness of botanical products and most plant compounds have been reported to be highly toxic to mosquitoes and act as an adult or larval mosquito repellents. This phenomenon has encouraged the use of natural products. Plants can be an alternative source for controlling mosquito vectors as they are rich in various phytochemicals that are specialized in killing mosquito larvae without affecting other organisms and the environment (Pedro et al. 2014).

PROBLEM STATEMENT

Malaysia recorded the highest number of dengue cases in four years at over 130,000, rising 61 percent compared to 2018. Meanwhile 182 deaths were recorded in 2019. There were many strategies used in prevention and control of dengue in the Vector borne Disease Control Programme. This includes anti larval measures, inspection of premises, identify and source reduction of larvae breeding habitats, anti-adult mosquito's activity, health education, community participation and enforcement activities. All these strategies to combat dengue have to constantly monitored and reviewed as their effectiveness and to modify if necessary. Therefore, this study was conducted to use alternative home based herbs extract for larviciding in the control and prevention of the breeding of Aedes Aegypti mosquito larvae.

METHODOLOGY

This study was conducted at the Bukit Mertajam Clinical Training Center in Seberang Perai Tengah. This study is based on a quasi experimental study in which it evaluated the effect of herbal extract used to determine the mortality of *Aedes aegypti* mosquito larvae. The ingredients used in this study are herbs such as *Piper nigrum*, *Pandanus amaryllifolius*, *Cymbopogon nardus*, *Cinnamomum burmanii* and *Azadirachta Indica*. Equipments used in this study are based on the WHO Guideline for Laboratory and Field Testing of Mosquito Larvicides (2005). The dosage of each herb extract in study is from 0 grams (control). 2 grams, 3 grams, 5 grams and 10 grams were placed into an ovitrap container containing 10 larvae. According to the WHO Guideline For Laboratory and Field Testing Of Mosquito Larvicides (2005), the solvent should be dissolved in a screw-cap bottle with aluminium foil over the mouth of the bottle. Shake the bottle to spread the material in the solvent. The concentration was tested by adding 0.1–1.0 ml of the appropriate dilution to 100 ml or 200 ml of deionized water or distilled water. The lowest dose should be provided in advance. Observation is done every 6 hours by taking 4 readings in 24 hours.

RESULTS

Mortality rates of dengue mosquito larvae using herbs (*Piper nigrum*, *Pandanus amaryllifolius*, *Cymbopogon nardus*, *Cinnamomum burmanii*, *Azadirachta Indica*) with different doses were analyzed using non-parametric test. Therefore, the Kruskal Wallis test was used as in table 1. For *P. nigrum* analysis showed there is no significant difference in mean rank for each dose tested with a value of 8.50.

Table 1: Mortality of Aedes Larvae using *Piper nigrum*.

Dos (gram)	N	Mortality Mean Rank	Test Statistic	P
2	4	8.50		
3	4	8.50	0.000	1.000
5	4	8.50		
10	4	8.50		

P< 0.05**

P. amaryllifolius analysis in table 2 showed that there was a mean difference in the mean of each dose tested where the dose of 10 grams recorded higher mortality of 14.50 compared to the other doses.

Table 2: Mortality of Aedes Larvae using *Pandanus amaryllifolius*.

Dos (gram)	N	Mortality Mean Rank	Test Statistic	P
2	4	4.38		
3	4	6.00	10.653	0.014
5	4	9.13		
10	4	14.50		

P< 0.05**

Whereas for *C. nardus* analysis there is a mean difference in the mean of each dose tested where the dose of 5 grams and the dose of 10 grams respectively recorded the highest death of 12.00.

Table 3: Mortality of Aedes Larvae using *Cymbopogon nardus*.

Dos (gram)	N	Mortality Mean Rank	Test Statistic	P
2	4	2.88		
3	4	7.13	12.458	0.006
5	4	12.00		
10	4	12.00		

P< 0.05**

For *C. burmanii*, the analysis showed that there was a mean difference in the mean of each dose tested where doses of 3 grams, doses of 5 grams and doses of 10 grams each recorded high mortality of 9.00.

Table 4: Mortality of Aedes Larvae using *Cinnamomum burmanii*.

Dos (gram)	N	Mortality Mean Rank	Test Statistic	P
2	4	7.00		
3	4	9.00	3.000	0.392
5	4	9.00		
10	4	9.00		

P< 0.05**

As in table 5 for *A. indica* analysis showed that there was a mean difference in the mortality of each dose tested. The dose of 10 grams recorded the highest mortality of 13.63 and it is significant with p below 0.05.

Table 5: Mortality of Aedes Larvae using *Azadirachta Indica*.

Dos (gram)	N	Mortality Mean Rank	Test Statistic	P
2	4	3.75		
3	4	6.88	9.598	0.022
5	4	9.75		
10	4	13.63		

P< 0.05**

Mortality rates of mosquito larvae using herbs (*P. nigrum*, *P. amaryllifolius*, *C, nardus*, *C. burmanii*, *A.*

Indica) with different duration of larviciding hours were analyzed using non-parametric test. The Kruskal Wallis test was used to test to determine the most effective duration of larviciding. Results in table 6 revealed that *P. nigrum* does not shows any significant difference in mean rank between 6 to 24 of contact hours with p value above then 0.05.

Table 6: Mortality of Aedes Larvae with duration of contact hours using *Piper nigrum*.

Time (hour)	N	Mortality Mean Rank	Test Statistic	P
6	4	5.50		
12	4	7.50	3.571	0.312
18	4	9.50		
24	4	11.50		

P< 0.05**

For *P. amaryllifolius* analysis showed the mean rank in the 24 hours recorded the highest mortality with a value of 11.50 but it is significant with p value above then 0.005 as it in table 7.

Table 7: Mortality of Aedes Larvae with duration of contact hours using *Pandanus amaryllifolius*.

Time (hour)	N	Mortality Mean Rank	Test Statistic	P
6	4	5.50		
12	4	7.50	3.571	0.312
18	4	9.50		
24	4	11.50		

P< 0.05**

Table 8 reveal result for *C. nardus* analysis. The mean difference in the meantime over the 24 hours recorded the highest mortality with a mean of 10.38 but it is significant as the p value above then 0.05.

Table 8: Mortality of Aedes Larvae with duration of contact hours using *Cymbopogon nardus*.

Time (hour)	N	Mortality Mean Rank	Test Statistic	P
6	4	7.00		
12	4	9.00	3.000	0.392
18	4	9.00		
24	4	9.00		

P< 0.05**

While for *C. burmanii* analysis showed in table 9. a mean mortality difference between 6 hours of exposure compared above then 12 hours. The p value recorded 0.392 means the difference is not significant.

Table 9: Mortality of Aedes Larvae with duration of contact hours using *Cinnamomum burmanii*.

Time (hour)	N	Mortality Mean Rank	Test Statistic	P
6	4	7.00		
12	4	9.00	3.000	0.392
18	4	9.00		
24	4	9.00		

P< 0.05**

For *A. Indica* the analysis showed (Table 10) the highest mean time recorded time period of 24 hours with 11.63 hours. Even though each time period shows different mortality mean rank but it is not significant with p value above then 0.05.

Table 10: Mortality of Aedes Larvae with duration of contact hours using *Azadirachta Indica*.

Time (hour)	N	Mortality Mean Rank	Test Statistic	P
6	4	4.88		
12	4	7.38	4.853	0.183
18	4	10.13		
24	4	11.63		

P< 0.05**

Mortality rates of mosquito larvae using different herbs were analyzed using non-parametric. Therefore, the Kruskal Wallis test was used again to compare mortality with different type of herbs extract in larviciding. The analysis showed a mean difference between the tested herbs and the black pepper recorded the highest mortality with a value of 59.00 while the lowest was a mean of 14.63. The p value shows that the mortality is significantly difference.

Table 11: Kruskal Wallis test to determine mortality of Aedes Larvae with duration of contact hours using Azadirachta

Types Of Herbs	N	Mortality Mean Rank	Test Statistic	P
Black pepper	16	59.00		
Pandan	16	27.44		
Fragrant	16	43.88	52.191	0.000**
Lemongrass	16	57.59		
Cinnamon	16	59.00		

P< 0.05**

DISCUSSION

In this proposal, there are several improvements that can be made that through future studies should be tested the effectiveness of herbs studied using other plant organs such as roots or seeds as larvicidal. Also, future studies may use mosquito larvae tested in large quantities as this study uses small numbers. Besides, the temperature is also a factor to be considered as temperature affects larval breeding where the larvae cannot reproduce normally if the temperature is above 10 ° C. Subsequently, society is encouraged to use natural larvicidal as it is readily available and has no health effects on humans.

CONCLUSION

This study concludes that extracts of home based herbs can be used as an alternative to the control and prevention of aedes mosquito larvae. It can be seen that all herbs demonstrate as a lethal concentration (LC) at a specific dose. Among them, black pepper extracts produce the most effective lethal concentration as aedes mosquito larvae larvicide. With this invention the villagers can use

these herbs in the absence of abates. This herbs are easily available in their environment and does not cost much. More herbs should be tested for this purpose to identify the active ingredient in each herb to be used as an alternative measure in dengue control.

ACKNOWLEDGEMENT

The authors are thankful to Mr. Umathevan (former Trainer of BM Clinical Training Centre), and Mr. S. Veeramohan (MAEH) technically assisting in this study and editing the article.

REFERENCES

Benelli G., Murugan K., Panneerselvam C., Madhiyazhagan P., Conti B., Nicoletti M. (2015) Old ingredients for a new recipe? Neem cake, a low-cost botanical by-product in the fight against mosquito-borne diseases. Parasitol Res 114:391–397

Chemistry Daily 2007. Cinnamaldehyde. http//www.chemistrydaily.com/chemistry/Cinnamaldehyde. (3 Maret 2009)

Parmar, V.S, Jain, S.C, Bisht, K.S, Jain, R., Taneja, P., Jha, A. (1997),Phytochemistry of the genus Piper, Phytochemistry, 46, 597- 673.

Pedro M. Gutierrez Jr., Aubrey N. Antepuesto, Bryle Adrian. L. Eugenio, Maria Fleurellei L. Santos. 2014. Larvicidal Activity of Selected Plant extracts against the Dengue vector Aedes aegypti Mosquito. International Research Journal of Biological Sciences. 3(4):23-32.

Rohani, A., Chu, W. L., Saadiyah, I., Lee, H. L. & Phang, S. M. 2001. Insecticide resistance status of Aedes albopictus and Aedes aegypti collected from urban and rural areas in major towns of Malaysia. Tropical Biomedicine 18(1): 29–39.

Rohman, T. S. (2007). Pengaruh Daun Tembakau (Nicotiana tabacum), Biji Mimba (Azadirachta indica), dan Daun Paitan (Tithonia diversifolia) Terhadap Kutu Daun Toxoptera citricidus Pada Tanaman Jeruk (Citrus sp). Skripsi. Malang: Jurusan Biologi Fakultas Sains dan Teknologi Universitas Islam Negeri Malang

Kementerian Kesihatan Malaysia. (2009). Laporan Tahunan 2009. Kuala Lumpur: Cawangan Penyakit Bawaan Vektor. Kementerian Kesihatan Malaysia

Kementerian Kesihatan Malaysia (KKM). (2012, Julai). Kenyataan Akhbar Ketua Pengarah Kesihatan Malaysia. Situasi Semasa Demam Denggi Di Malaysia. Retrieved from file:///c:/users/user/downloads/kenyataan%20akhbar%20kpk%20untuk%20denggi%20mg%2028%20dan%20anti%20aedes%20ranger%20ridsect%2017%20july%202012.pdf

Scott I.M., Jensen H.R., Philogène B.J., Arnason J.T. (2008) A review of Piper spp. (Piperaceae) phytochemistry, insecticidal activity and mode of action.Phytochem Rev ;7:65–75

World Health Organization (2005). Guidelines For Laboratory and Field Testing Mosquito Larvicideas. Geneva : WHO Press.

World Health Organization (2015). Dengue and severe dengue. WHO.

MAEH Journal of Environmental Health eISSN 2637-1359
Jurnal Kesihatan Persekitaran MAEH
Published By Malaysian Association of Environmental Health
http://www.maeh4u.org.my/journal

RESEARCH ARTICLE

Cross-sectional Study of Heat Stress and Blood Pressure Among Quarry Workers in Bukit Mertajam

Nursyahira Samsudin, Muniandy M Nathan, Muhammad Ashraf Amzah

Institut Latihan Kementerian Kesihatan Malaysia Sungai Buloh

**Corresponding author: nmun61@yahoo.com*

Abstract

A cross-sectional study was conducted on quarry workers located in Bukit Mertajam. The objective of this study was to study the exposure to heat and blood pressure of quarry workers. A total of 38 employees was selected as respondents in this study. The variables studied were the Heat stress index, systolic and diastolic blood pressure, duration of work and heat exposure time. The results showed that there was no significant relationship between work duration and heat stress where the p = 0.564 values exceeded the alpha value of 0.05. The study also found that there was no significant relationship between heat exposure and heat stress with p=0.639 and above the alpha value 0.05. The results showed that the heat exposure period had a significant relationship between heat exposure and systolic blood pressure (p = 0.001) where this value was less than alpha 0.05 but there was no significant relationship between heat exposure and diastolic blood pressure (p = 0.295) where this value exceeds p = 0.05. Correlation analysis of Heat Stress with systolic and diastolic blood pressure showed that there was no significant relationship where the Heat Stress value with systolic blood pressure was r = 0.037, p = 0.825 while sig Heat pressure with blood diastolic pressure was r = 0.236, p = 0.153, where both values exceed the alpha value of 0.05. Heat can respond to the human body due to environmental and non-environmental factors.

.

Keywords**:** *Heat Stress, systolic and diastolic blood pressure.*

INTRODUCTION

Working environment is a broad term and means all your surroundings when working. Any physical working environment is combination of air temperature, humidity, light. noise and heat radiation. Among all this the four factors, which is associated with the production of heat from the body, is called heat stress. The physical condition of working environment affects the capacity or performance of a worker. Productivity, efficiency, and effectiveness of work are strongly influenced by the climate (weather) of work (Suma'mur, 2009).

Working in a hot environment or exposure to high temperatures can cause stress to the body. When this stress combined with physical activities can lead to dehydration, fatigue. and disruptions in the body When dehydration and fatigue or fatigue combine with stress can cause health problems such as heat rash, heat cramps, heat exhaustion, heat stroke and heat exhaustion. Heat stress is a physical hazard and can cause severe health problems, either directly or indirectly to workers. Heat stress can occur when the body fails to control the internal temperature and may not return to normal temperature by itself.

Workers in many occupations are at high risk for exposure to heat stress. Some of the higher risk occupations include local council workers, grass cutters, land surveyors, road builders, firefighter, bakery worker, miner, military personnel, construction worker, factory worker, security guards, boiler room worker, landscaper, some athletes and agricultural worker. Therefore, a comfortable and comfortable work environment is essential for employees to work optimally and productively.

Heat stress occurs when our body is unable to cool itself enough to maintain a healthy temperature. Normally, the body cools itself by sweating, but sometimes sweating isn't enough and the body temperature keeps rising.

PROBLEM STATEMENT AND RESEARCH OBJECTIVE

Many employers and workers in Malaysia remain relatively unaware of how dangerous working under the sun is despite some places having seen temperatures up to 37°C. The Department of Occupational Safety and Health (DOSH) enforcement activities showed that various workplaces had a high risk of machinery or work processes that generated high amounts of heat. The awareness among employers and workers on the exposure to heat stress situations is low and has to be overcome," it said in an e-mail response to queries on the dangers of heatstroke among workers. DOSH, it said, came up with guidelines for employers to deal with heat stress situations at workplaces in 2016, which should be in place in all sectors, including construction.

According to Section 15(1) and Section 15(2)(e) of Occupational Safety and Health Act 1994 stipulates the duty of employers and self-employed persons to their employees. The provision and maintenance of a working environment for the employees should be as far as is practicable, safe and without risk to health while at work. Under Factories and Machinery Act 1967 Section 22(d) (i) stipulates effective and suitable provision shall be made for securing and maintaining such temperature in ensuring reasonable conditions of comfort and prevention from bodily injury to any person employed in a factory. Section 22(d) (ii) stipulates, a standard of reasonable temperature may be prescribed by the Minister to prohibit the use of any methods of maintaining a reasonable temperature, which in his opinion are likely to be injurious.

DOSH said that as of July 2018, 151 cases of employers flouting rules on their workers' safety had been brought to court, resulting in RM1.9mil in penalties. Last year, there were 288 cases with RM 3.2mil penalties. There were also 716 compounds and 19,695 notices issued against errant employers.

