

The evaluation of toluene and xylene exposure and work ability among fishermen in Rayong province, Thailand

Srirat Lormphongs

Department of Industrial Hygiene and Safety, Faculty of Public Health, Burapha University Chonburi Province, Thailand

Received:
November 09, 2017

Accepted:
February 28, 2018

Published:
May 30, 2018

Abstract

The fisherman who are exposed to toluene and xylene on a daily basis from the petrol used in the combustible engines of their small fishing boats. The fishermen must go out to sea since early dawn and return in the late evening, and relatively little to no use of any protective equipment or apparatus to provide an occupationally safe breathing system. The study group of 120 fishermen had a mean age of 44.98 years. 81.6% worked less than or equal to 7 hours per day. During a full work week, 68.0% worked 7 days per week. Out of all responses, 0.8% always used respiratory protection; of those who used protection only used cotton masks. When the fishermen finished working for the day, more than 30% of the study group showed symptoms of adverse health effects including headache, body fatigue, fatigue only in arms and legs, and coughing. Most of them had workability at a good level (69.2%). Air samples were measured by individual "Organic Vapor Monitors (3M 3500)" attached to the lapel of each study group subject. Results of the study group (n=120) showed average \pm SD Toluene level of 29.61 ± 53.934 ppb and Xylene 248.86 ± 41.635 ppb. Urine samples were collected after the work shift. Results of urine samples (n=120) showed average \pm SD level of Hippuric acid at 391.47 ± 391.305 mg/g creatinine and Methylhippuric acid was 73.04 ± 178.053 mg/g creatinine. The relationship between toluene, xylene, hippuric acid, methylhippuric acid and workability of the study group showed to be not significant. There should be concern about organized training and education to provide knowledge and understanding of the hazardous working environment.

*Corresponding author email:
srirat@hotmail.com

Keywords: Toluene, Xylene, Workability, Fishermen, Rayong

Introduction

Toluene and xylene are volatile organic compounds and that evaporate or dissipate into vapor under normal room temperature and pressure conditions. The abundance and long accumulation of toluene and xylene will affect the bioassay and lead to dangerous adverse health effects. Fishermen or those who are in a similar line of field and are involved in similar type of work are at risk to illness related issues from the work especially caused by impaired breathing. Toluene and xylene compound can enter into the body in 3 ways, viz. 1) By absorption thru the skin resulting

in dry skin which may lead to irritation and inflamed skin. 2) Through breathing which may causing irritation to respiratory system, the blood permeation into the lungs which may affect the central nervous system and 3) by consumption of contaminated foods which may cause irritation to the digestive system and have harmful effects to the liver and kidneys. As for the development of the toxin of toluene and xylene, they are both considered acute and chronic toxins (Dennison *et al.*, 2005; Angerer and Kramer, 1997). Workability was regarded as an important factor for personal profession. Anybody having a high performance in their daily fishing routine can perform



his work with high quality and catch a productive quantity. The type of work that can reduce the working ability is the work that exerts high energy and work that is an occupationally hazardous environment, viz., where the exposure to chemical compounds and may lead to poor management of the work (Ilmarinen, 2003; Ilmarinen, 2004; Martinez and Latorre, 2006). The group of coastal fishermen is the local economy where fishing for a living in Rayong Province has resulted in more than 1,600 fishermen who catch daily in small production for their profession. In general, they utilize small boats that use fixed combustible engines that run on petrol (gasoline), which include a chemical mixture of toluene and xylene compound. From basic interviews, it was revealed that they continuously run their small boat engines at all times during their daily catch as they work from the morning thru the evening or sometimes late into the night. Most of them have only elementary school education and do not wear any protective device to allow for proper breathing protection from dangerous chemical compounds used in the engine or other harmful respiratory hazards that are health detriments.

Thus, exposure to toluene and xylene is relatively high, which leads to increased chances of developing illness and results in negative effects on workability. From the above mentioned reasons, the evaluation of toluene and xylene in the atmosphere of the fishermen and their workability is beneficial in looking for new methods and solutions work as fisherman and development of its industry and similar industries occupational health in the near future. The objective was to evaluate toluene and xylene exposure, metabolites, symptoms and workability among fishermen in Rayong Province, Thailand.

