SUMMARY

Risk of Toluene Exposure on Malondialdehyde (MDA) and Liver Function (Study on Employees of Production Branch in Printing Industry)

Printing company X and Y are printing industrial in Surabaya. These companies manufactures various products including book, magazine, tabloid, calendar, and invitation. The raw material used in the printing production process are ink, solvent, and cleaner containing toluene. Toluene is volatile so that it easily enters the employees' body through respiration. Long-term exposure will cause hepatotoxic and nephrotoxic effects on the employees which will lead to chronic health problems.

Toluene which enters the body experiences biotransformation stage I and II. In the biotransformation stage I, the cytochrome enzyme of 450 (CYP) in the liver will become benzoic acid. In the stage II, the benzoic acid will be metabolized into hipuric acid through conjugation reaction with glycine. During the toluene toxin detoxification process, liver will produce reactive oxygen group (ROS) whose nature is free radical. The formation of reactive oxygen will result in liver cell damage. The most initial damage mechanism of cell or tissue caused by free radical found is lipid peroxide. Lipid peroxide mostly emerges in the cell membrane, especially in saturated fatty acids which is the most important component in compiling the membrane.

This research was observational research through cross sectional design. The research subject was 30 employees which have met the criteria. Method used was questionnaire, interview, documentation and measurement (toluene concentration, temperature, humidity, air movement, Malondialdehyde (MDA), SGOT, SGPT, Total protein and body weight). The dependent variable of this research was the concentration of toluene in the air, temperature, humidity, air movement, and individual characteristics (age, working hour, working day, working period, nutritional status, and the use of PPE, smoking habit, and sport habit). The interview technique used was questionnaire, the measurement of Malondialdehyde (MDA), SGOT, SGPT and Total protein was done through the employees' blood sampling performed in the integrated laboratory of Health Polytechnic of Surabaya using spectrophotometry, the measurement of toluene concentration is in the air, humidity and velocity of airstream was done using *Gas Chromatography* (GC), Heat Stress Monitor QT-32-WBGT Meter and Anemometer by the worker of UPT K3 of Surabaya, and the measurement of risk characteristics obtained through the calculation of risk rate estimation using RQ Kolluru equation.

The research result obtained the information that the toluene concentration ($C_6H_5CH_3$) in the working place air of all printing companies was below the Threshold Value (188 mg/m^3), while the toluene concentration in the working place environment in one of measurement points of the printing company had higher value that Refference of Concentration (RfC) which is 5 mg/m^3. Statistical

test result of linear regression using enter method showed that the effect of working environment factor was strong towards the Risk (RQ) which was by R Square = 0,674 where the variable of toluene concentration had the strongest effect compared to others environmental variable such as Standardized Coefficients (Beta) = 0,558. Individual characteristics factor test result showed strongest effect on the risk (RQ) as much as R Square = 0,876, working period variable showed the strongest effect by Standardized Coefficients (Beta) = 0,545. The linear regression test also showed weak effect of risk variable (RQ) on Malondialdehyde (MDA) was R Square = 0,000, the risk variable (RQ) towards SGOT was R Square = 0.000, the risk variable (RQ) towards SGPT was R Square = 0.000, while the risk variable (RQ) towards the total protein was R Square = 0.000. The present research also analyzed the risk of the recent toluene exposure in 10 years onwards and life time for 30 years of exposure obtained risk level total (RQ) of additional employee number in the ten years later and for 30 years of toluene exposure.

The conclusion of this research was that the analysis used to asses and estimate the risk caused by environmental hazard exposure based on environmental and individual characteristic factors in the reality instead of based on assumption, simulation and regulation found that there was no strong effect in the statistical result, and there was no obligation for the printing company to control the chemical material exposure, particularly toluene. Constant exposure would be accumulated forming acute effect changing into chronic effect.

RINGKASAN

Risiko Pajanan Toluena terhadap Malondialdehide (MDA) dan Fungsi Hati (Studi pada Pekerja Bagian Produksi di Industri Percetakan)

Percetakan X dan percetakan Y merupakan industri percetakan yang terletak di Surabaya. Perusahaan ini memproduksi diantaranya buku, majalah, tabloid, kalender, undangan. Bahan baku yang digunakan dalam proses produksi percetakan diantaranya tinta, pelarut dan pembersih mengandung toluena. Toluena memiliki sifat sangat mudah menguap sehingga sangat mudah masuk kedalam tubuh pekerja melalui pernafasan. Pajanan dalam jangka waktu lama akan mengakibatkan pekerja mengalami efek hepatotoksik dan nefrotoksik yang akan akan menyebabkan gangguan kesehatan kronis bagi pekerja.

Toluena yang masuk kedalam tubuh mengalami biotransformasi tahap I dan tahap II. Pada biotransformasi tahap I dengan enzim Sitokrom 450 (CYP) yang ada dalam hati menjadi *benzoic acid*. Pada tahap II *benzoic acid* akan di metabolism menjadi asam hipurat setelah reaksi konjugasi dengan glisin. Selama proses detoksifikasi toksin toluena, hati akan menghasilkan kelompok oksigen rekatif (ROS) yang bersifat radikal bebas. Kerusakan sel hati dapat terjadi dari hasil pembentukan oksigen rekatif tersebut. Mekanisme terjadinya kerusakan sel atau jaringan karena radikal bebas ditemukan paling awal adalah peroksida lipid. Peroksida lipid paling banyak terjadi di membrane sel, terutama sam lemak jenuh yang merupakan komponen penting dalam menyusun membran.