Research in occupational heat stress in developing countries like Malaysia is limited because of several challenges and constraints. There are a few challenges such as permission conduct research and to publish the data of industries, resistance for change from employers and workers, improper record of any occupational disease by the employer or worker.

Therefore this study was designed to find the current status of heat stress and its association elevated blood pressure between occupational heat exposure and health impacts among factory workers. This study will to examine this association between blood pressure and heat stress among workers in quarry workers of FYS Marketing Sdn Bhd Bukit Mertajam. This research will provide valuable information to protect worker's health with regard to heat exposure in working environment and to review the current guideline on heat stress management by DOSH.

METHODOLOGY

This cross sectional study was conducted in a quarry company in Bukit Mertajam. A universal sampling method was used to evaluate heat stress and blood pressure among all employees. Demographic data of all 38 respondence were collected using validated self-administered questionnaire. Wet Bulb Globe Temperature (WBGT) instrument were used according to the standard operating procedure to measure the heat stress among study group. WBGT used to determine by computing air temperature (TA) and relative humidity (RH %) in accordance to the standardized Heat Stress Index table. Data on blood pressure were obtained using the Omron Blood Pressure Meter. Systolic and diastolic blood pressure were measured.

FINDINGS

A non-parametric test were run for all parameters as the Shapiro will test shows p value for each test was below 0.05. Therefore, non-parametric test was run for all analysis. Spearman rho correlation test was used to analyse the correlation between heat stress and duration of service among 38 respondents reveal that the value r = 0.097 with p = 0.564 (table 1.0) Therefore there is no positive correlation between duration of employment and heat stress of the workers.

Table 1: Correlation between heat stress and duration of service

	Heat stress		
	N	r	p
Duration of work	38	0.097	0.564

** *p,0.05*

To determine correlation between duration of heat exposure in a working day with Heat Stress was analyzed using Kruskal Wallis test was used. The results in table 2.0 indicate that duration of working in a day does not gives any significant effect to heat stress (p=0.650). However, the highest ranking heat stress was recorded among those works more than 7 hours in a day.

Table 2: Correlation test between exposure duration and heat stress.

Duration of heat exposure	Heat Stress			
	N	Mean rank	Test statistic	p
1-3 hours	7	17.14		
4-6 hours	17	18.76	0.896	0.639
>7 hours	14	21.57		

** *p,0.05*

In order to find the effect of heat stress to workers blood pressure Kruskal-Wallis was used to compare mean heat stress between systolic and diastolic blood pressure. The analysis shows that the highest mean systolic and diastolic blood pressure showed that the highest mean systolic 26.76 and 22.62 for diastolic was recorded among 5 to 6 hour working in a heat producing working environment. Thus duration of occupational heat exposure does significantly affect the systolic (p = 0.001) but not significant with diastolic (p = 0.295).

Table 3: Mean systolic and diastolic with duration of exposure.

Duration of heat exposure	Blood pressure			
			systolic	
	N	Mean rank	Test statistic	p
1-3 hours	7	11.71		
4-6 hours	17	26.76	13.461	0.001
>7 hours	14	14.57		

Duration of heat exposure	Blood pressure			
			diastolic	
	N	Mean rank	Test statistic	p
1-3 hours	7	16.57		
4-6 hours	17	22.62	2.442	0.295
>7 hours	14	0.295		

*** p,0.05*

Correlation spearman test was performed to test the correlation between heat stress with systolic and diastolic blood pressure showed. Output of the test indicate r = 0.037 with p = 0.825 for systolic blood pressure and r = 0.236 with p = 0.153 for diastolic blood pressure. Therefore heat Stress does not affect the systolic and diastolic blood pressure where with p value exceeding 0.05.

Table 4: Correlation Spearman Test to compare mean systolic and diastolic with duration of exposure.

Blood pressure	Heat stress		
	N	r	p
systolic	38	0.037	0.825
diastolic	38	0.236	0.153

*** p,0.05*

CONCLUSION

The human body can react with heat due to environmental or non-environmental factors. A healthy body can maintain an internal temperature of about 37oC. Temperature changes of less than 1oC occur at certain times depending on the level of physical activity or emotional state. Temperature changes of more than 1oC occur during illness or when environmental conditions exceed the body's ability to handle extreme heat. In very hot conditions, the rate of heat reception is higher than the rate of heat loss and body temperature begins to rise. Increasing body temperature can lead to heat-related illnesses. In addition, it is hoped that future studies will provide more detailed emphasis on other aspects of the environment and physiology so that Heat Stress events can be detected early and as a precautionary measure in the event of more serious and serious health problems.

Occupational heat stress is a major health burden with several potential negative health and well-being outcomes. Workers in certain industries are regularly exposed to heat stress due to thermal heat in working environment. Duration of working in such working environment does has positive effect to blood pressure especially on systolic. Prolonged exposure to heat stress will adverse health effect to the workers. Therefore, it is much essential in the current scenario to study the broader spectrum of health impacts due to heat stress among workers. This may provide valuable data and information to protect their health through proper planning and implementing suitable interventions to reduce morbidity and mortality of workers. Such policies subsequently will increase the productivity of any workplace. All employers are required to adopt and adapt the relevant guideline in managing heat stress at workplace and to fulfil one of the general duties under the Occupational Safety and Health Act 1994 and the Factories and Machinery Act 1967.

REFERENCES

Epstein Y, Moran DS. Thermal comfort and the heat stress indices. Ind Health. 2006 Jul;44(3):388-98.

Glazer JL. (2005) Management of heatstroke and heat exhaustion. Am Fam Physician. Jun 1;71(11):2133-40.

Kovats RS, Hajat S. Heat stress and public health: a critical review. Annu Rev Public Health. 2008;29:41-55

Lundgren K, Kuklane K, Gao C, Holmér I. Effects of heat stress on working populations when facing climate change. Ind Health. 2013;51(1):3-15.

Kunst AE, Looman CW, Makenbach JP. Oudoor air temperature and mortality in the Netherlands : a time series analysis. American Journal of Epidemiology 1993; 137(3): 331-41.

Mancia, Giuseppe, and Guido Grassi. 2002. “Systolic and

Diastolic Blood Pressure Control in Antihypertensive Drug Trials." : 1461–64.

Nag PK, Dutta P, Nag A. Critical body temperature profile as indicator of heat stress vulnerability. Ind Health. 2013;51(1):113-22.

National Heart Lung and Blood. 2016. "What Is High Blood Pressure?" American Heart Association.

Kementerian Sumber Manusia. "Garis Panduan Pengurusan Tegasan Haba di Tempat Kerja 2016."

Stauss HM, Morgan DA, Anderson KE, Massett MP, Kregel KC. Modulation of baroreflex sensitivity and spectral power of blood pressure by heat stress and aging. Am J Physiol. 1997 Feb;272(2 Pt 2):H776-84.

Suma'mur P.K. (1996). Higene Perusahaan Dan Kesehatan Kerja. Jakarta: PT Toko Gunung Agung.

Yang Y, Chan AP. Heat stress intervention research in construction: gaps and recommendations. Ind Health. 2017 Jun 8;55(3):201-209.

Turnbull F, Neal B, Ninomiya T, Algert C, Arima H, Barzi F, Bulpitt C, Chalmers J, Fagard R, Gleason A, Heritier S, Li N, Perkovic V, Woodward M, MacMahon S. Effects of different regimens to lower blood pressure on major cardiovascular events in older and younger adults: meta-analysis of randomised trials. BMJ. 2008 May 17;336(7653):1121-3.

MAEH Journal of Environmental Health eISSN 2637-1359
Jurnal Kesihatan Persekitaran MAEH
Published By Malaysian Association of Environmental Health
http://www.maeh4u.org.my/journal

RESEARCH ARTICLE

A Review on Public Health Concern Caused by *Escherichia coli* O157:H7

Adamu MuhammedTukur*, Garba Lawan, Shuaibu Isa

Department of Microbiology, Faculty of Science, Gombe State University, Gombe, Gombe State, Nigeria

**Corresponding author: microtukur@gmail.com*

Abstract

The public health issues related to *Escherichia coli* safety remains a major issue in the 21st century which affects both the advanced and third-world countries. Hemorrhagic fever caused by *E.coli* O157:H7 has become a global public health dilemma. Worldwide incidences cause by *E.coli* particularly O157:H7 make it an important pathogen that occurred in all countries. Infection cause by O157:H7 range from asymptomatic which may become severe in some cases. *Escherichia coli* O157:H7 can cause infections at a very low dose in humans which is a much lower dose than for most other pathogens of the intestines. Its preference to thrive within the warmer-temperature seasons compared to periods with low temperatures make it a novel pathogen in the tropical regions. It can cause infections at a very low dose in humans which is a much lower dose than for most other pathogens of the intestines: Despite the vital community and clinical health hazards pose by *E.coli* O157:H7 worldwide, a very few studies were conducted in developing countries. Continues surveillance to determine the prevalence of the pathogen as well as accurate diagnostic procedures may immensely help in tackling the pathogen

***Keywords*:** Escherichia coli, hemorrhagic fever, enteric diseases, foodborne pathogens

INTRODUCTION

Dr. Theodor Escherich in 1885 discovered what is now known as *E.coli* through his investigation on the cause of infant diarrhea. The stool sample of the infant was shown to contain a pathogenic bacteria which has been highlighted as an important human pathogen since then. The discovery of Shigella dysenteriae as an agent of epidemic bacterial dysentery was reported by Kioshi Shiga in 1898 (Shiga, 1898). In 1955, that hemolytic uremic syndrome (HUS) was first described and defined (Gasser *et al*., 1955), while Keusch *et al*., 1972) showed that Shiga toxins contribute to bloody diarrhea. Some bacteria are known for their ability to cause foodborne illnesses, *E.coli* that produce Shiga- toxin (STEC) are among the pathogens linked to such diseases (Kaufmann *et al*., 2006). *Escherichia coli* that cause infections in humans are classified into 6 main pathotypes: Entero-pathogenic *E.coli* (EPEC), entero-toxigenic *E.coli* (ETEC), diffusely adhering *E.coli* (DAEC), entero-aggregative *E.coli* (EAEC), entero-invasive *E.coli* (EIEC) and EHEC (Entero-haemorragic *E.coli*) based on toxin productions and pathogenicity. The aforementioned pathotypes of *E.coli* are identified to adopt what is referred to as multistep systems of pathogenesis which involved series of steps including; evasion of the host defenses, colonization of the mucosal site, multiplication within the animal, and tissue degenaration of the invaded location (Torres *et al*., 2005 and Nataro & Kaper 1998).

Escherichia coli, a commonly found member of the natural microflora of human and animal intestinal tract, is a Gram-negative facultative organism and a member of the Enterobacteriaceae (Nys *et al*., 2004, Von Baum and Marre, 2005). They are one of the most commonly isolates found in faecal matter of mammals (Elder *et al*., 2000; Brown *et al*., 2001). These bacteria can easily be transferred to cattle carcasses from hides contaminated with fecal matter during slaughtering and beef processing (Reid *et al*., 2002). Among the enterics, 0157:H7 and non 0157: H7 serotypes of *E.coli* that produce shiga toxin have been recognized as the causative agents for HC (haemorrhagic colitis) and HUS (haemorrhagic uraemic syndrome) in humans respectively (Von Baum and Marre, 2005). The two serotypes are of medical importance due their role in outbreaks globally, their ability to cause severe illness and also very minimal number of cells required to trigger an infection among susceptible human population (Duffy and Garvey, 2001).

PUBLIC HEALTH CONCERN

A total 5220 deaths in 28 616 *E. coli* bacteraemia patients, a mortality rate of 18.2% was reported in a United Kingdom (Abernethy et al, 2015). Previously, *Salmonella* and *E.coli* were estimated to cause 1.3 million deaths and 62,000 incidence of gastroenteritis respectively per annum in the US (Mead *et al*., 1999). However, among the two, the 0157:H7 strain was identified as the most important in terms of pathogenicity which

was epidemiologically found to be responsible for many outbreaks due to food ingestion in Japan and Europe. Escherichia coli O157:H7 causes 73,000 illnesses in the United States annually based on reported data in2005 which indicated a significant decrease in number of incidences (Josefa *et al*, 2005) .Similarly, Non 0157:H7 food-borne outbreaks have also been reported and the common isolated serotypes in these cases were O26 and O111. According to estimations by the CDC, 0157:H7 caused about 73,000 illness and a total of 61 deaths per annum in the United States while non-0157 STEC account for an additional 37,740 illnesses with 30 deaths (White, 2002). After hemorrhagic colitis was found to be caused by *E.coli* as a cause of hemorrhagic colitis the CDC reassessed samples collected between 1973-1983, the report showed that only one isolate have been identified as O157:H7 out of 3,000 *E.coli* strains serotyped. Similar reassessment in United Kingdom public Laboratory conducted between 1978 and 1982 also isolated only 1 O157:H7 serotype out of 15,000 *E.coli* isolates.

However, between 1978 and 1982 the Canadian CDC reassessed 2,000 isolates found in stool samples out of which six isolates were confirmed to be O157:H7 (Griffin and Tauxe, 1997). For that reason, it seems that the occurrence of O157:H7 strains has actually raised during the last decades and the data about its prevalence in some countries remained intact since its discovery. According to records, the largest outbreak caused by O157:H7 serotype was reported in 1996 from Japan, about nine thousand citizens were affected and the implicated source of infection was contaminated radish sprout (Michino *et al*., 1998). Transmission of the O157:H7 can also occur through person to person. Waterborne and person-person being transmissions were reported to be increasing (Meng *et al*., 2001). In Malaysia, 22.6-88% prevalence has been reported for *Escherichia coli* in agricultural products (Adzitey, 2011). In addition, incidence of O157:H7 serotype was reported to be 28.6% for the Southern, 38.8% for the Central, 36.5% for the Eastern and 35.6% for the Northern region (Chey *et al*., 2004). Recently, surveillance data from Sweden, Finland and Canada showed a 2961 30-day deaths in 30,923 incident *E. coli.* (Melissa *et al*, 2021)

PERIODIC INFECTIONS

Periodic infection caused by O157:H7 are frequently isolated in Canada compared to the USA, but such infection has been reported to have increased in some regions within the USA. However, geographical pattern of spread of diseases appeared to be less frequent in southern compared to northern region of the US and in Canada it was found to be less common in southern compared to western region Many studies have reported seasonal effect on prevalence of Salmonella and O157:H7 serotype ((Nataro *et al*., 1998) (Griffin, 1995). Armstrong, 1996, Dargatz *et al,* 2003, Rivera-Betancourt *et al.,* 2004 and Edrington *et al*., 2006). Other report indicated seasonal variations have no effect on prevalence of O157:H7 serotype. Various infection routes have been described; transmission via food and human contact. Animal reservoirs were found to be the major source of infections for humans in the United Kingdom (Dayna *et al*, (2008); Locking *et al*, 2001; O'Brien *et al*., 2001). Worldwide incidences cause by STEC particularly O157:H7 make it an important pathogen that occurred in all countries but are most frequent in some parts of the United States, Canada and United Kingdom. Based on estimates about 73,480 cases of O157:H7 infections are recorded each year in the United States ((Altekruse *et al*., 1999; Nataro and Kaper, 1998; Tauxe, 1997; Mead *et al*, 1999). On the other hand, from 2000-2005, 24 countries in the European Union have documented 62% cases of O157 infections out of 14,000 incidences (Fisher and Meakins, 2006). About 90 outbreaks were reviewed in Scandinavia, UK, USA, Japan, Ireland and Canada and results have shown that secondary sources were responsible for approximately 20% of the total outbreak episodes. In addition, the time interval for episodes of the incidences revealed that there was sustained spread of the pathogen after the outbreak among communities affected and it seems to be sporadic (Snedeker *et al*, 2009).

Several analyses have determined the occurrence rate of O157 in bovine and assessments on documented results suggested some wide discrepancies among results provided by researchers. Fecal samples analysis collected from cattle indicated a prevalence of 0.28-48.8% in dairy farms. Similarly, a prevalence of 0.4% to 40% in calves in the United States while 1.7% to 48.8% were documented in other countries from North America, Europe and Asia. The occurrence rate of O157:H7 seems to be higher within the warmer-temperature seasons compared to periods with low temperatures (Hussain and Bolinger, 2005, Hussain and Sakuma, 2005). Moreover, O157 serotypes is also found in smaller mammals such as sheep researchers have shown. Bovine and sheep intestinal contents samples were reported to harbor about 4.7% and 0.7% respectively of O157:H7 serotypes after slaughtering in the United Kingdom (Milnes, 2008). However, variability tend to be higher between various cattle carriages as prevalence appeared to be higher in one place totally absent in another place (Mathews *et al*, 2006). The distribution of prevalence is highly affected by external and internal factors in the farmlands and of course the animal origins. Sometimes many herds showed positive fecal samples while others were negative (Synge and Paiba, 2000).

