Determination of the Health Costs of Effective Detoxification Based on Effective Doses of Benzene Exposure To workers in oil and gas mining companies, Central Java, Indonesia

Ayu Prima Kartika[1], Vivi Budiarti[1], Achmat Kuncoro[1], Charles Kimura[1], Abdul Rohim Tualeka[2]

[1]Student Departement of Occupational Health and Safety, Public Health Faculty, Airlangga University, Surabaya,
[2]Department of Occupational Health and Safety, Faculty of Public Health, Airlangga University, Indonesia

Abstract

Benzene is a natural component of crude oil and gasoline. Benzene occurs naturally in crude oil at levels of up to 4 g / l and benzene has been classified as a group carcinogen. This research was conducted in oil and gas mining companies, West Java, Indonesia. This research was conducted using a cross sectional method. The sample in this study were 30 respondents. The variables that became the data of this study included benzene concentration (C) daily exposure time (tE), frequency of annual exposure (fE), duration of exposure (Dt), height, weight, age, respiration rate (BR), and urine of workers.

The results showed an average measurement of benzene concentration in oil and gas mining companies, West Java, Indonesia on the KPC portion of 0.1 ppm and in the laboratory section at 0.2 ppm, which means it is still below the Threshold Value (NAB) which is equal to 0.5 ppm5. Obtained the highest effective dose to be consumed by respondents in the KPC unit for beef liver is $6x10^{-4}$ kg at a cost of IDR 33,31046813, chicken $3x10^{-4}$ kg at a cost of IDR 13,1251,9985, and avocado is $4x10^{-6}$ kg at a cost of IDR 0,16206628 , while the highest effective dose to be consumed by respondents in the laboratory unit for beef liver is $1x10^{-2}$ kg at a cost of IDR 12,14687477, chicken $6x10^{-4}$ kg at a cost of IDR 22,14504841, and avocado is $6x10^{-6}$ kg at a cost of IDR 0, 27344083. Control recommendations are to adopt a lifestyle that can minimize exposure to poisons and improve detoxification pathways.

Keywords: *Costs Effective, Dose Effective , Detoxification, Benzene*

Introduction

Benzene is a natural component of crude oil and gasoline. Benzene exposure results in health-related effects and diseases such as cancer. Exposure can occur as a result of the use of petroleum products which contain benzene in it. Benzene occurs naturally in crude oil at levels of up to 4 g /l. These activities include the processing of petroleum products, coal coke, the production of toluene, xylene, and other aromatic compounds. The presence of benzene in gasoline and as a widely used industrial solvent can result in significant exposure and broad emissions to the environment[1].

Long-term exposure to benzene can cause leukemia, and benzene has been classified as a group 1 carcinogen[2]. The dominant pathway for exposure to benzene in humans through inhalation. Detoxification is a process to remove these persistent and potentially dangerous chemicals from the human body for disease prevention and health recovery[3].

The body is an extraordinary system that has a innate mechanism to convert harmful substances into non-toxic compounds that can be removed from the body. This detoxification process, called the detoxification metabolic pathway, involves a series of complex biochemical reactions in cells that are just beginning to be understood by modern science. Briefly, there are two phases in this metabolic pathway. In phase I, a group of enzymes collectively known as cytochrome P450 is responsible for the biotransformation of poisons which are mostly fat-soluble into molecules that are more water-soluble.[4]. It should be noted that intermediates produced in phase I can be more toxic than original poisons because they are more reactive and can increase oxidative pressure in cells. These substances must be

quickly processed through phase II reactions to prevent damage to cells[4].