Penelitian ini merupakan penelitian observasional dengan rancang bangun *cross sectional*. Subjek penelitian ini berjumlah 30 orang pekerja yang telah memenuhi kriteria. Metode yang digunakan adalah dengan cara kuesioner, wawancara, dokumentasi dan pengukuran (konsentrasi tolena, suhu, kelembaban, pergerakan udara, Malondiladehide (MDA), SGOT, SGPT, Total protein dan berat badan). Variabel terikat dalam penelitian ini adalah Risiko (RQ), *Malondialdehide* (MDA), SGOT, SGPT, Total Protein. Variabel bebas dalam penelitian ini adalah konsentrasi toluena di udara, suhu, kelembaban, pergerakan udara, karakteristik individu (umur, jam kerja, hari kerja, masa kerja, status gizi, penggunaan APD, Kebiasaan merokok dan kebiasaan olahraga). teknik wawancara menggunakan kuesioner, pengukuran Malondialdehide (MDA), SGOT, SGPT dan Total protein dilakukan dengan mengambil sampel darah pekerja dan di lakukan pengukuran di Laboratorium terpadu Poltekkes Surabaya secara spectrofotometri, pengukuran konsentrasi toluena di udara, suhu, kelembaban dan kecepatan aliran udara dilakukan dengan menggunakan *Gas Chromatography* (GC), Heat Stress Monitor QT-32-WBGT Meter dan Anemometer oleh petugas UPT K3 Surabaya, dan pengukuran Karakteristik risiko didapat dengan perhitungan perkiraan tingkat risiko dengan persamaan perhitungan RQ Kolluru.

Hasil penelitian di ketahui konsentrasi Toluena ($C_6H_5CH_3$) di udara tempat kerja di percetakan semua di bawah Nilai Ambang Batas (NAB) (188

mg/m^3), sedangkan konsentrasi toluena di lingkungan tempat kerja di salah satu titik pengukuran di percetakan mempunyai nilai lebih tinggi dari Minimal Risk Level (MRL) pajanan akut (7,6 mg/m^3) yaitu 8,89 mg/m^3. Hasil pengujian statistik regresi linier dengan metode enter menunjukkan kuat pengaruh faktor lingkungan kerja terhadap Risisko (RQ) sebesar R Square = 0.876 dimana variabel konsentrasi toluena yang memiliki pengaruh terkuat dibandingkan dengan variabel lingkungan lainnya yaitu Standardized Coefficients (Beta) = 0.794. hasil pengujian faktor karakterisktik individu menunjukkan pengaruh yang lemah terhadap risiko (RQ) sebesar R Square = 0.06, variabel massa kerja menunjukkan pengaruh terkuat yaitu Standardized Coefficients (Beta) = 0.056. uji regresi linier juga menunjukkan hasil pengaruh yang lemah variabel risiko (RQ) terhadap Malondiladehide (MDA) R Square = 0.007, variabel risiko (RQ) terhadap SGOT R Square = 0.034, variabel risiko (RQ) terhadap SGPT R Square = 0.005, variabel risiko (RQ) terhadap total protein R Square = 0.007. Penelitian juga menganalisis risiko pajanan toluena saat ini, 10 tahun yang akan dating dan life time untuk 30 tahun pajanan, didapatkan hasil untuk jumlah tingkat risiko (RQ) mengalami panambahan jumlah pekerja yang berisiko untuk 10 tahun yang akan dating dan untuk 30 tahun pajanan toluena.

Kesimpulan dari penelitian ini adalah Analisis yang digunakan untuk menilai dan menaksir risiko yang disebabkan oleh pajanan bahaya lingkungan yang didasarkan pada data faktor lingkungan dan faktor karakteristik individu yang sebenarnya bukan dengan asumsi, simulasi dan pengaturan. tidak terdapat pengaruh yang kuat dalam hasil statistik tidak mempengaruhi kewajiban percetakan untuk melakukan pengendalian pajanan bahan kimia khususnya toluena. Pajanan yang terus menerus akan diakumulasi membentuk efek akut berubah menjadi efek kronik.

ABSTRACT

Toluene Exposure Risk on Malondialdehyde (MDA) and Liver Function (Study on Employees of Production Branch in Printing Industry)

Printing industry used raw material containing 75% of toluene in printing ink, solvent, varnish, glue, and moisturizer of the printing tools. Toluene ($C_6H_5CH_3$) is non corrosive volatile liquid which has aromatic odor. This research aims to analyze the effect of toluene exposure on Malondialdehyde (MDA) and liver function on employees' printing in Surabaya.