Similarly, one of several studies conducted in Scotland which involved 474 cattle herds concluded that joining together dynamic epidemiological paradigm and the documented prevalence, including considerable diversity of shedding from each animal (so-called super shedders, excrete large amount while many shed small number of bacteria), indicated a unique procedure where approximately twenty percent of highly contagious cattle's shed 80% of the bacteria (Chase-Tapping *et al*, 2008).

Cattle's super shedding is related to the establishment of the bacteria in lymphoid follicle-dense mucosal region near the anal region. Bovines that harbor the bacteria at fore mentioned location release significant amount microorganisms persistently compared to animals that have the bacteria at different locations. The super-shedders can significantly increase prevalence of O157:H7 serotypes among the normal shedder if they coexist on the same farmland and possibly infects another cattle in the same pen. Potential risk associated with mixing super shedders and low-shedders on the same farms have been studied and the report have shown that phage type 21/28 was frequently isolated microorganism which help in cross-infection. Sex and level of stress are some of the risk factors for colonization by the bacteria. The female gender of cattle is more prone to colonization. In addition, weaning and movements were also recognized as risk factors but factors originating the environment including feed and water source were not implicated according to the report (Chase-Tapping *et al,* 2007).

DISTRIBUTION

Escherichia coli O157:H7 is transmitted to humans primarily through consumption of contaminated foods, such as raw or undercooked ground meat products and raw milk. Faecal contamination of water and other foods, as well as cross-contamination during food preparation (with beef and other meat products, contaminated surfaces and kitchen utensils), will also lead to infection (WHO, 2018). *Escherichia coli* primarily inhabit the intestine of warm-blooded animals and humans where the bacteria exist as the normal flora (Bell, 2002). Transmission is usually via contact with animals, contaminated food or during processing and preparations animal carcass. Enteric pathogens

(enterobacteriaceae) such as the *E.coli* are distributed from livestock to food crops through various routes such as irrigation with polluted water, dissemination by air, application of manures, transmission through biological agents such as insects and wildlife (Janisiewicz et al, 1999). Domestic and wild animals provide a regular source of EHEC in the environment due to persistent dissemination feacal contamination (Bell, 2002). Distribution from human to human has been highlighted on several occasions in children's kindergarten and health care delivery institutions. According to a study, household transmission is most frequent among individuals within the age of <5 years and adolescents (Parry and Salmon, 1998).

Furthermore, assessment of secondary spread in 90 outbreaks that occurred from 1982 to 2006 identified person to person contact as the route of secondary transmission in houses and nurseries (45.6% vs 11.1%) and institutions (4.5%); bathing water 10% and 55% from unknown sources. The maximum mean percentage of 2º occurrence have been documented in incidences involving patients with average age below six years while the minimum within the age of 17–59 years (Snedeker *et al,* 2009). Talley *et al*, 2009 studied the role of biological agents in distribution of the bacteria particularly invertebrates, which are commonly found on fields of leafy plants and neighboring farmlands, in produce contamination.

During the investigation, a confinement was formed for house flies on a medium containing O157:H7 serotype marked with green fluorescent protein (GFP) followed by testing their ability to transmit the pathogen to spinach plants. The insects were capable of transmitting the GFP-tagged bacteria on outer layer of 50–100% of leaves viewed using fluorescence microscopy and in 100% of samples tested by PCR. Obviously, flies are capable of contaminating leafy vegetables, and this confirms the significance of the role played by insects in the transmission and subsequent contamination of fresh produce. Agricultural production environments and animals including cattle and poultry are noted sources of *E coli* and *Salmonella*. Mode of transmission of these pathogens were linked to ground beef in a number of food-borne out-breaks (CDC, 2002).

Numerous investigations on the microbiological hygiene of cattle at slaughter have indicated that hide contamination is highly associated with cross-contamination to animal carcasses which possibily results from slaughtering and processing (Bell *et al*, 1997, Elder *et al*, 2000, McEvoy *et al*, 2000; Omisakin, 2003 and Arthur *et al*, 2007). The route of transmission of *E.coli* is shown below in fig .1.

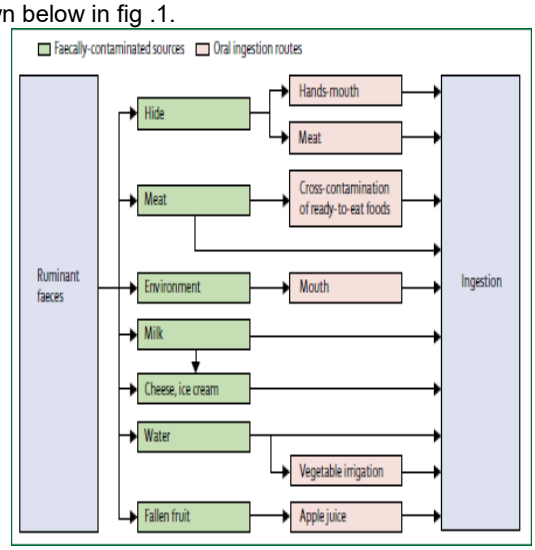


Figure 1 Route of Distribution for *Escherichia coli* (Hugh, 2010)

DISEASES CAUSED BY *E.COLI* O157:H7

More than 70 distinct types of STEC which trigger human diseases globally have been identified (Brooks *et al*., 2005; Armstrong *et al.,* 1996; Nataro and Kaper 1998). It can cause an illness that begins with minor diarrhea to a severe diarrhea with blood, in some cases results in hemorrhagic form of the disease. Among the serotypes, O157:H7 seems to be frequently related to aggressive infections (Brooks *et al*., 2005, Rivero *et al.*, 2010 and Tozzi *et al*., 2003). The disease has been related to contact with animals and their products, animal manure and contamination of vegetables; drinking water and edible fruits have also been implicated (Swerdlow *et al.*, 1992). Partially-cooked meat which harbored *E.coli* O157H7 have been implicated in 50% of foodborne outbreaks in the US (Gansheroff and O'Brien 2000). Healthy cattle may harbor O157:H7 serotype of *E.coli* which can be disseminated transiently and occasionally via feces (Cray & Moon 1995).

Escherichia coli O157:H7 can cause infections at a very low dose (1 and 100 CFU) in humans which is a much lower dose than for most other pathogens of the intestines (Paton and Paton, 1998). The bacteria can get attached to human intestine cells prior to infection for subsequent invasion and multiplication in the human host (Welinder-Olsson and Kaijser, 2005). Several human infection including HS and some forms of diarrhea have been associated with the pathogen since its first identification. It is also associated with severe forms of the infections - Hemolytic Uremic Syndrome. Generally, O157:H7 serotype cause infection that is self-limiting which depends on strain type and extent of the disease may vary. Hemolytic colitis is the most important disease related to O157:H7, its clinical symptoms include bloody diarrhea and abdominal pain which may subsequently develop to HUS or renal failure (Paton and Paton, 1998; Griffin and Tauxe, 1991; Johnson *et al*., 2006). Based on estimations about 8% of people harboring O157:H7 may eventually develop Hemolytic Uremic Syndrome (McNabb *et al*., 2008 and Tarr, 2009). Morbidity and mortality due to EHEC is mainly caused by diarrhea-associated HUS, resulting in death in up to 5% of cases and frequent permanent renal injury at a rate of 25% (Garg *et al*., 2003). This leads to platelet activation and local intravascular thrombosis or thrombotic microangiopathy, blood clot formation within the vasculature, and ultimately, a reduction in platelet counts.

Infection caused by O157:H7 range from asymptomatic which may become severe in some cases. Most information obtained on the infection are usually obtained from outbreaks and sometimes these data may not be reliable or seems to be biased (Manning *et al*, 2008). However, outbreak data such as those obtained from outbreak in Japan and the 2006 outbreak associated with spinach in the USA (more than 50% people hospitalized) are chosen by most researchers for epidemiological studies (Hataya, 1997 and CDC, 2006). Higher incidence of HUS seemed to occur mostly in infants <5 years old. According to the reports, levels Gb3 receptor sites are higher in children which bound to Shiga toxin that possibly circulate. Malfunctions of the renal cells can lead to azotemia- identified by the increase of nitrogenous compounds resulting from poor filtration by the kidneys (Inward *et al*., 1997, Tarr, 2009 and Tarr *et al*., 2005). In patients with post-diarrheal kidney failure, no prophylaxis was known to be effective (Machedo *et al*, 2009).

Despite the vital community and clinical health hazards pose by *E.coli* O157:H7 worldwide, a very few studies were conducted in developing countries. Stringent policies dealing with improper food supplies and agricultural practices will be urgently required to tackle some potential menace associated with distribution of the pathogen. Epidemiological investigation may play a crucial

role in providing useful data for interventions and decision making in health planning.

REFERENCES

Adzitey, F. (2011). Escherichia coli, Its Prevalence and Antimicrobial Resistance in Malaysia: A Mini Review. *Microbiolo*gy Journal.10, 1-6.

Abernethy J.K , Johnson A.P , Guy R , Hinton N , Sheridan E.A and Hope RJ (2015) Thirty day all-cause mortality in patients with Escherichia coli bacteraemia in England. *Clin Microbiol Infect.* (3):25-32

Armstrong, G.L, Morris J.G and Hallingworth, J. (1996). Emerging Food Pathogens: Escherichia coli O157:H7 as Model of Entry of a New Pathogen into the Food Supply of the Developed World. *Epidemiology Review* 18, 29-51.

Arthur, T.M., Wheeler T.L. and Bosilevac J.M. (2007). Effects of minimal hide wash cabinet on the levels and prevalence of *Escherichia coli* 0157:H7 and *Salmonella* on the hides of beef cattle at slaughter. *Journal of Food Protection*. **70**, 1076-1079.

Bell, C. (2002). Approach to the control of entero-haemorrhagic Escherichia coli (EHEC). *International journal of food microbiology*, 78(3), pp.197–216.
Brooks J.T, Sowers E.G, Wells J.G and GriffinP.M (2005). Non-shiga Toxin Escherichia coli Infection in the United States, 1983-2002. *J.Infect.Dis*. 192, 1422-1429.

Centers for Disease Control and Prevention. (2006). Ongoing multistate outbreak of Escherichia coli serotype O157: H7 infections associated with consumption of fresh spinach—United States, September 2006. *Morb. Mortal. Wkly Rep*. 55, 1045–1046.

Chye, F.Y, Khan M. and Abdullah, A. (2004). Bacteriological Quality and Safety of Raw Milk in Malaysia. *Food Microbiol*. 21, 535-541.

Cray, W.C. and Moon, H.W. (1995) Experimental Infection of Calves and Adult Cattle with Escherichia coli O157:H7. *Appl. Env. Microbiol.*.61, 1586-1590.

Dargatz, D.A, Headrick M.L and Fedorka-Cray, P.J. (2003). Prevalence and antimicrobial susceptibility of *Salmonella* spp isolates from cattle and feedlots in 1999 and 2000. *Journal of Applied Microbiology*. 95, 753-761.

Dayna, M.A., Mohammad K. and Micheal, N.G. (2008). *Salmonella* and *Escherichia coli* 0157:H7 contamination of hides and carcasses of cull cattle presented for slaughter in United States : An evolution of prevalence and Bacterial Loads by Immunomagnetic separation and Direct plating methods *J.Appl. Environ. Microbiol*. 74 (20), 6289-6297.

Duffy, G., Garvey, P., (2001). Survival and growth of verocytotoxigenic E. coli in foods. In: Duffy, G., Garvey, P., McDowell, D.A. (Eds.), Verocytotoxigenic E. coli. Food & Nutrition Press, Connecticut, pp. 305– 322.

Edrington,T.S, T.R Callaway, S.E. Ives,. Engler M..J, Looper M.L, Anderson R.C, and .Nisbet D.J. (2006). Seasonal shedding of Escherichia coli O157:H7 in Ruminants: a new hypothesis. *Foodborne pathogenic Disease.* (**3),** 413-421.

Elder, R.O., Laegred, W.W. and Keen, J.E. (2000). Correlation of enteroherrhagic *Escherichia coli* 0157 prevalence in faeces, hides and carcases of beef cattle during processing. *Procedings of National Academy of Science* 97: 2999-3003.

Fisher, I., and Meakins, S. (2006). Surveillance of enteric pathogens in Europe and beyond: Enternet annual report for 2004. http://www.eurosurveillance.org/ViewArticle.aspx

Garg, A.X., Suri, R.S., Barrowman, N., Rehman, F., Matsell, D., Rosas-Arellano, M.P., Salvadori, M., Haynes, R.B., and Clark, W.F. (2003). Long-term renal prognosis of diarrhea-associated hemolytic uremic syndrome. *JAMA* 290: 1360– 1370.

Gensheroff, L.J and O'Brien, A.D. (2000). Escherichia coli O157:H7 in Beef Cattle Presented for Slaughter in the USA: Higher Prevalence Rates than Previously Estimated. *Proc. Natnl. Acad. Sci*. USA. 9(7), 2959-2961.

Griffin, P.M. (1995). Escherichia coli O157:H7 and Other Enterohemorrhagic Escherichia coli. In. Blaser, M, Smith, P.D, Ravdin, J.I. Infection of Gastrointestinal Tract. Raven Press. New York. Pp.739.

Griffin, P.M and Tauxe, R.V (1991). The Epidemiology of infection Caused by Escherichia coli O157:H7, Other Enterohemorrhagic Escherichia coli and Associated Hemolytic Uremic Syndrome. *Epidemiol. Rev*. (13), 60-98.

Hataya H. (1997). Report on the Outbreak of *E.coli* O157 Infection in Sakai City. Sakai City, December 1997.

Hugh P. (2010) *Escherichia coli* O157. *Lancet*, 376: 1428–35

Hussein H.S, Bollinger LM. (2005). Prevalence of Shiga toxin-producing *Escherichia coli* in beef cattle. *J Food Prot.* 68**,** 2224–41.

Inward, C. D., Howie, A. J., Taylor, C. M., Milford, D.V., Fitzpatrick, M. M., and Rafaat, F.(1997). Renal histopathology in fatal cases of diarrhoea-associated haemolytic uraemic syndrome. *Pediatr. Nephrol*. 11, 556–559.

Janisiewicz, W., Brown, M., Conway, W., Buchanan, R., Sapers, G. and Fratamico, P. (1999). Fate of *Escherichia coli* O157: H7 on fresh-cut apple tissue and its potential for transmission by fruit flies. *Appl. Environ. Microbiol*. 65, 1.

Johnson, K. E., Sears, C. L., and Thorpe, C. M. (2006). The emerging clinical importance of non-O157 Shiga toxin-producing *Escherichia coli. Clin. Infect. Dis.* 43, 1587–1595.

Josefa M.R, Phyllis H.S., Collen C, Patricia M.G., and David L.S. (2005) Epidemiology of Escherichia coli O157:H7 Outbreaks, United States, 1982–2002. *EID Journal*.11(4).

Kaufmann L, Zweifel C, Blanco M, Blanco J.E, Beutin L and Stephan R 2006. *Escherichia coli O157* and non-O157 Shiga Toxin-Producing *Escherichia coli* in Fecal Samples of Finished Pigs at Slaughter in Switzerland. *Journ Food Protect*. 69, 260-266.

Keusch, G. T., McIver, J.Grady, G. F. and Mata, L. J. (1972) The pathogenesis of Shigella Diarrhea: I. Enterotoxin production by Shigella dysenteriae 1. *J. Clin. Investig*. 51, 1212–1217.

Locking, M. E., Ramsay, C. N., O'Brien, S. J., Wright, E. M., Campbell, D. M., Reilly, W. J., Coia, J. E. and Browning, L. M. (2001). Risk factors for sporadic cases of Escherichia coli O157 infection: the importance of contact with animal excreta. *Epidemiol Infect.* 127, 215–220.

Manning, S. D., Springman, A. C., Motiwala, A. S., Qi, W., Lacher, D. W., Ouellette, L. M., Dietrich, S. E., Mladonicky, J. M., Somsel, P., and Rudrik, J. T. 2008. Variation in virulence among clades of *Escherichia coli* O157: H7 associated with disease outbreaks. *Proc. Natl. Acad. Sci.* USA 105, 4868.