Materials and Method

It was a cross-sectional study. The studying group was a group of small boat fishermen in Amphur Muang District of Rayong province totaling 120 persons who were willing to participate in this research and perform their work during the period of operation and collection of the data. The materials used in this study was through a questionnaire comprised of various sections used to collect occupational data, collection of air samples, and collection of urine samples for further analysis, viz. part No.1 was the questionnaire

which comprised of 5 parts, namely, 1) demographic characteristics, 2) working condition, 3) the performance and the use of personal protective equipment, 4) symptoms and 5) workability. Part No.2 was the collection of air samples, Organic Vapor Monitors (3M 3500) were the apparatus used to collect the air samples through its attachment to the lapel of the fishermen at all times of the working day by measuring the level of the concentration of the toluene and xylene compound in the surrounding atmosphere of their working condition. The apparatus used in this analysis was Headspace Gas Chromatography (GC) which was connected with a flame ionization detector (FID) by using a capillary column (Aquawax capillary columns) – the measuring unit was ppb. Part No.3 was the collection of the urine sample. There was a collection of urine after the end of work by using the 20 cc. plastic bottles and storing the bottles within the iced box coolers before proceeding to analyses where measurement of metabolites, hippuric acid and methylhippuric acid, were taken. The measuring apparatus used for the analysis of urine was with HPLC (High Performance Liquid Chromatography), and the measuring unit was mg/g creatinine.

In the analysis of the data by statistical analysis, there were 2 types of statistics viz. for descriptive research by using number, percent, mean, standard deviation, minimum and maximum to evaluate the demographic characteristics, working conditions, the operation and use of personal protective equipment, symptoms, workability, and analytical research gathered to study the relationship between the level of the concentration of toluene and xylene in the atmosphere of the working condition versus metabolites in the urine and workability by using Pearson correlation.

Results

Demographic characteristics

The study group comprised of 120 fishermen. All 120 subjects were male. Most of the participants in the study group were between ages 41 -50 years old at 29.3%. The range of the age for the sample group was between 15-67 years old with an average mean of 48.98 years (SD:11.244 years). In the study group, 86.7% were married. The highest educational level was elementary school which was 70.8% (Table 1).



Table 1: The number and percentage of the fishermen classified by demographic characteristics

Demographic characteristics	Number	Percentage
Sex		
Male	120	100.0
Age (years old)		
≤ 30	12	10.0
31 – 35	15	12.5
36 – 40	18	15.0
41 – 45	13	10.8
46 – 50	22	18.4
51 – 55	18	15.0
≥ 56	22	18.4
Range between 15 – 67 years old , mean 44.98 years old, standard deviation 11.244		
Status		
Single	10	8.3
Married	104	86.7
Widower/Divorce/Separation	6	5.0
Highest education level		
Elementary school	85	70.8
Elementary secondary school	21	17.5
Final secondary school	9	7.5
Certificate	3	2.5
Bachelor degree	2	1.6

Working condition

In the interview study, it was discovered that 1/4 of the participants has less than or equal to 5 years of working experience in the fishing industry. 23.3% was in the range of 6-10 years. The mean was a 14.28 years (SD: 10.601 years) with the range of experience between 1-40 years. On a daily basis, most of the fisherman have to perform their main duty of fishing, it was less than or equal to 7 hours a day for 81.6% of the group. While working at work days per week, 68.0% of the group work 7 days per week.

The operation and the use of personal protective equipment

In the interview results, only 0.8 % used personal protective breathing equipment regularly, 8.3 % sometimes used, and 90.8% do not use any equipment at all. It was discovered that everyone who does use protective equipment uses a cloth mask (100.0%). For those who do use a cloth mask (n=11), the study showed that protection from the bad smell (81.8%) was the top reason, protection of dust or smoke (72.7%) was the second highest reason, followed by the protection from petrol vapors (18.2%).

The method of keeping the cleanliness of the cloth mask device, it was found out that most of them do nothing (27.3%) and 18.2% would use only water to wash and rinse the mask. As for the fishermen who do not use personal protective equipment (n=109), the top reason for not wearing protection was that it was uncomfortable and inconvenient in breathing (85.3%); second reason was that they do not have the personal protective equipment (44.0%); and third, a few believe that it did not help much (4.6%).