The type of this research was observation of descriptive analysis through cross sectional design using risk analysis approach. The research sample taken was the employees working in the production branch having 2 years or working period as many as 30 people consisting of 11 employees working in Printing Company X and 19 employees working in Printing Company Y.

The research result obtained the information that the toluene concentration ($C_6H_5CH_3$) in the working place air of all printing companies was below the Threshold Value (188 mg/m^3), while the toluene concentration in the working place environment in one of measurement points of the printing company had higher value that Refference of Concentration (RfC) which is 5 mg/m^3. Statistical test result of linear regression using enter method showed that the effect of working environment factor was strong towards the Risk (RQ) which was by R Square = 0,674 where the variable of toluene concentration had the strongest effect compared to others environmental variable such as Standardized Coefficients (Beta) = 0,558. Individual characteristics factor test result showed strongest effect on the risk (RQ) as much as R Square = 0,876, working period variable showed the strongest effect by Standardized Coefficients (Beta) = 0,545. The linear regression test also showed weak effect of risk variable (RQ) on Malondialdehyde (MDA) was R Square = 0,000, the risk variable (RQ) towards SGOT was R Square = 0.000, the risk variable (RQ) towards SGPT was R Square = 0.000, while the risk variable (RQ) towards the total protein was R Square = 0.000. The present research also analyzed the risk of the recent toluene exposure in 10 years onwards and life time for 30 years of exposure obtained risk level total (RQ) of additional employee number in the ten years later and for 30 years of toluene exposure.

The conclusion of this research is that there is a need of controlling the risk by conducting risk assessment, risk management, and communicating the risk performed in the printing companies in Surabaya, considering that the other chemical material and production tools factors exposed on the employees constantly.

Keywords: Toluene Exposure, RQ, Working Environment, Individual Characteristics, MDA, Liver function risk

ABSTRAK

Risiko Pajanan Toluena terhadap Malondialdehide (MDA) dan Fungsi Hati
(Studi pada Pekerja Bagian Produksi di Industri Percetakan)

Industri percetakan menggunakan bahan baku mengandung toluena sekitar 75% yang digunakan di dalam tinta cetak, pelarut, varnish, lem dan pelembab mesin printing. Toluen $(C_6H_5CH_3)$ merupakan cairan folatil non korosif yang memiliki bau aromatik. Penelitian ini bertujuan untuk menganalisis pengaruh pajanan toluena terhadap Malondialdehide (MDA) dan fungsi hati pada pekerja percetakan di Surabaya.

Jenis penelitian ini adalah observasi bersifat analitik deskriptif dengan desain c*ross sectional* menggunakan pendekatan Analisis Risiko. Sampel dalam penelitian ini yaitu pekerja yang bekerja di bagian produksi, masa kerja minimal 2 tahun dengan jumlah sampel 30 yaitu 11 pekerja di percetakan X dan 19 pekerja di percetakan Y.

Hasil penelitian di ketahui konsentrasi Toluena $(C_6H_5CH_3)$ di udara tempat kerja di percetakan semua di bawah Nilai Ambang Batas (NAB) (188 mg/m^3), sedangkan konsentrasi toluena di lingkungan tempat kerja di salah satu titik pengukuran di percetakan mempunyai nilai lebih tinggi dari Minimal Risk Level (MRL) pajanan akut (7,6 mg/m^3) yaitu 8,89 mg/m^3. Hasil pengujian statistik regresi linier dengan metode enter menunjukkan kuat pengaruh faktor lingkungan kerja terhadap Risisko (RQ) sebesar R Square = 0.876 dimana variabel konsentrasi toluena yang memiliki pengaruh terkuat dibandingkan dengan variabel lingkungan lainnya yaitu Standardized Coefficients (Beta) = 0.794. hasil pengujian faktor karakterisktik individu menunjukkan pengaruh yang lemah terhadap risiko (RQ) sebesar R Square = 0.06, variabel massa kerja menunjukkan pengaruh terkuat yaitu Standardized Coefficients (Beta) = 0.056. uji regresi linier juga menunjukkan hasil pengaruh yang lemah variabel risiko (RQ) terhadap Malondiladehide (MDA) R Square = 0.007, variabel risiko (RQ) terhadap SGOT R Square = 0.034, variabel risiko (RQ) terhadap SGPT R Square = 0.005, variabel risiko (RQ) terhadap total protein R Square = 0.007. Penelitian juga menganalisis risiko pajanan toluena saat ini, 10 tahun yang akan dating dan life time untuk 30 tahun pajanan, didapatkan hasil untuk jumlah tingkat risiko (RQ) mengalami panambahan jumlah pekerja yang berisiko untuk 10 tahun yang akan dating dan untuk 30 tahun pajanan toluena.

Kesimpulan dari penelitian ini adalah perlu adanya pengendalian risiko dengan melakukan enilaian risiko, management risiko dan mengkomunikasikan risiko yang dilakukan di percetakan kota Surabaya mengingat adanya bahan kimia lain dan faktor peralatan produksi yang memajan pekerja secara terus menerus.

Kata kunci : Pajanan Toluena, RQ, lingkungan kerja, Karakteristik Individu, MDA, risiko fungsi hati