Matthews, L., Mellor, D., Low, J., Gally, D., Pearce, M., Chase-Topping, M., Heesterbeek, J., Shaw, D., Reid, S. and Naylor, S. 2006. Heterogeneous shedding of *Escherichia coli* O157 in cattle and its implications for control. *Proc. Natl. Acad. Sci*. USA.

McEvoy, J.M., McDowell, D.A., Doherty, A.M., Sheridan, J.J., and Blair, I.S. 2003. The prevalence of *Salmonella* spp in bovine, faecal, rumen and carcass samples at a commercial abattoir. *Journal of Applied Microbial*. 94, 693-700.

McNabb, S., Jones, G., Jajosky, R. A., Worshams, C., Anderson, W., Javier, A., Nitschke, D. and Hall-Baker, P., Adams, D., Sharp, P., (2008). Summary of notifiable diseases—United States, 2006. *Morb. Mortal. Wkly Rep*. 55, 1–92.
Melissa C. MacKinnon, Scott A. McEwen, David L. Pearl, Outi Lyytikäinen, Gunnar Jacobsson, Peter Collignon, Daniel B. Gregson, Louis Valiquette & Kevin B. Laupland (2021) Mortality in Escherichia coli bloodstream infections: a multinational population-based cohort study. *BMC Infectious Diseases*.(21):606

Meng, J, Kresovich, S., Zhao, S, Doyle, M.P. and Zhao, T. 2001 Enterohemorrhagic *Escherichia coli*. In: Doyle, M.P, Beuchat, L.R, Monville, T.J. Food Microbiology; Fundamentals and Frontiers. 2nd Edn. Pp. 193-213.

Michino, H., Sakai, N., Araki, k, Hiroe, K, Minami, S, Nakayama, T, Tanaka, H, Fujita, N, Usami, S, Yonekawa, M, Sadamoto, K, and Takaya, S (1998) Recent Outbreak of Infections Caused by Escherichia coli O157:H7 in Japan. pp. 73-81. ASM Press.

Nataro, J.P and Kaper, J.B. (1998) Diarrheagic Escherichia coli. *Clin. microbiol. Rev*. 11(1), 142.

Nys, S., Okeke, I. N., Kariuki, S., Dinant, G. J., Driessen, C., Stobberingh, E. E. (2004). Antibiotic resistance of faecal Escherichia coli from healthy volunteers from eight developing countries, Journal of Antimicrobial Chemotherapy, 54 (5), 952–955.

O'Brien, S. J., Adak, G. K. and Gilham, C. 2001. Contact with farming environment as a major risk factor for Shiga toxin (Vero cytotoxin)- producing Escherichia coli O157 infection in humans. *Emerg. Infect. Dis.* **7**, 1049–1051.

Omisakin, F.M., Strachan, N.J.C McRae, I.D. 2003. Concentration and prevalence of *Escherichia coli* 0157 in cattle feces at slaughter *Applied Environmental Microbiology.* 69, 2444-2447.

Pal M. (2005) Importance of zoonoses in public health. Indian Journal of Animal Sciences, **75**: 589-591.

Pal M.(2007) Zoonoses. 2nd edition. Satyam Publishers.

Parry, S.M and Salmon RL. 1998. Sporadic STEC O157 Infections: secondary household transmission in Wales. *Emerg Infect Dis.* 4**,** 657–61.

Paton, J. C., and Paton, A. W. (1998). Pathogenesis and diagnosis of Shiga toxin-producing Escherichia coli infections. *Clin. Microbiol. Rev*. **11**, 450–479.

Rivera-Betancourt, M., Reagan, J.O., Shackelford, SD., Arthur, T.M, K.E Westmoreland, K.E, Bellinger, G., M. Rossman, M, and Koomahraie M. 2004. Prevalence of *Escherichia coli* O157:H7, Listeria monocytogenes, and Salmonella in two geographically distant commercial beef processing plants in the United States. *Journal of Food Protection.* 67**,** 295-302.

Rivero, M.A, Parma, A.E., Passuci, J.A and Rodriguez, E.M. (2010) Role and Clinical Cause of Verotoxigenic Escherichia coli Infection in Childhood Acute Diarrhea in Argentina. *J.Med.Microbiol*. (59) 345-352.

Shiga, K. (1898). Ueber den Dysenterie-bacillus (Bacillus dysenteriae). *Zentralbl, Bakteriol. Orig*. (5) 913-918.

Snedeker K.G, Shaw D.J, Locking ME. Prescott R. (2009) Primary and secondary cases in *Escherichia coli* O157 outbreaks: a statistical analysis. *BMC Infect Dis*. (9), 144-149

Swerdlow, D.L., Donnel, H.D, Woodruft, B.A., Brady, R.C., Griffin, P.M and Tippen, S. (1992) A Waterborne Outbreak in Missouri of *Escherichia coli* O157:H7 Associated with Bloody Diarrhea and Death. *Ann. Int. Med.* 117, 812-819.

Talley, J., Gilliland, S., Wayadande, A., DeSilva, U., Wasala, L., Gerry, A. and Fletcher, J. 2009. Association of Escherichia coli O157: H7 with filth flies (Muscidae and Calliphoridae) captured in leafy greens fields and experimental transmission of E. coli O157: H7 to spinach leaves by house flies (Diptera: Muscidae). *J. Food Prot.* 174(72), 1547–1552.

Tarr, P. I. (2009). Shiga toxin-associated hemolytic uremic syndrome and thrombotic thrombocytopenic purpura: Distinct mechanisms of pathogenesis. *Kidney Int*. S29–S32.

Tarr, P. I., Gordon, C. A., and Chandler, W. L. (2005). Shiga-toxin-producing *Escherichia coli* and haemolytic uraemic syndrome. *Lancet* 365, 1073–1086.

Tauxe, R. (1997). Emerging foodborne diseases: An evolving public health challenge. *Dairy Food Environ. Sanitation* 17, 788–795.

Torres, A.G., Kaper, J.B. and Zhou, X. 2005. Adherence of diarrheagenic Escherichia coli strains to epithelial cells. *Infection and immunity*, 73(1), pp.18–29.

Von Baum, H., and Marre, R. (2005) Antimicrobial resistance of *Escherichia coli* and Therapeutic implications. *International Journal of Medical Microbiology*. 295, 503-511.

White, D.G., McDermott, P.F., Zhao, S., and Wagner, D. 2002 Antimicrobial resistance of food borne pathogens. *Microbes and infection*. 4, 405-4.

World Health Organization (2018) Facts Sheet: E. coli.

MAEH Journal of Environmental Health eISSN 2637-1359
Jurnal Kesihatan Persekitaran MAEH
Published By Malaysian Association of Environmental Health
http://www.maeh4u.org.my/journal

RESEARCH ARTICLE

Environmental Ergonomics Affecting Students Comfort In A Vocational College

Fahmi Mazalan[a,b], Farah Ayuni Shafie[a*]

[a] *Centre of Environmental Health and Safety, Faculty of Health Sciences, Universiti Teknologi MARA, Selangor*
[b] *Kepong District Health Office, Jalan Jinjang Permai, Jinjang Utara, Kuala Lumpur, Wilayah Persekutuan Kuala Lumpur*

**Corresponding author: farahayuni@uitm.edu.my*

Abstract

Environmental ergonomics is defined a scientific study of the effects of ambient environmental conditions on human comfort, performance and health. Knowledge on ergonomics, importance of safety, and environmental ergonomic conditions are the essential factors to ensure students' comfort during practical work in the workshop. This study aims to assess environmental ergonomic conditions regarding lighting, noise and temperature that affect students' comfort during practical session in a vocational college. This study compared two groups namely Welding Technology and Electronic Technology. Welding Technology students are exposed to high noise, high temperature, and need adequate lighting while Electronic Technology students are not exposed to the high noise and high temperature during the practical session. There is a significant difference of environmental ergonomic conditions between Welding and Electronic Technology students ($0.01 = p < 0.05$). There is no significant difference in comfort level between Welding and Electronic Technology students ($0.39 = p > 0.05$). There is association between environmental ergonomics and students' comfort level ($0.04, 0.02, 0.01 = p < 0.05$). The interaction between students and their surrounding environment is one of the key important aspect in workshops. A number of 79.6% students agreed that the noise of the machine interrupts them emotionally during practical work. Majority of the environmental ergonomics measurement level in the workshop did not comply with the established standards. The environmental ergonomics is helpful to contribute ideas for improvements in the design of the workplace to enhance students' comfort.

Keywords: *Environmental ergonomics, students' comfort, vocational college, workshop*

INTRODUCTION

Environmental ergonomics is a scientific study of the effects of ambient environmental conditions on human comfort, performance and health (Hedge et al., 2000). Knowledge on ergonomics, importance of safety, and environmental ergonomic conditions are the essential factors that ensure comfort during practical work in the workshop (Mohd Rizal et al., 2010). Environmental ergonomics is concerned with how the people interact with the environment from the perspective of ergonomics. Environmental ergonomics is an important and valuable tool in workshop building design (Dianat et al., 2016).

In a work environment, the continuous and dynamic interaction between people and their surroundings can causes physiological and psychological strain which consequently affects their comfort, performance, productivity, safety and health (Parsons et al., 2000). To ensure reliability in the assessment of the environmental ergonomic conditions in each working environment, it has been suggested that both objective measurements such as physical measurements of lighting, noise, and temperature along with subjective assessments should both be taken into account. Subjective assessments should include comfort, satisfaction, perceived job performance, and health and safety consequence (Dianat et al., 2013).

Ergonomics is the aspect that should be emphasised when practicing in a workshop to prevent accidents and to create a positive working environment in the aforementioned workshop thus reducing stress and inducing satisfaction and well-being among the students in the workshop. Reduction in stress and emotional disturbances can lead to increment of emotional and motivational support. Poorly designed working environments or inadequate management of environmental factors could significantly affect one's

health, well-being, and overall performance (Skilling et al., 2017).

METHODOLOGY

Study design and setting

The study was conducted at a vocational college in central Johor. This study adopted the cross-sectional design to identify the correlation between environmental ergonomic conditions and students' comfort during practical session. This study presented on the effects of environmental ergonomic conditions on the comfort of students, and ergonomics assessments were made. This study compared two groups namely exposed group and control group. Exposed group is students of Welding Technology while control group is students of Electronic Technology. Welding Technology students are exposed to high noise, high temperature, and need adequate lighting while Electronic Technology students are not exposed to the high noise and high temperature during the practical session. This study used instruments such as Light Meter, Sound Level Meter, and Heat Stress Monitor to get readings in the workshop. The questionnaire was used to measure the comfort level among students and to obtain their information.

Study samples

The study samples consist of students from vocational college. A number of 226 students of Welding Technology course and Electronic Technology course were chosen as the study sample because the Welding Technology students are exposed to high noise, high temperature, and need adequate lighting during the practical session. Electronic Technology students were chosen as control group because the students are not exposed to the high noise and high temperature. Students with myopia and hearing problems were considered as exclusion criteria for the study.

Data collection

Physical measurements of the environmental ergonomic conditions regarding lighting, noise, and temperature, the tools were used were sound level meter (model Cirrus CR:812C), light meter (model Extech HD450), and heat stress monitor (model 3M™ QUESTemp™ 36). To measure the comfort level of students during practical session in the workshop, a questionnaire was distributed to the students to be answered to measure the comfort level among students of Welding Technology and Electronic Technology courses during practical session. There are 30 questions in this questionnaire, each item uses a 3-point Likert scale; (1) Disagree, (2) Not sure, and (3) Agree. The questionnaire is divided into two parts, Part A is the demographic information of the respondents, and Part B encompasses questions that covers the aspects of knowledge on ergonomic, the importance of safety and environmental ergonomic conditions.

Data analysis

The analysis of the data, including descriptive statistics, was performed using IBM SPSS Statistical Version 23. This software was used to obtain the frequency, percentage, and mean of the statistical data of environmental ergonomic conditions and students' comfort. Besides that, this software was used to determine the normality of the data for hypothesis testing. The alpha value set in this study is 0.05. To test the hypothesis, this test is based on the significant value of t-test for Equality of Means. The hypothesis testing was conducted to determine whether an environmental ergonomic conditions was affecting the comfort level of students during practical session in the workshop. Testing of this hypothesis is based on the significant value of Pearson Chi-square test. A significance level of $p < 0.05$ was considered for all statistical tests.

RESULTS AND DISCUSSION

Ergonomics assessment

The results showed that ergonomic environments such as lighting, noise, and temperature influence students during the workshop at a high level with a mean value of 2.61 (Table 1). Students also agreed that the noise of the machine interrupts their emotionally when doing practical work. This can be proven by the highest mean value recorded on the item 10 at 2.75. Overall, items 3, 8, and 10 indicate most highest mean values of 2.71, 2.71, and 2.75.

Table 1 The data analysis for environmental ergonomic conditons.

Questions	Agree		Not Sure		Disagree		Mean
	f	%	f	%	f	%	
Machines such as welding machines, metal cutting machines and grinding machines are placed in a well-lit area.	144	63.7	52	23.0	30	13.3	2.46
The height of the light source is suitable for lighting in the workshop.	162	71.7	34	15.0	30	13.3	2.58
I am comfortable with the space in the workshop when doing practical work.	168	74.3	33	14.6	25	11.1	2.71
There is air circulation to prevent hot air in the workshop.	146	64.6	49	21.7	31	13.7	2.52
All openings such as windows, transparent roofs and doors in the workshop work well.	144	63.7	53	23.5	29	12.8	2.51
I feel comfortable with the environmental condition when doing practical work in the workshop.	146	64.6	57	25.2	23	10.2	2.53
A clean and orderly working environment is a factor that provides comfort when doing practical work.	165	73.0	39	17.3	22	9.7	2.64
The workshop wall area does not place objects that can cause injury.	165	73.3	38	16.6	23	10.1	2.71
It is too noisy in the workshop and that disturbs my concentration during practical work.	158	69.9	43	19.1	25	10.9	2.65

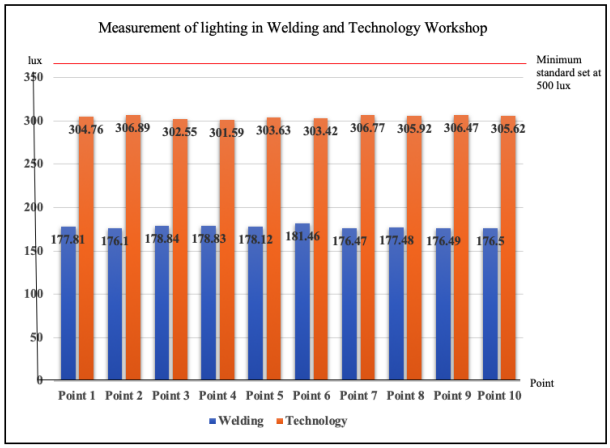
The noise of the machine interrupts me emotionally to pressure me.	180	79.6	31	11.5	15	8.8	2.75
							2.61

Environmental ergonomic conditions

There is a significant difference of environmental ergonomic conditions between Welding and Electronic Technology students (0.01 = p < 0.05). This hypothesis is approved and supported by the independent sample t-tests that were performed.

i. Lighting

Measurement of lighting was taken at ten different areas in the Welding and Technology workshops. The mean value of the lighting level for the Welding Technology group is 177.81 lux while for the Electronic Technology group is 304.76 lux. There are two sources of lighting in Welding and Electronic Technology workshop which are natural and mechanical lighting. Guidelines on Occupational Safety and Health for Lighting at Workplace 2018 set the minimum standard for educational buildings (teaching workshop) is 500 lux. Fig. 1 shows that all measurements of lighting level for both Welding and Electronic Technology workshop is not compliant with the standard. Based on the observations at the workshop, this problem is due to dysfunctional and damaged fluorescent lights. This problem limits the lighting source in the workshop and the students were exposed to visual discomfort and physical accidents. Inadequate lighting condition can cause discomfort to the occupants of a workplace and also affect both human performances at general tasks and visual performance (Dianat et al, 2013).