Symptoms

From the interview regarding the symptoms after the end of the workday, the fishermen answered per their feeling, those who complained of frequent symptoms (inclusive of being at sometimes) was over 30%. For those who answered that they felt fatigue, 42.5% said they felt fatigued especially at their hands and legs, 40.7% said fatigue was over the body, while 35.0% complained of headaches and 32.5% of complained of coughing.

The level of the score of the workability

From the study of the level of the score of the workability of the fishermen (n=120), it was found out



that most of them had the score at a very good level (69.2%). Second tier or good level (20.8%) and the moderate level (10.0%), respectively (Table 2).

Table 2: The number and percentage of fishermen classified by level of the score for workability among the study group in Rayong province

The level of the score of the workability	Fishermen (n=120)	
	Number	Percent
Lower level (7-27 score)	0	0.0
Moderate level (28-36 score)	12	10.0
Good level (37-43 score)	83	69.2
Very good level (45-49 score)	25	20.8
Mean ±SD	41.35 ±2.978	
Range (Minimum – Maximum)	33 - 47	

The concentration of toluene and xylene in the atmosphere of working (individual sample collection)

Most of the fishermen (n=120) had concentration levels of toluene in the atmosphere of working (individual sample collection) throughout the course of their daily work period showing values that were non-detectable (76.7%) and having the mean concentration at 29.61 ppb (SD:53.934 ppb). The concentration levels of xylene in the atmosphere of working study group (individual sample collection) had the value between 200.1 – 300.0 ppb (90.0%) and had a mean concentration of 248.86 ppb (SD: 41.635 ppb).

The concentration of metabolites of toluene and xylene in the urine

The data collection for analysis of concentration levels of metabolites of toluene and xylene in the urine of the fishermen after the end of the daily work period were collected as individual samples. Most of the concentration of hippuric acid in the urine (n=120) having values between 100.1 – 200.0 mg/g creatinine (18.3%) and a mean value of 391.47 mg/g creatinine (SD: 391.305 mg/g creatinine). As for the concentration of methylhippuric acid in the urine (n=120), it was found out that most of the concentration of methylhippuric acid in the urine having values between 1.0 – 50.0 mg/g creatinine (24.2 %) and a mean value of 73.04 mg/g creatinine (SD:78.05 mg/g creatinine).

The relationship between concentration levels of toluene and xylene in the working atmosphere, concentration levels of metabolites of toluene and xylene in the urine, and the workability of the fishermen

In order to look for the relationship between the concentration levels of toluene and xylene in the atmosphere of working and the workability of the fishermen, it was found out that there was no relation to each other. In addition, when we look for the concentration of metabolites of toluene and xylene in the urine and the workability of the fishermen, it was also found out that there was no relation between the data (Table 3).

Table 3: The relationship between the concentration levels of toluene and xylene in the atmosphere of working (individual sample collection), the concentration levels of metabolites of toluene and xylene in the urine, and the workability of the fishermen

Variable	R	p
Toluene - Workability	0.032	0.732
Xylene - Workability	0.087	0.346
Hippuric acid - Workability	0.062	0.501
Methylhippuric acid -Workability	0.026	0.875

Discussion

In this study, the analyst had studied the group of fishermen who operate small fishing boats. He studied the group under typical working conditions in which each day most of them had performed their main duties concerning fishing less than or equaling up to 5 hours a day (81.6%) and workings 7 days a week (68.0%). Through observation, the group of small fishing boats were highly susceptible to the exposure of toluene and xylene compound especially when going out into the open sea water to perform their daily fishing activates where exposure to the petrol chemical compounds are more likely. During each day of evaluation, each study individual was at risk for exposure to toluene and xylene in the atmosphere of working emitting from the small boat’s engine. Due to the emissions of polluting contaminates in the atmosphere, there was possible increased risk of toluene and xylene intake into the body from breathing, the skin exposure or even ingestion through food contamination. From the questionnaire and observation, it was revealed out of the study group of the small fishing boats only 0.8%