In phase II, various conjugate reactions that differ between a second series of enzymes called conjugates and toxic intermediates from phase I occur. These conjugations attach molecules such as glucuronic acid, sulfate, glutathione, glycine, taurine, or methyl groups to toxic intermediates to make them more soluble in water and unreactive, effectively "detoxifying" these toxic intermediates. These poisons which are converted biotransformation through two phases can then be removed from the cell and released through bile (into feces), urine, or sweat[4]. While the human body has the innate ability to detox, there are many factors that can affect the activity of enzymes involved in this process. Diet, lifestyle, environment, genetics, age, gender, disease, and influence of drugs. Among these factors, there are things that can be controlled, namely the diet. The purpose of this study was to determine the effective health costs in accordance with the effective dosage of benzene and the types of foods that can detoxify benzene in the blood of workers in oil and gas mining companies, West Java, Indonesia, including beef liver, chicken and avocado. environment, while maintaining optimal detoxification capabilities through diet and lifestyle to prevent disease.

Methods and Materials

This research was conducted in oil and gas mining companies, West Java, Indonesia. This research was conducted using a cross sectional method. Urine examination to determine levels of benzene exposure to workers. Workers who are sampled must meet the specified criteria (Inclusion). The inclusion criteria that must be fulfilled are the age of the worker> 20 years and the working period> 5 years. The sample in this study were 30 respondents namely 15 people in the Laboratory section and 15 people in the KPC section.

The data that will be used consists of primary data to be taken including inhalation benzene dosage, urine sample, filling out questionnaires and interviewing workers. Secondary data that will be used is environmental monitoring data from the company. The variables that became the data of this study included benzene concentration (C) daily exposure time (tE), frequency of annual exposure (fE), duration of exposure (Dt), height, weight, age, respiration rate (BR), and urine of workers.

Benzene inhalation sampling was carried out using a personal sampling pump that charcoal tubes had been installed which referred to NIOSH 1501 and sampling and measurement of phenol levels in workers' urine was carried out based on NIOSH 8305. Measurements of environmental physics parameters were carried out to know the working environment conditions and were used in calculating exposure concentrations benzene.

The benzene dose measured at the time of the study was an intake through inhalation. Because this study will know the chronic effects of benzene exposure, the value of Chronic Daily Intake (CDI) will be calculated.

Then, look for intake (formula) with the formula as below:

$$\text{Intake} = \frac{C \times IR \times tE \times fE \times Dt}{Wb \times 70 \times 365}$$

C = benzene concentration (mg / ml)

IR = *Inhalation rate* (m^3/days),

tE = work time / day (hours)

fE = work time / week (days)

Dt = working time (years)

Wb = weight (kg)

Calculate the effective dose per day with the results of calculating the intake above, using the formula below:

$$\text{Effective dose of food} = \frac{\text{intake toxin/day} \times \text{Mr enzim detox}}{\text{Mr toxin}}$$

The last is to calculate the cost of intake of each food using the formula as below:

$$\text{Cost of intake} = \text{Effective dose} \times \text{price per Kg of food}$$

Information (in Indonesia):

Tabel 1. Cost in Indonesia

No.	Ingredient	Weight	Price (IDR)
1	Beef liver	1 kg	50000
2	Chicken	1 kg	35000
3	Avocado	1kg	45000

RESULT

Distribution of Characteristics of Workers

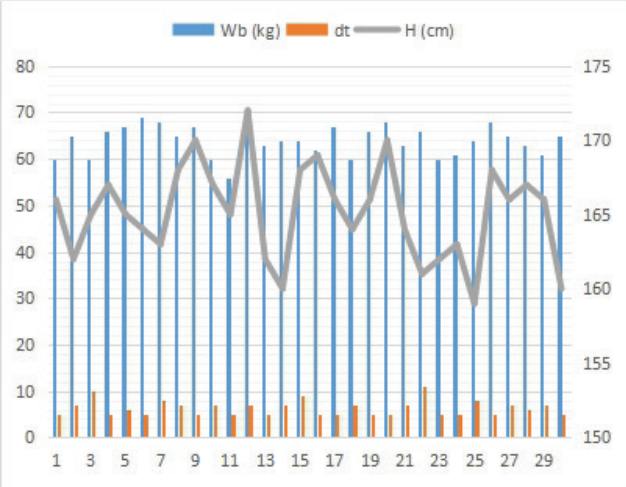

Figure 1. Distribution of Characteristics of Workers

Figure 1. Obtained the average weight data (W) of respondents is 64 kg, the average height (H) of respondents is 165 cm, the average length of work (Dt) of respondents is 5 years. The duration of work in a day is 8 hours both for workers in KCP units and laboratory workers and the number of working days in a year (Dt) is 274.