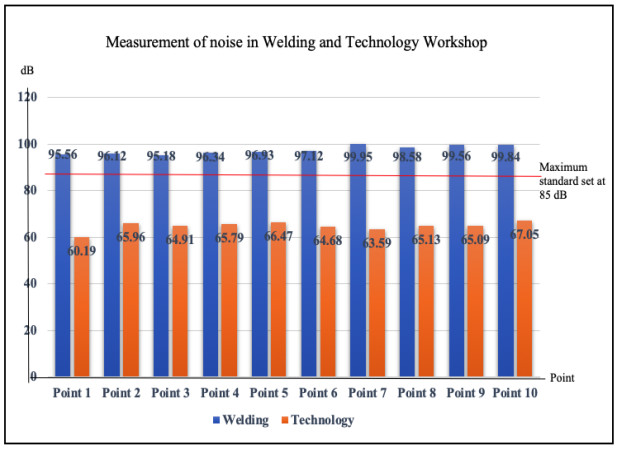


*According to Guidelines on Occupational Safety and Health for Lighting at Workplace 2018

Fig 1 Measurement of lighting in Welding and Technology workshops.

ii. Noise

The measurement of noise was taken at ten different areas in the Welding and Technology workshops. The mean value of the noise level for the Welding Technology group is 97.52 dB while for the Electronic Technology group is 64.89 dB. Occupational Safety And Health (Noise Exposure) Regulations 2019 set the maximum standard is 85 dB.Fig 2 shows that all measurements of noise level in Welding Technology workshop do not comply with the standard while the measurement of noise point level in Electronic Technology workshop complies with the standard. The cause of high noise level in the workshop is generated from the machines such as grinding machines and metal cutting machines. Short-term exposure to high noise levels can lead to temporary hearing loss or reduced ability to hear within a person's normal range, tinnitus which is described as a ringing in the ears and can affect sleep, inability to communicate, distraction, and reduced concentration (Skilling et al, 2017). Numerous researchers agree that noise is a major factor of discomfort and disturbance for employees (Perrin et al., 2017).

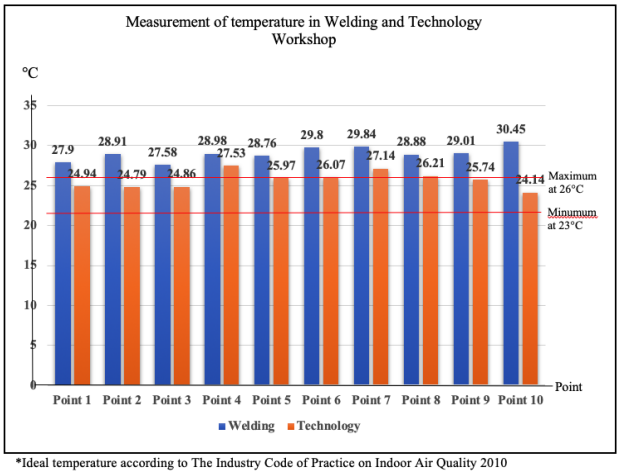


*According to Occupational Safety And Health (Noise Exposure) Regulations 2019

Fig 2 Measurement of noise in Welding and Technology workshops.

iii. Temperature

The measurement of temperature was taken at ten different areas in the Welding and Technology workshops. The mean value of the temperature level for the Welding Technology group is 29.01°C while for the Electronic Technology group is 25.78°C. The Industry Code of Practice on Indoor Air Quality 2010 stated that the ideal temperature for the working environment is between 23°C to 26°C. Fig 3 shows that all the measurements of temperature level in Welding Technology workshop do not comply with the standard while there are four points of measurement of temperature level in the Electronic Technology workshop that do not comply with the standard. The primary reason for the high temperature level in the workshop is poor ventilation system that is caused by dysfunctional exhaust fan. Apart from that, the heat produced by the grinding machines and metal cutting machines also lead to high level of temperature in the workshop. This problem may lead to heat stress and heatstroke which will lead to one having the inability to process information or communicate coherently. Thermal discomfort caused by the internal or external environment being too hot or too cold might lead to a variety of psychological or physical effects (Skilling et al, 2017).



*Ideal temperature according to The Industry Code of Practice on Indoor Air Quality 2010

Fig 3 Measurement of temperature in Welding and Technology workshops.

Students' level of comfort

There is no significant difference in comfort level between Welding and Electronic Technology students. (0.39 = p > 0.05). This hypothesis is approved and supported by the independent sample t-tests that were performed. Environmental ergonomic conditions is important as it influences the students' during their practical work in the workshop. This can be proven by the mean of environmental ergonomic conditions has the highest mean value which is 2.61. A total 79.6% students agreed that the noise of the machine interrupts their emotionally when doing practical work. Excessive noise level at school areas can affect psychology and physiology of both teachers and students (Ismail et al., 2015). A total 63.7% students also agreed the machines such as welding machines, metal cutting machines and grinding machines are placed in a well-lit area. This should be emphasized because poor lighting and poor visibility can contribute to accidents and poor performance as well as "momentary blindness" (Skilling et al., 2017).

Environmental ergonomics affecting students' comfort level

There is association between environmental ergonomics and students' comfort level (0.04, 0.02, 0.01 = p < 0.05). This hypothesis is approved and supported by the Pearson Chi-square test. Based on the data analysed from the questionnaire, environmental ergonomic conditions has the high mean value (2.61). 79.6% students also agreed that the noise of the machine interrupts their emotionally when doing practical work. A physiological and psychological strain on the person affected by the dynamic and longing interaction occur between human beings and their perspective surroundings (Parsons et al., 2000).

In addition, majority of the environmental ergonomic conditions measurement level in the workshop did not comply with the recommended standards. This problem occurred due to dysfunctional and damaged fluorescent lights, noise generated from the machines, and poor ventilation system that is caused by dysfunctional exhaust fan. This will affect students' physical and psychological aspects and quality of work. There are instances in which students' comfort is tampered due to the environmental disturbances in the workshop. Poorly designed work environment and poorly managed environmental factors, such as noise, extreme temperature, and inadequate lighting, can significantly affect one's overall work environment, health, well-being, and performance (Skilling et al., 2017).

There are several signs which reflect poor housekeeping and cleanliness at the vocational college workshop. Some of these signs are cluttered and poorly arranged work areas, untidy and dangerous storage of materials such as materials stuffed in corners and overcrowded shelves, dusty and dirty floors, tools and equipment left in work areas instead of being returned to proper storage places and broken containers and damaged materials. In order to improve students' comfort in the workshop, the school management should establish a housekeeping programme: a programme that focuses on an organised storage and movement of materials. The housekeeping responsibilities can be integrated in their work by having these students to clean up after their waste and unused materials, in addition to inspecting their work area to ensure the cleaning process is properly done and completed. Knowing the ways to keep their workspace safe and comfortable is pertinent to ensure comfort while doing practical work in the workshop. A previous study concluded that vocational education students have limited knowledge on how to prevent health risks at work and lack a systematic way to approach hazard control (Öner et al., 2017).

CONCLUSION

The findings of this study have provided additional evidence and a useful support on the effects of environmental ergonomics on students' comfort, particularly in vocational college workshops. The recommended lighting, noise, and temperature levels were not met in about half of the workshops surveyed. Poorly designed work environment and poorly managed environmental factors, such as noise, extreme temperature, and inadequate lighting, can significantly affect one's overall work environment, health, well-being, and performance. The results of this study have helped to contributes ideas for improvements on environmental ergonomic conditions and the design of the workplace to enhance students' comfor as Environmental ergonomics can be a valuable tool in workshop building design. The details of control measures are presented in Table 2.

Table 2: Control measures for environmental ergonomic parameters in the workshop**.**

Parameter	Control measure
Lighting	Increase the lighting to a comfortable level by providing lighting with adjustable intensity to increase the viewing time and the brightness of the work piece. Use light colours and matte finishes on walls, ceilings and floors to reflect light and enhance the output of the lighting system. Paint stationary and moving parts of machinery with contrasting colours, such as black and orange. With print materials, use black type against a white or light-coloured background.

Temperature	Increase air movement by mounting large diameters ceiling fan, exhaust fan, and air-conditioning. Control the amount of work and rate of work students are expected to do.
Noise	Choosing low-noise tools and machinery, maintaining and lubricating machinery and equipment, placing a barrier between the noise source and employee, and enclosing or isolating the noise source. Conduct a noise conservation training programme by limiting the amount of time the students spends at a noise source and providing quiet areas where students can gain relief from hazardous noise sources.

ACKNOWLEDGEMENT

The authors were gratefully acknowledged the ethical permission of Institute of Research Management and Innovation (IRMI) Universiti Teknologi MARA (UiTM) with reference of 600-IRMI (5/1/6) and the Ministry of Higher Education (MOHE) Malaysia.

REFERENCES

Akta Keselamatan dan Kesihatan Pekerjaan 1994 (Akta 514). “Peraturan-Peraturan Dan Perintah-Perintah”. Kuala Lumpur: International Law Book Services.

Dianat, I., Sedghi, A., Bagherzade, J., Jafarabadi, M. A., & Stedmon, A. W. (2013). *Objective and subjective assessments of lighting in a hospital setting: implications for health, safety and performance. Ergonomics, 56(10), 1535-1545*.

Dianat, I., Vahedi, A., & Dehnavi, S. (2016). Association between objective and subjective assessments of environmental ergonomic factors in manufacturing plants. *International Journal of Industrial Ergonomics, 54, 26-31.*

Marzuki, I., Samsuri., A. & Yuen, F. S. (2015). Study on environmental noise pollution at three different primary schools in Kuala Terengganu, Terengganu State*. Journal Sustainable Science Management, 10, 103-111.*

Öner, S., Tanır, F., Aktaş, H., Okyay, R. A., & Şaşmaz, T. (2017). Use of personal protective equipment and factors associated with injuries among vocational and technical high school students. *Evaluation, 36,41.*

Parsons, K. C. (2000). Environmental ergonomics: a review of principles, methods, and models. *Applied Ergonomics, 31(6), 581-594.*

Perrin Jegen, N., and Chevret, P. (2017). Effect of noise on comfort in open-plan offices: application of an assessment questionnaire*. Ergonomics 60; 6-17.*

Said, M., Rizal, M., & Zahari, R. (2010). Kajian Aplikasi Ergonomik Terhadap Pelajar Ketika Melakukan Kerja-Kerja Amali Bengkel Di Kalangan Pelajar-Pelajar 4 SPH PKPG. *Kajian Aplikasi Ergonomik Terhadap Pelajar Ketika Melakukan Kerja-Kerja Amali Bengkel Di Kalangan Pelajar-Pelajar 4 SPH PKPG, 1-8.*

Mustafa, S.A. 2007. *Aplikasi Ergonomik Dalam Sistem Kerja Untuk Kesejahteraan Motivasi Pekerja Menggunakan Terminal Paparan Visual*. Tesis Ijazah Sarjana Sains, Universiti Sains Malaysia.

Skilling, E. J., & Munro, C. (2017). Environmental ergonomics. In *Human Factors in the Chemical and Process Industries* (271-290). Elsevier.

MAEH Journal of Environmental Health eISSN 2637-1359
Jurnal Kesihatan Persekitaran MAEH
Published By Malaysian Association of Environmental Health
http://www.maeh4u.org.my/journal

RESEARCH ARTICLE

Risk Assessment for Municipal Waste Collection at Majlis Bandaraya Kuala Terengganu, Terengganu

Mohd Nur Hakimi Ramzi Abd Samad*[a], Muhammad Izzat Hanif Mohammad Nasir[a], Nurhafidah Mohamad Arif[b], Mohd Amirul Adli Zakaria[c]

[a] *Majlis Bandaraya Kuala Terengganu, Terengganu*
[b] *Majlis Bandaraya Ipoh, Perak*
[c] *Pejabat Kesihatan Daerah Marang, Terengganu*

Corresponding author: mnhakimi@mbkt.gov.my

Abstract

This purpose of this study is to identify the health hazard, risk assessment and risk control (HIRARC) at the Municipal Waste Collection. The HIRARC was specifically performed at Kuala Terengganu City Council (MBKT). The objectives were to carry out workplace assessment at the municipal waste collections by applying hazard identification, risk assessment and risk control guidelines, followed by identifying at least six associated safety hazards and six health hazards at MBKT municipal waste collection facility and to determine the most critical safety and health hazard and then ultimately propose the appropriate recommendations, accordingly. Also, Job Hazard Analysis (JHA) was conducted for waste collectors to be cautious at the workplace while executing each job tasks. The quantitative and qualitative risk assessments data collection methods were used in risk matrix table including semi-quantitative risk assessment. Data was collected through inspections, observation, interview and record accidents review. A total of 22 hazards were classified into physical, chemical, biological, psychological, mechanical and ergonomic hazard categories. The most critical safety hazard is physical hazard while the most critical health hazard is ergonomic hazard. Hierarchy of control was used to control risk and prevent hazard from becoming serious problem in the future. The recommendation and suggestion were documented and forwarded to the management for reviewing.

.

Keywords: *Municipal waste collection, workplace assessment, risk assessment, health hazard, ergonomic.*

INTRODUCTION

Kuala Terengganu Town administration, known as Kuala Terengganu Municipal Council since 1979 and then recognized as Kuala Terengganu City Council (MBKT) since 2008 (MBKT, 2019). Kuala Terengganu District combined with Kuala Nerus District is an administrative area of 60,528.60 hectares with a population of 406,317

In Malaysia, HIRARC guidelines were published by the Department of Occupational Safety and Health (DOSH). The guidelines explain a systematic approach to identify hazards and assess their related risks to provide objective measures to control the hazards.

The functional elements in municipal solid waste management from the point of generation to final disposal are waste generation, collection, transportation, recovery/treatment and disposal. The flowchart of work process/work activity is shown in Figure 1.

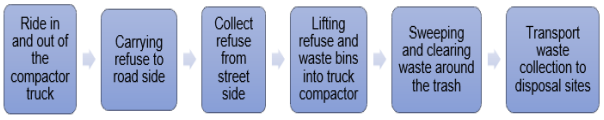


Figure 1: Work Process/ Work activity

The work process/work activity was discussed in detail in Table 1. These involve ride in and out of the compactor truck, carrying refuse to the roadside, collect refuse at roadside to load into compactor truck, lifting refuse and waste bins into compactor truck, sweeping and clearing waste around the trash and transport waste collection to disposal sites.

Table 1: Work process / work activity

Work Activity	Descriptions
Ride in and out of the compactor truck	Every truck has 1 driver and 2 or 3 crews. At 6.30 a.m., the workers heads to the field to perform the collection work. The workers ride on and out from compactor truck and stands on a footrest platform while holding onto a handhold bar.
Carrying refuse to the roadside	The workers pick up refuse from door to door then put on the roadside. Usually, wastes collection points are at road junctions.
Collect refuse from roadside to load into compactor truck	The worker collects refuse from collection point to load into compactor truck.
Lifting refuse and waste bins into compactor truck	The worker lifts refuse and waste bins into and out of compactor truck. During waste loading into compactor body, the worker uses the platen. The platen feeds wastes through the hopper opening, packing refuse into the compactor body.
Sweeping and clearing waste around the trash	Sweeping and cleaning around the trash bin within 5 meters radius of the roadside. All wastes should be collected.
Transport waste collection to disposal sites	After wastes were collected, the compactor truck will transport waste to the disposal site at Sungai Ikan Sanitary Landfill.

The purpose of this study is to carry out workplace assessment for municipal waste collection by using hazard identification, risk assessment and risk control guidelines at MBKT.

METHODOLOGY

Risk Assessment

Hazard classification was carried out through job hazard analysis (JHA) to identify the category and class of hazards. This was followed by quantitative risk assessment using a standard scale.

Job Hazard Analysis (JHA)

JHA is one of the methods used for hazard identification at workplace. It was conducted on tasks involving the waste collectors. Hazards were classified into two main groups as safety hazard and health hazard. Those hazards were then classified into types of hazard as follows: physical, chemical, mechanical, biological, ergonomic and psychological. Table 2 discussed JHA for waste collection activities.