had used the personal protective equipment every working day, and of that small percentage they had used the cloth mask to cover their mouth and nose. By the researcher's observations, the cloth mask was regarded as an unsuitable protective device for breathing and not an effective method in the protection of exposure to toluene and xylene in the atmosphere of working which can easily enter the body through extensive inhalation. This observation and study matches the study of Chang *et al.* (2007), in which they had studied the exposure to xylene within and outside the protective mask. It was discovered that air samples outside the mask had concentration values of xylene at 52.6 ppb (SD: 63.7 ppb) and within the mask 2.09 ppb (SD: 2.74 ppb) on average. Operators who wear the protective mask can reduce exposure to xylene by 90%. Their study concluded that if the local government assists in selecting and providing the appropriate type of protective device for breathing and suitable per technical matters, it will help to reduce exposure to toluene and xylene for the small boat fishermen during their daily fishing routine.

From the questionnaire, the reasons of not using the personal protective equipment (n=109),

It was discovered that a majority of the responses complained that it was uncomfortable and lead to uneasy breathing (85.3%), nearly half responded that they did not wear protective equipment since they do not possess it (44.0%), and finally a small percentage believed that wearing protective gear did not help much after using (4.6%). It was observed that the study group had a negative point of view concerning the use of personal protective equipment to some extent that they could not realize the importance or necessity of using the protective device for their breathing. Therefore, there should be consideration for all stakeholders and concerned working units to promote education and look for ways to help gain a new perspective to realize the dangers of exposure to petrol chemical compounds and the importance of protective devices. In addition, education and resources should be provided on how to procure, use, clean, protect, and safely store the devices correctly so that every small boat fisherman can operate safely from a technical aspect. From the questionnaire of small boat fishermen, it was found out that most did not know that they were being exposed to toluene and xylene in their working atmosphere, which was a result from never attending any training courses. From the recommendations of the researcher, there should be published literature and campaigns to help educate

about the dangers of toluene and xylene exposure in the working environment and precautionary methods for protection.

As for workability, it was found out that the small boat fishermen had a good level of workability (69.2%), but when questioning concerning the sickness or various injuries that were obstacles in their work. It was found out that only 40.0% who answered said they can work during normal working hours. The remaining responded that they required rest for the whole day due to health problem or would stop working going to see the doctor.

The productivity of small boat fishermen can be evaluated through present healthful existence, a belief that in the next 2 years they will surely resume working normally (82.7%). But from the study of Martinez and Latorre (2006) concerning the healthful existence with the workability, it was found out that the evaluation of general healthful existence (SF-36) in relation to workability had statistical significance ($p < 0.0001$) and from the study of Toumi *et al.* (2001), it was found out that most of the workability will be reduced per the sickness concerning the mind and the sickness from skeletal and muscular systems. As for the evaluation of exposure to toluene and xylene in the atmosphere of working which was attached to the lapel of fishermen, it was found out that the concentration of toluene and xylene in the atmosphere of the working of the fishermen was not over the standard limit recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) (2009). However, conclusions from a previous study by Mandiracioglu *et al.* (2011) revealed that a group of furniture workers who had exposure to toluene and xylene during their work shift of more than 8 hours a day had concentration levels of toluene in the blood higher than those workers who worked less than 8 hours a day.

In reducing the occupational risk from exposure to toluene and xylene in the surrounding work atmosphere and the evaluation of concentration levels of metabolites in the urine of the fishermen after the end of the work, it was discovered that hippuric acid in the urine was not over the standard of American Conference of Governmental Industrial Hygienists (ACGIH) (2009), but in the case of the fishermen that was analyzed, it was found out that most of them had low values of hippuric acid in the urine (after work) which it did not match with the research work of Chang *et al.* (2007). In the study by Chang *et al.* (2007), the researchers had studied delayed effects by



isolating the ejection of hippuric acid in the urine of the field workers. Exposures of toluene and xylene resulted in showing that the average of the concentration of hippuric acid in the urine before work was more significant than after work.