Distribution of benzene concentration in the workplace

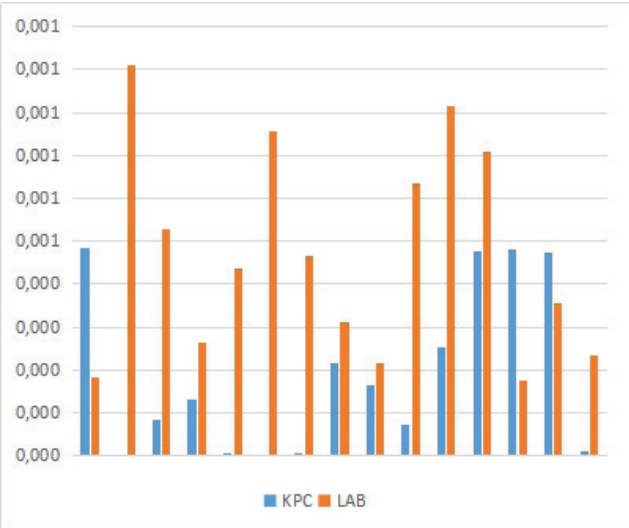

Figure 2. Distribution of benzene concentration in the workplace

Figure 2. Obtained results The average concentration of benzene in oil and gas mining companies, West Java, Indonesia in the KPC section is 0.191 mg / m3 or 0.1 ppm and in the laboratory part is 0.466 mg / m3 or 0.2 ppm . Based on the Minister of Manpower and Transmigration Regulation No. PER.13 / MEN / X / 2011 of 2011 concerning the Threshold Value of Physical and Chemical Factors in the Workplace, benzene NAB recommended to prevent the occurrence of health impacts is 0.5 ppm.

Comparison Weight and Benzene Concentration

Figure 3. Comparison Weight and Benzene concentration

Figure 3. The highest benzene concentration in the KPC unit was 0.2 ppm (respondent 13) with a body weight of 63 kg, while the smallest benzene concentration in the KCP unit was 0.0013 ppm with a body weight of 68 kg (respondent 7). The biggest weight in the Kcp unit respondents was 68 kg (respondents 7 and 12), while the smallest was 60 kg. The highest concentration in laboratory units was 0.3 ppm (respondents 17) with a body weight of 67, while the lowest was 0.21 ppm (respondents 46-51). the largest weight in laboratory units was 68 (respondents 20 and 26), while the smallest was 60 kg (respondents 18 and 23).

Comparison of Benzene Concentrations with Effective Doses and Effective Prices

Tabel 2. Comparison of Benzene Concentrations with Effective Doses and Effective Cost