Table 2: Job Hazard Analysis for Waste Collection Activities

Job task	Type of hazard	Hazard classification	Hazard cause	Consequence	Existing (E)/ Potential (P)
Ride in and out of the truck compactor to collect waste	Safety	Physical	Trip and fall	Body injury	P
	Health	Ergonomic	Repetitive movement	Scrapes and bruises on leg	E
Carrying refuse from door to door and put to the street side	Safety	Physical	Sharp objects	Cuts and punctures	E
		Biological	Exposed to contaminated waste	Bacterial and viral infection	P
		Chemical	Exposed to chemical waste	Inhalation and direct contact	P
	Health	Biological	Exposed to bacteria and virus	Infection through sharp objects	P
		Ergonomic	Repetitive movement	Could result in musculoskeletal disorder	E
		Psychological	Workload	Mental stress	E
Carrying, lifting, pushing, pulling refuse and waste bin towards truck compactor	Safety	Physical	Sharp objects	Cuts and punctures	E
		Chemical	Exposed to chemical waste	Injection and direct contact	P
		Biological	Exposed to contaminated waste	Bacterial and viral infection	P

Job task	Type of hazard	Hazard classification	Hazard cause	Consequence	Existing (E)/ Potential (P)
	Health	Biological	Exposed to bacteria and virus	Infection through sharp objects	P
		Chemical	Spillages of chemical waste	Inhalation and direct contact	P
		Ergonomic	Manual handling	Could result in musculoskeletal disorder	E
Loading waste into compactor	Safety	Mechanical	Impact by bin	Bodily injury	P
		Physical	Caught by moving parts of hydraulic lift	Hand injury	P
	Health	Ergonomic	Heavy load	Could result in musculoskeletal disorder	P
Sweeping and clearing waste around the trash	Safety	Physical	Slip, trip and fall	Bodily injury	E
	Health	Ergonomic	Repetitive movement	Could result in musculoskeletal disorder	E
Transporting waste collected to disposal sites	Safety	Mechanical	Impact by vehicles	Bodily injury	P
	Health	Physical	Vibrations	Low back pain	P
		Chemical	Exposure to carbon dioxide	Respiratory problem	P

DISCUSSION

HIRARC for municipal waste collection in the field was conducted to identify the hazards and to improve the safety at the workplace. This particularly focuses on waste collectors at MBKT. The hazards were analysed to prioritize the risk and assess the existing control measures for better improvements. Identification of hazards was conducted using workplace observation, inspection, interview, job hazard analysis and incident/ accident review. Hazards occur for various reasons during the waste collecting at the field. NIOSH have reported that there are trash collectors dying after being caught in compactor on refuse vehicle in North Carolina (NIOSH, 2015).

The main objective was to carry out workplace assessment for municipal waste collection by using hazard identification, risk assessment and risk control guidelines at MBKT. Six (6) safety hazards and six (6) health hazards were identified through workplace observation, inspection, interviews and review of accident/ incident information. Basic information regarding the process flow or job activities was collected through interview with the supervisor and waste collectors. This helped to select the best method to identify the hazards at the field.

Finally, identified hazards were classified into 2 main groups, safety hazards and health hazards. These two main classes of hazards were categorized into 6 main types. The categories are physical, chemical, biological, ergonomic, mechanical and psychological. The level of risks was determined as high, medium and low based on the likelihood and severity.

Literature review is used to gather up an information and data of the research study about the safety and health in municipal solid waste collection. The highlights are more on types of waste collection, safety and health hazards among waste collectors, hazard identification and risk assessment, and regulation on employees and employers. On the other hand, personal protective equipment will also be discussed.

According to Ministry of Housing and Local Government (KPKT), municipal solid waste is waste that includes predominantly household waste and commercial waste (Yahaya, 2012). The most common municipal waste collection includes plastic, rubber product, wastepaper, vehicles waste, sewage sludge, construction waste and household waste, medical waste and e-waste (GreenBeston, 2018). Waste collection process is the only instance where the inhabitants meet the waste collectors and representatives of the municipal council waste management. The method of waste collection significantly influences the quality and quantity of recovered material and mode of disposal.

The waste collected includes mixed chemical based product such as detergent, pesticide and pharmaceutical product. Generally, waste collectors were exposed to contaminated waste that pose biological hazard such as mould and fungi, sewage,

stinging insects, harmful plants and animal and bird droppings. Sources of biological hazard include microorganisms with bacteria, virus, and parasites. These sources may cause a variety of health effects ranging from skin irritation and allergies to infections such as Hepatitis B/C or tuberculosis.

The general injuries and mortality common among waste collectors are due to waste that's highly heterogeneous, sharp waste such as broken glass and injuring themselves by getting cut if not wearing proper PPE. Working conditions and environment also contribute in general injuries such as slippery surface, limited workspace and dim lighting. The waste collectors may have musculoskeletal disorder during lifting and carrying heavy loads and repetitive movement. Some of the general injuries may prove fatal such as vehicular accidents. Mechanical hazards may be in impact from bins or hydraulic lift on compactor truck. Working on or near hydraulic equipment and the present or potential of hydraulic failure should require an outline of safe work procedure (State of Queensland, 2017).

The most critical safety hazard was physical hazard where waste collectors tend to cut and injure from sharp objects such as broken glass, aluminium tin, razor blade, plastics and others. However, some chemical and physical hazards identified directly affects the waste collectors due to households not segregating their waste at the source. Moreover, waste collectors often slip, trip and falls at the field.

At the time of the incident, PPE such as safety boots, glove and safety vest were not worn. The employees were unprepared for any kind of splashes and did not protect themselves. It is the responsibility of the employer to provide the PPE, and the employees should be receiving proper training for the usage of PPE. Based on OSHA 1994, section 24 states that general duties for employee at work state are to take responsibility on PPE, co-operate with employer, use PPE properly and comply with instructions and measures. They are prohibited in the job task to cling on platform near hydraulic lift and jump out of the compactor truck. It may prevent hazards such as tripping and falling to the workers during waste collection.

Commonly observed health problems among waste collectors in municipal solid waste collection include fatigue, headache, skin irritation, eye irritation, gastrointestinal problems, psychological problems, allergies, dermal injuries and musculoskeletal disorder (Bogale, Kumie, & Tefera, 2014). The implementation of HIRARC found the most critical health hazard was ergonomic hazard during manual handling and load waste collection that may lead to musculoskeletal disorder including shoulder, arm, hand and back pain. Household collection is mainly a job which requires repeated heavy physical activities such as lifting, carrying, pulling, and pushing (Bogale *et al*., 2014).

Periodic workplace inspection and supervision play an important role to ensure appropriate occupational safety and health administration. This process should be systematic and be recorded for reliability result and complete analysis regarding legislation requirement. The risk assessment process should be continuous to improve safety and health of the workers at the workplace (Ahmad *et al*., 2016).

Awareness among waste collectors on health risk associated with hazards found at workplace is still lacking. This was found through interviewing the workers during workplace inspection. Training to employees was inducted only once during employment is considered not enough.

RECOMMENDATION

This recommendation is to implement risk control to the hazards in order to prevent any accidents at the workplace. Elimination is the most effective way to destroy hazard. However, all the hazards were using administrative control which is risk control method to reduce risk. This is a method with management in provision work procedure in a proper way or safe work procedure.

Moreover, this includes supervision and training to the workers. Engineering control also can be utilised to prevent cuts and injury to the waste collectors. The workers should use Litter Picker Trash Tools Garbage to collect waste. The last method is compulsory use of personal protective equipment.

The most critical safety hazard is physical hazard. The workers tend to cut and injure from the sharp objects such as broken glass, aluminium tin, razor blade, plastics and others. Also, there have been slips, trip and falls at the workplace. Hierarchy of control as a system used in the workplace to minimize or eliminate exposure to hazards has been suggested to overcome the serious problem (NIOSH, 2015). The most critical health hazard is ergonomic hazard. The workers complaint about their back pain and may cause Musculoskeletal Disorder (MSD) if not prevented. Table 9 explains risk control for the most critical safety hazard while Table 10 is for the most critical health hazard.

Table 9: Risk control for the most critical safety hazard

Hierarchy of Control	Control Measure
Elimination	NIL
Substitution	NIL
Isolation	NIL
Engineering Control	-Use Litter Picker Trash Tools Garbage to collect waste
Administrative Control	-Change work shift -Safe work procedure -Training -Supervision
PPE	Gloves, Safety boots, Safety Vest, Long Sleeve shirt, Long Pants

Table 10: Risk control for the most critical health hazard

Hierarchy of Control	Control Measure
Elimination	NIL
Substitution	NIL
Isolation	NIL
Engineering Control	NIL
Administrative Control	-Change work shift -Manual Handling Training
PPE	Safety boots, gloves, safety vest, long sleeve shirt, and long sleeve pants

Based on Table 9 and Table 10, hierarchy of control method is used to prevent hazard reoccurrence. The elimination, substitution and isolation were not applicable to risk control for safety hazards.

CONCLUSION

The recommendation for the most critical safety hazards were to provide the proper preparation procedures or secure system of work (administrative control) by having a shift for the workers. Then the suggested measure was using a tool to pick up garbage instead of using bare hands (engineering control). And finally, is using a proper or suitable glove such as HYFLEX ® 11-500 that could prevent hand from cuts and injury from sharp object (personal protective equipment). Furthermore, the recommended step for health hazard was ergonomic hazard during manual handling and load waste collection with the suggested measure was providing proper work procedures or secure systems of work and training for employees (administrative control).

The back belt or spinal support back brace to support back bone from harm was not PPE. It is for avoiding musculoskeletal disorder among waste collectors. All of these control methods need to be assessed through a review of its effectiveness by daily or periodical inspection, appointing external auditors to monitor and inspect all the control measures, step that have been made and proposing any improvement from time to time that aims to identify the existing shortcomings. Subsequently amendments or corrective action were made so that there was continuous improvement in risk control management in the workplace. Reviewing the suggestion on control measure should also be practised.

Finally, the employer should convey HIRARC to the employees, monitor the follow up action and keep the records. The person-in-charge in the departments should be responsible for the hazards and their control and they required to maintain all records of assessments for at least 3 years.

REFERENCES

Ahmad, A. C., Nianti, I., Zin, M., Othman, M. K., & Muhamad, N. H. (2016). *Hazard Identification , Risk Assessment and Risk Control (HIRARC) Accidents at Power Plant*. *00105*, 1–6.

Bogale, D., Kumie, A., & Tefera, W. (2014). Assessment of occupational injuries among Addis Ababa city municipal solid waste collectors: a cross-sectional study. Retrieved November 10, 2019, from BMC Public Health website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3932046/

DOSH. (2018). Guidelines for manual handling at workplace 2018. Retrieved November 22, 2019, from http://www.dosh.gov.my/index.php/en/competent-person-form/occupational-health/guidelines/ergonomic/2959-guidelines-for-manual-handling-at-workplace-2018

GreenBeston. (2018). What is Municipal Solid Waste. Retrieved November 1, 2019, from BESTON website: https://greenbeston.com/what-is-municipal-solid-waste/

International Labour Organization. (2019). International Labour Standards on Occupational Safety and Health. Retrieved November 16, 2019, from International Labour Organization website: https://www.ilo.org/global/standards/subjects-covered-by-international-labour-standards/occupational-safety-and-health/lang--en/index.htm

John, S. (2016). Safe Waste Collection. Retrieved November 1, 2019, from WorkSafe website: https://www.worksafenb.ca/docs/Safe-Waste-Collection-Workers-Guide.pdf

MBKT (2019). Profile locality of Kuala Terengganu City Council. Retrieved November 4, 2019, from Official Portal Kuala Terengganu City Council website: http://mbkt.terengganu.gov.my/en/mbkt/profile/background

National Institute for Occupational Safety and Health (NIOSH). (2015). Trash Collector Dies After Being Caught In Compactor of Refuse Vehicle-North Carolina. Retrieved December 2, 2019, from Centers for Disease Control and Prevention website: https://www.safetyandhealthmagazine.com/articles/17021-its-pretty-dangerous-to-be-a-garbage-man

National Institute for Occupational Safety and Health (NIOSH) (2015). The National Institute for Occupational Safety and Health (NIOSH) Overview Administrative Controls and PPE.

Ministry of Labour, Training and Skills Development. (2012). Back Belts in Manual Materials Handling. Retrieved December 1, 2019, from Ministry of Labour, Training and Skills Development website: https://www.labour.gov.on.ca/english/hs/pubs/gl_backbelts.php

State of Queensland. (2017). Hyraulics safety. Retrieved November 11, 2019, from Office of Industrial Relations Workplace Health and Safety Queensland website: https://www.worksafe.qld.gov.au/__data/assets/pdf_file/0003/134751/hydraulics-safety.pdf

Wan Nawawi, W. N., Khalid, S. A., Ramli, N., & Daud, N. M. (2017). Attitude and expectation: Food waste recycling as a business opportunity in Terengganu. *Pertanika Journal of Social Sciences and Humanities*, *25*(November), 65–73.

Yahaya, N. (2012). Solid Waste Management in Malaysia: The Way Forward. Retrieved October 16, 2019, from National Solid Waste Management Department website: http://ensearch.org/wp-content/uploads/2012/07/Paper-13.pdf

MAEH Journal of Environmental Health eISSN 2637-1359
Jurnal Kesihatan Persekitaran MAEH
Published By Malaysian Association of Environmental Health
http://www.maeh4u.org.my/journal

RESEARCH ARTICLE

Kajian Kepuasan Kerjaya Dalam Kalangan Pegawai Kesihatan Persekitaran Dan Penolong Pegawai Kesihatan Persekitaran Di Kementerian Kesihatan Malaysia

Mohamad Ridzuan Mohamad Salleh[a], Rosnani Ab Hamid[a], Abd Hamid Osman[b], Azam Othman[c], Shafizi Abdul Wahab[a], Kayrul Hidayah Mansor[d], Ummi Nadiah Yusoff*[e], Mohd Hatta Mutalip[f]

[a] *Bahagian Kesihatan Persekitaran, Jabatan Kerajaan Tempatan, Kementerian Kesejahteraan Bandar, Perumahan dan Kerajaan Tempatan Malaysia*
[b] *Bahagian Kawalan Penyakit, Kementerian Kesihatan Malaysia*
[c] *Cawangan Pembangunan Profesyen, Bahagian Perkembangan Kesihatan Awam, Kementerian Kesihatan Malaysia*
[d] *Jabatan Kesihatan Negeri Johor, Kementerian Kesihatan Malaysia*
[e] *Bahagian Kawalan Penyakit, Putrajaya, Malaysia*
[f] *Institut Kesihatan Umum*

**Corresponding author: umminadiah@moh.gov.my*

Abstrak

Satu kajian keratan rentas mengenai kepuasan kerjaya dalam kalangan Pegawai Kesihatan Persekitaran (PKP) dan Penolong Pegawai Kesihatan Persekitaran (PPKP), di Kementerian Kesihatan Malaysia dijalankan bertujuan untuk mengenalpasti tahap kepuasan kerjaya dalam kalangan profesion ini. Borang soalselidik yang diadaptasi dan divalidasi daripada *Minnesota Satisfaction Questionnaire* (MSQ), University of Minnesota (1977) digunakan untuk menjana skor keseluruhan dan purata skor bagi kepuasan kerjaya. Analisa data deskriptif dan One-way ANOVA dijalankan menggunakan SPSS Versi 19 dengan penetapan nilai signifikan bacaan nilai $p<0.05$. Sejumlah 385 reponden terpilih dengan komposisi mereka yang bertugas di Jabatan Kesihatan Negeri (13.4%), Pejabat Kesihatan Daerah (65.1 %), Pejabat Kesihatan Kawasan di Negeri Sabah (5.6 %), Pejabat Kesihatan Bahagian di Negeri Sarawak (8.1 %), Pintu-pintu Masuk Negara (6.7 %) dan hospital-hospital kerajaan (1.1 %). Majoriti adalah Melayu (69.8%), lelaki (74.9%) dan bujang (70.1 %). Min umur responden adalah 33.4 (±9.832) dan 16.5% responden telah berkhidmat lebih 15 tahun. Dapatan kajian menunjukkan majoriti 69.9% responden berpuashati dengan kerjaya. Tiga Indikator tertinggi adalah perkhidmatan sosial (89.64%), kuasa (87.5%) dan kerjasama (85.7%). Manakala tiga indikator tertinggi tidak bepuas hati adalah keselamatan (61.88%), penyeliaan sumber manusia (60.22%), penyeliaan teknikal (61.96%). Analisis *One-way* ANOVA signifikan pada nilai $p <0.05$ menunjukkan faktor-faktor demografi yang mempengaruhi kepuasan kerjaya dalam kalangan responden adalah bangsa. Manakala faktor yang tidak mempengaruhi kepuasan kerjaya adalah negeri, jantina, kelayakan akademik tertinggi dan tempoh perkhidmatan. Kajian ini menunjukkan faktor demografi yang mempengaruhi kepuasan kerjaya dalam kalangan responden adalah bangsa. Suatu kajian susulan yang lebih komprehensif perlu dijalankan bagi mengenalpasti faktor-faktor ketidakpuasan kerjaya dalam kalangan PKP dan PPKP di KKM seterusnya meningkatkan penggunaan sumber manusia yang lebih efisien dan memajukan perkembangan kerjaya profesion PKP dan PPKP di Kementerian Kesihatan.