In looking for the relationship between the concentration of toluene and xylene in the working atmosphere from the attached lapel, the concentration of hippuric acid and methylhippuric acid in the urine, and workability, it was discovered that there was no relation with concentration levels of the aforementioned chemical compounds and their affect with workability. It can be assumed that toluene and xylene which was contaminated in the air can enter into the body from the breathing, the exposure thru the skin and the food course and will disperse along with the blood flow and it will be metabolized by the changing procession of the structure at liver's cellular level; for example, toluene metabolizing into hippuric acid and being discharged thru the kidney in the excretion of urine. This process was a possible cause for the insignificant results in hippuric acid concentration levels of the study group that were exposed to toluene. However, these results did not match with the study of Jimenez-Garza *et al.*(2012) which showed levels of hippuric acid in the urine having direct relation with the concentration of toluene through body intake, and the concentration levels of xylene in the working atmosphere which was attached to the lapel versus the concentration levels of methylhippuric acid showing a statistically significant relationship.

From all the data above and reasoning provided by the researcher, the small fishing boat fishermen are at significant risk to exposure to toluene and xylene in their working environment. Therefore they should get the knowledge and gain understanding regarding the dangers of toluene and xylene in their daily working conditions. Programs to promote health and proper safety instruction for use of the protective respiratory devices. This also includes assistance to the small boat fishermen to evaluate their workability in order to monitor the effectiveness of the protective devices. Precautionary measures should be put in place in order to protect oneself and prevent adverse health effects for small boat fishermen in the future.

Conclusion

The roof runoff quality from two types of roofing there should be concern about organized training and

education to provide knowledge and understanding of the hazard working environment. The correct and suitable respiration protective equipment should be used while operating fishermen boats with petrol engines.

Acknowledgment

This research has received supporting funds for research from grants by the government supporting fund (the country budget) for the year 2015 of Burapha University in which this research study had been completed. This study would not have been possible if not for well received group of participants and the cooperation from every small boat fishermen located in Amphur Muang District, Rayong Province, for their assistance and the help throughout this study and research. We would like to wishfully thank Miss Acamsiri Lormphongs in helping with the preparation of the apparatus for the collection of the urine samples and others who contributed since the beginning of the research to study's completion.

References

- ACGIH, 2009. Threshold limit values for the Chemical substances and physical agents and Biological exposure indices. American Conference of Governmental Industrial Hygienists. Cincinnati. Ohio. USA.
- Angerer J. and Kramer A. Occupational chronic exposure to organic solvents XVI, 1997. Ambient and biological monitoring of workers exposed to toluene. International Archives of Occupational and Environmental Health. 69 (2): 91- 96.
- Chang FK, Chen ML, Cheng SF, Shih TS and Mao IF, 2007. Dermal absorption of solvents as a major source of exposure among shipyard spray painters. J Occup Environ Med. 49: 430 - 436.
- Dennison JE, Bigelow PL, Mumtaz MM, Anderson ME, Dobrev ID and Yang RS, 2005. Evaluation of potential toxicity from co-exposure to three CNS depressants (toluene, ethylbenzene and xylene) under resting and working conditions using PBPK. J Occup Environ Hyg. 2(3): 127 -135.
- Ilmarinen J, 2003. Promoting of work ability during aging. In Kumashiro, M. (Ed). Aging and work. London and New York: Taylor & Fracis. pp. 21-35.



- Ilmarinen J, 2004. Past, present and future of work ability. Finnish Institute of Occupational Health, Finland.
- Jimenez-Garza and Marquez-Gamino, 2012. CYP2E1 phenotype in Mexican workers occupationally exposed to low levels of toluene. *Toxicol Lett.* 210 (2): 254 - 263.
- Mandiracioglu A, Akgur S, Kocabiyyik N and Sener U, 2011, Evaluation of neuropsychological symptoms and exposure to benzene, toluene and xylene among two different furniture worker groups in Izmir. *Toxico Ind Health.* 27 (9): 802-809.
- Martinez MC and Latorre Mdo R, 2006. Health and work ability among office workers. *Rev Saude Publica.* 40 (5): 851-858.
- Tuomi K, Huuhtanen P, Nykyri E and Ilmarinen J, 2001. Promotion of work ability, the quality of work and retirement. *Occup Med.* 51 (5): 318 - 324.