Kata kunci:
Kepuasan kerjaya, Penolong Pegawai Kesihatan Persekitaran, Pegawai Kesihatan Persekitaran, Kementerian Kesihatan Malaysia

PENGENALAN

Kepuasan kerjaya sangat penting dalam meramal keseimbangan sistem, mengurang perpindahan pekerja keluar dari sesebuah organisasi dan peningkatan motivasi ahli-ahlinya. Jika motivasi ditakrifkan sebagai kesediaan berusaha dan mengekalkan usaha ke arah mencapai matlamat organisasi, seharusnya sistem yang berkesan wajiblah mencari faktor-faktor moral dan kepuasan, yang mana berkemampuan meramal sesuatu motivasi itu. Suatu kajian oleh Kementerian Kesihatan di 29 buah negara menunjukkan bahawa motivasi yang rendah dilihat sebagai faktor kedua terpenting yang menyumbang

kepada kepuasan kerjaya selain kekurangan tenaga pekerja (Mathauer & Imhoff, 2006).

Teori awal menerangkan bahawa kepuasan pekerja dan motivasi dipengaruhi oleh bayaran upah yang diterima oleh pekerja. Dalam ertikata lain kesan bayaran upah asas perlu wujud untuk mengekalkan kepuasan sesuatu kerjaya itu, namun ini tidak semesti mewujudkan kepuasan pekerjaan and pertambahan gaji tidak semesti menyumbang kepada peningkatan kepuasan kerjaya. Bagaimanapun kajian yang dijalankan di Afrika mendapati kenaikan gaji dan penambahbaikan lain ganti rugi, dalam konteks gaji dan aspek lain, tidak semestinya menghalang seseorang pekerja meninggalkan perkhidmatan (Kober et al, 2006).

Menurut Kreitner & Kinicki (2002) dan Wood et al. (2004), kepuasan kerjaya dapat dicapai apabila seorang itu menjadi sebahagian daripada organisasi, dengan ini mereka dapat melaksanakan tugasan sebaik mungkin dan menunjukkan komitmen. Kajian ini juga menunjukkan bahawa kepuasan kerjaya dan prestasi positif dipengaruhi oleh ganjaran. Kreitner & Kinicki (2002) mengenal pasti pelbagai faktor yang mempengaruhi kepuasan kerja, seperti keperluan pihak pengurusan untuk mewujudkan persekitaran yang menggalakkan, memastikan penglibatan pekerja dan menguruskan tekanan di tempat kerja. Untuk memahami kepuasan kerjaya adalah baik untuk membezakan semangat dan sikap, serta hubungannya kepuasan kerjaya (Locke, 1983).

Memandangkan peranan kritikal yang dimainkan oleh PKP dan PPKP dalam menentukan kecekapan, keberkesanan dan kemampanan sistem penjagaan kesihatan seperti yang ditetapkan di dalam Laporan WHO Teknikal 1980, ia adalah penting untuk memahami apa yang mendorong mereka dan sejauh mana mereka berpuas hati dengan organisasi dan lain-lain pembolehubah kontekstual.

Kepuasan kerjaya juga merupakan bahagian yang penting dalam memastikan penjagaan yang berkualiti. Perkhidmatan penjagaan kesihatan yang rendah mutunya mungkin menghasilkan penjagaan kurang cekap dan rendah kualitinya. Menurut Tzeng (2002) terdapat bukti korelasi positif antara kepuasan profesional dan kepuasan pesakit. Beberapa kajian telah dijalankan dalam kalangan profesional penjagaan kesihatan mengenai kepuasan kerja walaupun kebanyakan kajian di Afrika Selatan adalah terhad dalam kalangan jururawat dan profesion individu lain.

Memandangkan kekurangan yang ketara mengenai kajian kepuasan kerja di kalangan Pegawai Kesihatan Persekitaran dan Penolong Pegawai Kesihatan Persekitaran di Malaysia, kajian ini akan cuba untuk menangani jurang yang ada. Maklumat yang diperolehi diharap akan membantu dalam mengenalpasti faktor-faktor yang mempengaruhi kepuasan kerjaya dalam kalangan Pegawai Kesihatan Persekitaran dan Penolong Pegawai Kesihatan Persekitaran. Dapatan kajian ini boleh digunakan untuk pihak-pihak berkepentingan untuk menambahbaik seterusnya meningkatkan perkhidmatan PKP dan PPKP di Malaysia.

LATARBELAKANG PEGAWAI KESIHATAN PERSEKITARAN DAN PENOLONG PEGAWAI PERSEKITARAN DI MALAYSIA

Perundangan yang wujud menggambarkan bahawa tugas utama pengamal-pengamal kesihatan persekitaran pada masa itu ialah penguatkuasaan tanpa mengabaikan kepada aspek bangunan, pelupusan najis, air limbah, kebersihan makanan, kawalan penyakit serta bekalan air minum.

Mana-mana individu yang dilantik ke jawatan ini akan menjalani latihan asas di *King Edward College of Medicine*, Singapore. Latihan ini kemudiannya berpindah ke Jalan Young, Kuala Lumpur pada tahun 1968 yang dikendali bersama oleh *The Royal Society of Health*, London dan Kementerian Kesihatan Malaysia. Graduan yang mengikuti dengan jayanya kursus di atas akan dianugerahkan *Diploma Royal Society of Health for the Promotion of Health for Health Inspector* (RSH) (London) (EHOM, 2014).

Bermula sebagai *Sanitary Inspector* atau *Town Board Inspector* pada tahun 1960an telah beralih kepada Merinyu Kesihatan atau Inspektor Kesihatan pada tahun 1980an. Tahun 2002 menyaksikan nomenklutur Kesihatan yang sangat disegani pada suatu masa dahulu digantikan dengan sebutan Penolong Pegawai Kesihatan Persekitaran atau PPKP (EHOM, 2014).

Pewujudan skim berijazah ini juga dilihat sebagai persediaan Negara bangsa melangkah dan memasuki Fasa Moden Kesihatan Persekitaran dan seterusnya untuk menyediakan professional yang sentiasa bersedia untuk berhadapan dan menangani isu serta cabaran kesihatan persekitaran yang semakin kompleks (Pekeliling Perkhidmatan JPA, 2005).

Kajian ini akan menilai tahap kepuasan kerjaya, faktor yang mempengaruhi, perkaitan di antara ciri-ciri sosiodemografi dan perhubungan di antara indikator kepuasan kerjaya seperti kepuasan umum, peluang untuk membangunkan kerjaya, tanggungjawab, menangani tekanan tempat kerja, hubungan dalam kalangan kakitangan profesional penjagaan kesihatan dalam kalangan Pegawai Kesihatan Persekitaran dan Penolong Pegawai Kesihatan Persekitaran Kementerian Kesihatan Malaysia.

Kajian ini adalah untuk menentukan faktor-faktor yang mempengaruhi kepuasan kerjaya dalam kalangan Pegawai Kesihatan Persekitaran (PKP) dan Penolong Pegawai Kesihatan Persekitaran (PPKP) di Kementerian Kesihatan Malaysia, manakala objektif khusus untuk mengenalpasti sosiodemografi responden, menentukan tahap kepuasan kerjaya dan menentukan faktor-faktor yang mempengaruhi kepuasan kerjaya dalam kalangan PKP dan PPKP.

METODOLOGI

Borang Soal Selidik

Kajian keratan rentas ini dijalankan menggunakan borang soal selidik isi sendiri untuk pengumpulan data yang digunakan yang diadaptasi dan diterjemah ke Bahasa Melayu dari *Manual For The Minnesota Satisfaction Questionnair*e (MSQ) (Weiss et al, 1967).

Borang soal selidik ini mengandungi 2 bahagian di mana Bahagian A menerangkan ciri-ciri sosiodemografi responden seperti tempat bertugas, negeri, umur, jantina, bangsa, status perkahwinan, gaji bulanan, kelayakan akademik, tempoh perkhidmatan dan gred responden. Manakala Bahagian B pula mengandungi 100 soalan yang mengukur tahap kepuasan responden yang berasaskan 20 indikator kepuasan yang ditetapkan di bawah tajuk-tajuk berikut-

Skor MSQ mengukur skala kepuasan umum termasuklah nilai-nilai intrinsik dan ekstrinsik yang mana item-item bagi skala kepuasan umum adalah menggunakan 20 item (24, 25, 28, 30, 35, 43, 51, 61, 66, 67, 69, 72, 74, 75, 82, 93, 96, 98, 99 dan 100).

a) Penggunaan Kemampuan; Peluang untuk melakukan sesuatu menurut kemampuan diri.
b) Pencapaian; Perasaan mampu menyelesaikan tugas.

c) Kegiatan aktiviti; Sentiasa sibuk pada setiap masa.
d) Kemajuan Diri; Peluang memajukan diri dalam kerjaya.
e) Kuasa; Peluang untuk memberitahu orang bagi melakukan sesuatu.
f) Dasar dan amalan; Kaedah organisasi melaksanakan polisi kepada amalan.
g) Pampasan; Keseimbangan gaji dan beban kerja yang dilakukan.
h) Kerjasama; Cara pekerja berinteraksi sesama sendiri.
i) Kreativiti; Peluang mencuba dengan cara sendiri untuk melaksanakan tugas.
j) Kebebasan; Peluang melaksanakan tugas sendiri.
k) Nilai moral; Berkemampuan melaksanakan sesuatu yang tidak bertentangan dengan naluri diri.
l) Pengiktirafan; Penghargaan apabila melaksanakan tugas dengan baik.
m) Ketanggungjawaban; Kebebasan menggunakan pertimbangan sendiri.
n) Keselamatan; Perkerjaan saya merupakan kerjaya yang terjamin.
o) Sosial, Peluang melaksanakan sesuatu kepada orang lain
p) Status sosial, Peluang untuk menjadi orang penting dalam masyarakat
q) Penyeliaan sumber manusia, Cara Ketua saya mengendalikan pekerja
r) Penyeliaan Teknikal, Kecekapan penyelia membuat keputusan
s) Kepelbagaian, Peluang untuk melaksanakan sesuatu berbeza dari masa ke masa
t) Suasana pekerjaan, suasana pekerjaan

MSQ terdiri daripada 100 item dan setiap item merujuk kepada faktor dalam persekitaran kerja. Responden menunjukkan bagaimana dia berpuas hati dengan faktor di tempat kerja sekarang. Lima alternatif diberikan untuk setiap item iaitu “sangat tidak berpuas hati; tidak puas hati; tidak pasti; berpuas hati; sangat berpuas hati ". Mana-mana responden yang menjawab “sangat tidak berpuas hati; tidak puas hati atau tidak pasti” dikira sebagai tidak memuaskan manakala mana-mana responden yang menjawab “berpuas hati atau sangat berpuas hati" dikira sebagai memuaskan.

Pre-Test Borang Soal Selidik

Pre-test borang soal selidik telah dijalankan pada 30 Jun 2013 kepada 30 PKP dan PPKP yang bertugas di Jabatan Kesihatan Negeri Selangor (15 orang), Jabatan Kesihatan Wilayah Persekutuan Kuala Lumpur (10 orang) dan Ibu Pejabat KKM (5 orang) Mereka yang terlibat dalam pre-test ini tidak lagi dipilih sebagai responden dalam kajian sebenar. Hasil pre-test ini menunjukkan borang ini sesuai digunakan dan tiada pindaan besar dilakukan terhadapnya dalam kajian sebenar setelah divalidasi dengan nilai kebolehpercayaan *alpha Cronbach* adalah 0.7.

Rangka Sampel

Responden adalah terdiri daripada PKP dan PPKP yang sedang berkhidmat di Kementerian Kesihatan Malaysia yang bertugas di Pejabat Kesihatan Daerah, Hospital, Pintu-Pintu Masuk Negara – Darat, Laut dan Udara dan Jabatan Kesihatan Negeri dan Rangka sampel berasaskan daftar perjawatan PKP dan PPKP yang diperolehi daripada Unit Inspektorat dan Perundangan, Pejabat Timbalan Ketua Pengarah Kesihatan, KKM (KKM, 2013). PKP dan PPKP yang sedang bercuti bersalin, cuti belajar, cuti tanpa gaji atau yang sedang berkhidmat secara kontrak adalah tidak termasuk dalam kajian ini.

Analisis Data

Semua data yang dikumpul dianalisis menggunakan SPSS versi 16. Ujian Statistik Univariate dan Bivariate, *Simple t-test, One-way ANOVA dan Pearson Correlation test* telah dijalankan bagi mengenalpasti perbezaan dan perhubungan di antara indikator kepuasan kerjaya dan pembolehubah demografi.

Pemilihan Sampel

Konsep pensampelan merujuk kepada tindakan pemilihan sebahagian daripada populasi, melakukan pemerhatian terhadap kumpulan kecil ini, dan kemudiannya menjadikan dapatan kajian sebagai populasi yang dikaji. Kaedah ini digunakan untuk mengatasi kekangan atau limitasi kewangan, masa dan usaha (Ary *et al.,* 2006). Berdasarkan fakta ini pensampelan rawak mudah adalah teknik yang digunakan dalam kajian ini. Dalam pemilihan sampel pula formula yang dibangunkan Naing *et al.* (2006) telah digunakan yang mana **n = Z^2 (P1-P) / d^2;** di mana **n** = bilangan sampel; **Z** = tahap keyakinan; ***P*** = prevalen yang ditetapkan atau perkadaran yang bermaksud jika prevalen yang ditetapkan adalah 20%, maka P = 0.2; and **d** = Ketepatan yang bermaksud sekiranya ketepatan adalah 5%, maka d = 0.05. Oleh itu berdasarkan formula di atas bilangan sampel yang diperlukan n adalah 347, di mana **Z =** 95%, **P =** 85% (atau 0.85) dan **d** adalah 0.05. Untuk tujuan simpanan, tambahan 10% daripada jumlah sampel yang ditetapkan menjadikan jumlah sampel yang diperlukan untuk kajian ini adalah 385. Untuk pemilihan responden yang terlibat dalam kajian ini, senarai lengkap 3,910 PKP & PPKP berasaskan Daftar Perjawatan PKP dan PPKP tahun 2013 daripada UIP, Pejabat TKPK (KA), KKM dan dimasukkan ke dalam perisian SPSS 16 (UIP, 2013). Pemilihan responden adalah berdasarkan persampelan rawak sistematik dan perkadaran mengikut komposisi perjawatan PKP dan PPKP mengikut negeri.

KEPUTUSAN

Sosio Demografi

Sejumlah 385 reponden telah terpilih dengan kadar respons 358 (92.98%) menggunakan borang soal selidik yang diisi sendiri melalui Ketua Unit Inspektorat dan Perundangan, Jabatan Kesihatan Negeri di seluruh Negara (Jadual 1).

JADUAL 1: Taburan demografi mengikut lokasi, bangsa, jantina, umur, status perkahwinan, pendapatan, tempoh perkhidmatan dan gred (n = 358)

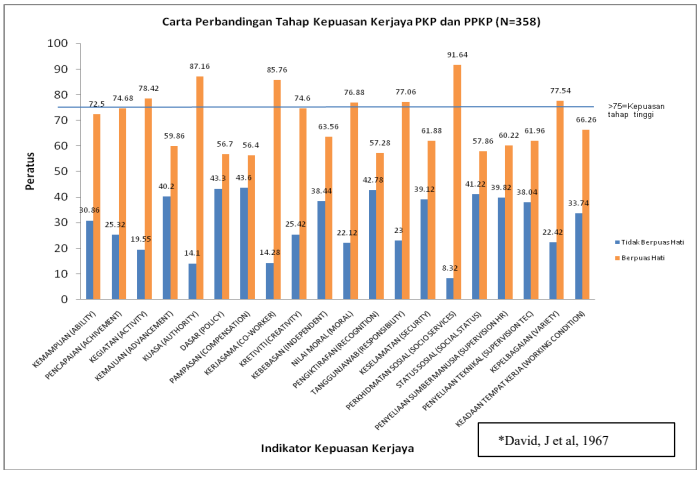
Demografi	n	%
Tempat bertugas		
Jabatan Kesihatan Negeri	48	13.4
Pejabat Kesihatan Daerah	233	65.1
PK Kawasan	20	5.6
PK Bahagian	29	8.1
Pintu-pintu masuk	24	6.7
Hospital	4	1.1
Keturunan		
Melayu	250	69.8
China	11	5.0
India	20	5.6
Sabah	41	11.8
Sarawak	29	8.1
Jantina		
Lelaki	268	74.9
Perempuan	90	25.1
Status Perkahwinan		
Berkahwin	106	29.6

Demografi	n	%
Bujang	252	70.1
Umur		
<25 tahun	50	14.0
>25 tahun	308	86.0
Pendapatan		
<RM3000	189	52.8
RM3001-4000	103	28.8
RM4001-5000	36	10.0
>RM5000	30	8.4
Tempoh perkhidmatan		
<15 tahun	299	83.5
>15 tahun	59	16.5
Kelayakan akademik		
Diploma	333	93.0
Sarjana Muda	16	4.5
Sarjana	9	2.5
Gred		
U41/U42	10	208
U36	21	5.9
U32	55	15.4
U29	272	76.0

Keputusan Soalselidik Responden

Keputusan Tahap Kepuasan Kerjaya

Status kepuasan diukur melalui maklumbalas yang diperolehi daripada responden berdasarkan skor dimana 75% atau lebih dianggap sebagai tahap kepuasan tinggi, 26% hingga 74% dianggap sebagai kepuasan sederhana dan 25% dan kurang dianggap sebagai tahap kepuasan rendah. Kepuasan kerjaya yang diukur berdasarkan kepada 20 indikator iaitu kemampuan (72.5%), pencapaian (74.68%), kegiatan (78.7%), kuasa (87.5%), Kerjasama (85.7%), kreativiti (74.6%), nilai moral (77.88%), tanggungjawab (77.06%), perkhidmatan sosial (89.64%), kepelbagaian (77.54), kemajuan (59.86%), dasar (56.7%), pampasan (56.4%), kebebasan (63.56%), pengiktirafan (57.28%), keselamatan (61.88%), status social (58.76%), penyeliaan sumber manusia (60.22%), penyeliaan teknikal (61.96%) dan keadaan tempat kerja (66.26%).



Rajah 3: Carta Perbandingan Tahap Kepuasan Kerjaya PKP dan PPKP

Faktor-faktor yang mempengaruhi tahap kepuasan kerjaya

Hasil ujian One-Way Anova (Jadual 2, 3 di lampiran) mendapati faktor demografi yang mempengaruhi indikator kepuasan kerjaya adalah bangsa (kemajuan - *advancement* F=4.841, p=0.001; dasar – *policy* F=4.561, p=0.001; pampasan - *compensation* F=3.540, p=0.008; pengiktirafan – *recognition* F=2.854, p=0.027; tanggungjawab - *responsiblity* F=3.114, p=0.015; keselamatan - *security* F=2.779, p=0.027; status sosial – *social status* F=5.019, p=0.001 ; penyeliaan sumber manusia – *supervision human relation* F=4.653, p=0.001 ; penyeliaan teknikal - *technical supervision* F=4.128, p=0.003; kepelbagaian F=4.252, p=0.001), tempat bertugas (kegiatan – *activity* F=2.650, p=0.023; pampasan - *compensation* F=3.190, p=0.008; keadaan tempat kerja – *working condition* F=4.375, p=0.001), status perkahwinan (dasar - *policy* F=5.038, p=0.007; pampasan - *compensation* F=6.040, p=0.003; keselamatan – *security* F=5.012, p=0.007; penyeliaan sumber manusia – *supervision human relation* F=3.868, p=0.022) , umur (keadaan tempat kerja – *working condition* F=4.480, p=0.004), gaji (pampasan - *compensation* F=5.723, p=0.001; keselamatan F=3.694, p=0.012; penyeliaan sumber manusia – *supervision human relation* F=2.942, p=0.033; keadaan termpat kerja – *working condition* F=4.034, p=0.008) ,gred jawatan (dasar - *policy* F=1.507, p=0.042; keselamatan - *security* F=1.620, p=0.021; status social – *social status* F=1.647, p=0.018; keadaan tempat kerja – *working condition* F=2.040, p=0.001), jantina (kemampuan – *ability* F=5.212, p=0.023, kerjasama – *co-worker* F= 11.369, p=0.001, keadaan tempat kerja – working condition F=5.675, p=0.018), tempoh perkhidmatan (pampasan-compensation F=4.751, p= 0.030, keadaan tempat kerja – working condition F=8.403, p= 0.004), akademik (kegiatan – activity F=3.214, p=0.041, kemajuan – *advancement* F=11.131, p=0.000) dan negeri (kemampuan – *ability* F=2.192, p=0.008, pencapaian – *achievement* F= 2.873, p= 0.000, kegiatan – *activity* F=2.309, p=0.005, kemajuan – *advancement* F=3.070, p=0.000, kuasa – *authority* F=3.281, p=0.000, dasar – *policy* F=2.767, p=0.000, pampasan- *compensation* F=4.136, p=0.000, kerjasama - *co-worker* F=1.993, p=0.018, kreativiti – *creativity* F=2.888, p=0.000, nilai moral- *moral value* F=3.515, p=0.000, pengiktirafan – recognition F=3.243, p=0.000, tanggungjawab – *responsibility* F= 3.528, p=0.000, keselamatan – security F=3.852, p=0.000, perkhidmatan social- *social service* F=2.511, p=0.002, status social – *social status* F=2.642, p=0.001, penyeliaan sumber manusia – *supervision human resource* F=3.000, p=0.000, penyeliaan teknikal – *supervision technical* F=4.270, p=0.000, kepelbagaian – *variety* F=1.959, p= 0.020, keadaan tempat kerja- *working condition* F=2.957, p=0.000)

PERBINCANGAN

Jumlah keseluruhan PKP dan PPKP yang berkhidmat di KKM sehingga 2012 adalah 3,910. Kajian ini melibatkan 358 responden yang dipilih secara rawak sistematik. Kadar maklumbalas kajian ini adalah sebanyak 92%. Hasil kajian mendapati 69.9% responden berpuashati dengan kerjaya manakala bakinya 30.1% tidak berpuashati. Hasil kajian ini juga mendapati faktor-faktor demografi yang mempengaruhi tahap kepuasan kerjaya adalah tempat bertugas, bangsa, status perkhawinan, umur, gaji, gred jawatan, jantina, tempoh perkhidmatan, akademi dan negeri bertugas. Manakala kajian yang dijalankan oleh Sivakami Janahiraman dan Thomas Paraidathathu (2007), *Job Satisfaction Among Malaysian Pharmacists* mendapati faktor demografi yang mempengaruhi tahap kepuasan adalah umur dengan nilai p=0.014, gred jawatan p=0.003 dan gaji p=0.000. Berdasarkan kepada klasifikasi tahap kepuasan didapati bahawa 35.0%, indikator berada pada tahap kepuasan tinggi, 65.0% tahap kepuasan sederhana dan tiada tahap kepuasan yang rendah.

KESIMPULAN

Kajian ini menunjukkan tahap kepuasan kerjaya PKP dan PPKP di KKM adalah pada tahap kepuasan sederhana dimana faktor-

faktor demografi yang mempengaruhi kepuasan ini adalah tempat bertugas, bangsa, status perkhawinan, umur, gaji, gred jawatan, jantina, tempoh perkhidmatan, akademi dan negeri bertugas. Adalah dicadangkan suatu kajian susulan yang lebih komprehensif dijalankan ke atas faktor-faktor ketidakpuasan kerjaya yang tinggi dalam kalangan PKP dan PPKP di KKM bagi indikator kemajuan, dasar, pampasan, kebebasan, pengiktirafan, keselamatan, status sosial, penyeliaan sumber manusia, penyeliaan teknikal, keadaan tempat kerja.

CADANGAN

Hasil daripada kajian ini, adalah dicadangkan supaya pihak Pengurusan KKM menggunakan parameter ini untuk membuat dasar dan polisi.

PENGHARGAAN

Kami ingin mengucapkan terima kasih kepada Ketua Pengarah Kesihatan kerana membenarkan artikel ini diterbitkan.Tidak lupa juga kepada Timbalan Pengarah Penyelidikan dan Sokongan Teknikal melalui National Institute of Health (NIH) kerana membiayai kajian ini. Kami juga mengucapkan terima kasih kepada Pengarah Bahagian Sains Kesihatan Bersekutu, KKM, Tuan Hj. Wagimon Bin Amat, Mantan Ketua Unit Inspektorat dan Perundangan (UIP), semua Ketua Unit Inspektorat dan Perundangan Jabatan Kesihatan Negeri, Pengarah Institut Kesihatan Umum, KKM dan semua Pengarah Kesihatan dan Timbalan Pengarah Kesihatan (Kesihatan Awam), Jabatan Kesihatan Negeri kerana memberi kebenaran dan sokongan sepanjang kajian ini dijalankan.

RUJUKAN

EHOM (2014) Kerjaya Sebagai Pegawai Kesihatan Persekitaran dan Penolong Pegawai Kesihatan Persekitaran di Malaysia. Persatuan Pegawai Kesihatan Persekitaran Malaysia.

JPA (2005). Perkeliling Perkhidmatan - Skim Pegawai dan Penolong Pegawai Kesihatan Persekitaran Bil 11 Tahun 2005. Jabatan Perkhidmatan Awam. Putrajaya.

Krietner, R., Kinicki, A. & Buelens, M. (2002). Organizational Behaviour. Second Edition. Berkshire: Mc Graw-Hill

Kober, K., Van Damme, W. (2006) Public sector nurses in Swaziland: can the downturn be reversed?. Hum Resour Health 4, 13.

Locke, E. (1983).The nature and causes of job satisfaction. In *Handbook of Industrial and Organizational Psychology*. New York: J. Wiley & Sons.

Mathauer, I., Imhoff, I. (2006). Health worker motivation in Africa: the role of non-financial incentives and human resource management tools. Hum Resour Health 4, 24

Tzeng, H.M. (2002). The influence of nurses working motivation and job satisfaction on intention to quit: An empirical investigation in Taiwan. *International Journal of Nursing Studies*, Nov. 39: 867-978.

Unit Inspektorat dan Perundangan, Pejabat Timbalan Ketua Pengarah Kesihatan, KKM (UIP, 2013). Maklumat Perjawatan PKP dan PPKP Sehingga 31 Disember 2012

Weiss, D. J., Dawis, R. V., & England, G. W. (1967). Manual for the Minnesota Satisfaction Questionnaire. Minnesota Studies in Vocational Rehabilitation, 22, 120.

WHO, (1980). The Environmental Health Officer In An Industrial Society. EURO Reports and Studies.

Wood, G., Yaacob, A., & Moriss, D. (2004). Attitude towards pay & Promotion in the Malaysian higher education sector. *Employee Relations*, 26(3); 137-150.

Yuswan, F. (2001). Tahap motivasi di kalangan Inspektor Kesihatan dalam perkhidmatan Kementerian Kesihatan Malaysia di Negeri Johor. Tesis Sarjana Kesihatan Masyarakat. Universiti Kebangsaan Malaysia.

Jadual 2: Analisa One-Way Anova bagi mengenalpasti faktor-faktor demografi yang mempengaruhi indikator kepuasan kerjaya (Indikator Kemampuan-Kebebasan)

Faktor Demografi		Indikator kepuasan kerjaya									
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Bangsa	F	1.029	0.69	0.496	**4.841**	1.619	**4.561**	**3.54**	1.883	0.327	0.548
	Sig	0.392	0.599	0.739	**0.001**	0.169	**0.001**	**0.008**	0.113	0.86	0.7
Tempat Bertugas	F	1.244	1.369	**2.65**	1.107	0.997	1.948	**3.19**	0.43	1.602	1.943
	Sig	0.288	0.235	**0.023**	0.356	0.419	0.086	**0.008**	0.828	0.159	0.087
Status Perkahwinan	F	1.347	1.491	0.279	0.786	0.037	**5.038**	**6.04**	0.282	0.166	0.632
	Sig	0.261	0.227	0.757	0.456	0.963	**0.007**	**0.003**	0.754	0.847	0.532
Umur	F	1.541	1.086	0.515	0.437	1.172	1.58	2.537	0.512	2.215	0.56
	Sig	0.204	0.355	0.672	0.727	0.32	0.194	0.057	0.675	0.086	0.642
Gaji	F	1.532	1.374	0.269	1.556	0.878	2.552	**5.723**	0.644	0.246	2.167
	Sig	0.206	0.25	0.848	0.2	0.453	0.055	**0.001**	0.587	0.864	0.092
Gred	F	1.365	1.12	0.921	1.304	1.056	**1.507**	1.198	1.104	1.353	1.11
	Sig	0.096	0.305	0.594	0.132	0.389	**0.042**	0.219	0.325	0.102	0.318
Jantina	F	**5.212**	0.110	0.164	1.070	3.395	2.996	1.396	**11.369**	0.061	0.909
	Sig	**0.023**	0.741	0.686	0.302	0.066	0.084	0.238	**0.001**	0.805	0.341
Tempoh Perkhidmatan	F	0.205	0.712	0.273	1.134	1.081	0.005	**4.751**	0.055	2.096	0.006
	Sig	0.651	0.399	0.612	0.288	0.299	0.945	**0.030**	0.815	0.149	0.939
Akademik	F	1.369	0.935	**3.214**	**11.131**	0.010	1.038	1.170	0.421	0.782	0.723
	Sig	0.256	0.394	**0.041**	**0.000**	0.990	0.355	0.312	0.657	0.458	0.486
Negeri	F	**2.192**	**2.873**	**2.309**	**3.070**	**3.281**	**2.767**	**4.136**	**1.993**	**2.888**	1.507
	Sig	**0.008**	**0.000**	**0.005**	**0.000**	**0.000**	**0.000**	**0.000**	**0.018**	**0.000**	0.106

Indikator

A = Kemampuan
B = Pencapaian
C = Kegiatan
D = Kemajuan
E = Kuasa
F = Dasar
G = Pampasan
H = Kerjasama
I = Kreativiti
J = Kebebasan

Jadual 3: Faktor-faktor demografi yang mempengaruhi indikator kepuasan kerjaya (Indikator Kreativiti-Keadaan Tempat Kerja)

Faktor Demografi		Indikator Kepuasan Kerjaya									
		K	**L**	**M**	**N**	**O**	**P**	**Q**	**R**	**S**	**T**
Bangsa	F	1.294	2.854	**3.114**	**2.779**	0.069	**5.019**	**4.653**	**4.128**	0.796	**4.525**
	Sig	0.272	0.024	**0.015**	**0.03**	0.991	**0.001**	**0.001**	**0.003**	0.528	**0.001**
Tempat Bertugas	F	0.16	1.752	1.049	1.084	1.731	1.627	1.14	0.732	0.22	**4.375**
	Sig	0.977	0.122	0.389	0.369	0.127	0.152	0.339	0.6	0.954	**0.001**
Status Perkahwinan	F	0.067	0.446	0.771	**5.012**	0.695	1.873	**3.868**	0.362	0.269	2.786
	Sig	0.935	0.64	0.463	**0.007**	0.5	0.155	**0.022**	0.696	0.765	0.063
Umur	F	1.411	0.53	1.428	1.326	1.514	1.314	1.177	0.264	0.872	**4.48**
	Sig	0.239	0.662	0.234	0.266	0.21	0.27	0.318	0.851	0.456	**0.004**
Gaji	F	1.834	1.184	1.523	**3.694**	0.767	1.018	**2.942**	2.378	0.896	**4.034**
	Sig	0.141	0.316	0.218	**0.012**	0.513	0.385	**0.033**	0.07	0.443	**0.008**
Gred	F	1.456	0.793	1.386	**1.62**	0.791	**1.647**	1.3	1.237	1.194	**2.04**
	Sig	0.057	0.783	0.085	**0.021**	0.785	**0.018**	0.134	0.183	0.222	**0.001**
Jantina	F	1.602	0.041	2.296	3.678	3.461	2.421	1.650	1.550	1.238	**5.675**
	Sig	0.207	0.839	0.130	0.056	0.064	0.121	0.200	0.214	0.267	**0.018**
Tempoh Perkhidmatan	F	0.225	0.564	1.546	0.011	0.007	1.002	0.338	0.044	0.347	**8.403**
	Sig	0.636	0.453	0.214	0.916	0.932	0.318	0.561	0.833	0.556	**0.004**
Akademik	F	0.250	0.410	0.355	0.313	0.133	1.842	0.011	0.642	0.023	0.406
	Sig	0.779	0.664	0.701	0.731	0.875	0.160	0.989	0.527	0.978	0.667
Negeri	F	**3.515**	**3.243**	**3.528**	**3.852**	**2.511**	**2.642**	**3.000**	**4.270**	**1.959**	**2.957**
	Sig	**0.000**	**0.000**	**0.000**	**0.000**	**0.002**	**0.001**	**0.000**	**0.000**	**0.020**	**0.000**

Indikator

K = Nilai Moral
L= Pengiktirafan
M = Tanggungjawab
N = Keselamatan
O = Perkhidmatan Sosial
P = Status Sosial
Q = Penyeliaan Sumber Manusia
R = Penyeliaan Teknikal
S = Kepelbagaian
T = Keadaan Tempat Kerja