No.	Unit	C (mg/m3)	effective dose of beef liver (kg)	effective dose of Chicken (kg)	effective dose of avo-cado (kg)	Cost beef liver	Cost chicken	Cost avocado
1	KPC	0,483	0,00066621	0,00037501	0,00000360	33,31046813	13,12519985	0,16206628
2	KPC	0,004	0,00000509	0,00000287	0,00000003	0,25464285	0,10033598	0,00123892
3	KPC	0,084	0,00011586	0,00006522	0,00000063	5,79312489	2,28264345	0,02818544
4	KPC	0,133	0,00016677	0,00009387	0,00000090	8,33858886	3,28562315	0,04056995
5	KPC	0,003	0,00000371	0,00000209	0,00000002	0,18528118	0,07300565	0,00090145
6	KPC	0,005	0,00000600	0,00000338	0,00000003	0,29985118	0,11814925	0,00145887
7	KPC	0,002	0,00000243	0,00000137	0,00000001	0,12170430	0,04795469	0,00059213
8	KPC	0,216	0,00027501	0,00015480	0,00000149	13,75071403	5,41814270	0,06690170
9	KPC	0,164	0,00020257	0,00011403	0,00000110	10,12870450	3,99097576	0,04927945
10	KPC	0,072	0,00009931	0,00005590	0,00000054	4,96553562	1,95655153	0,02415895
11	KPC	0,254	0,00037537	0,00021129	0,00000203	18,76854238	7,39529894	0,09131507
12	KPC	0,478	0,00058175	0,00032746	0,00000314	29,08732876	11,46117195	0,14151933
13	KPC	0,482	0,00063317	0,00035641	0,00000342	31,65857367	12,47431002	0,15402927
14	KPC	0,475	0,00061423	0,00034574	0,00000332	30,71132058	12,10106740	0,14942058
15	KPC	0,010	0,00001293	0,00000728	0,00000007	0,64655412	0,25475931	0,00314570
16	Lab	0,182	0,00024294	0,00013675	0,00000131	12,14687477	4,78618788	0,05909850
17	Lab	0,910	0,00112404	0,00063272	0,00000608	56,20195791	22,14504841	0,27344083
18	Lab	0,530	0,00073104	0,00041150	0,00000395	36,55185944	14,40239321	0,17783670
19	Lab	0,263	0,00032978	0,00018563	0,00000178	16,48908925	6,49713450	0,08022479
20	Lab	0,435	0,00052941	0,00029800	0,00000286	26,47068622	10,43014602	0,12878851
21	Lab	0,756	0,00099311	0,00055901	0,00000537	49,65535622	19,56551530	0,24158948
22	Lab	0,467	0,00058558	0,00032962	0,00000317	29,27910524	11,53673693	0,14245238
23	Lab	0,312	0,00043035	0,00024224	0,00000233	21,51732103	8,47838996	0,10468877
24	Lab	0,215	0,00029169	0,00016419	0,00000158	14,58456501	5,74670190	0,07095866
25	Lab	0,634	0,00081983	0,00046148	0,00000443	40,99153104	16,15174049	0,19943715
26	Lab	0,815	0,00099189	0,00055833	0,00000536	49,59450406	19,54153795	0,24129341
27	Lab	0,710	0,00090398	0,00050885	0,00000489	45,19910630	17,80963572	0,21990837
28	Lab	0,175	0,00022989	0,00012940	0,00000124	11,49429542	4,52905447	0,05592349
29	Lab	0,356	0,00048299	0,00027187	0,00000261	24,14932625	9,51546919	0,11749434
30	Lab	0,235	0,00029921	0,00016842	0,00000162	14,96026758	5,89473858	0,07278657

Table 2. Obtained the highest effective dose that must be consumed by respondents in the KPC unit for beef liver is $6x10^{-4}$ kg at a cost of IDR 33,31046813, chicken $3x10^{-4}$ kg at a cost of IDR 13,12519985, and avocado is $4x10^{-6}$ kg at a cost of IDR 0.16206628, while the highest effective dose to be consumed by respondents in the Laboratory unit for beef liver is $1x10^{-2}$ kg at a cost of IDR 12,14687477, chicken 6x104 kg at a cost of IDR 22,14504841, and avocado is $6x10^{-6}$ kg at a cost IDR 0.27344083.

Discussion

Threshold Limit Value (TLV), Weight, and Benzene Concentration

The results showed an average measurement of benzene concentration in oil and gas mining companies, West Java, Indonesia on the KPC portion of 0.1 ppm and in the laboratory section at 0.2 ppm, which means it is still below the Threshold Value (NAB) which is equal to 0.5 ppm[5]. The comparative diagram analysis between the concentration of benzene and the weight of the respondents showed that the respondents with the greatest weight did not have the highest concentration of benzene, and it was similar to the respondents with the smallest weight not having the lowest toluene concentration. This research is not in accordance with Mukono's research, that BTX has a mass of small molecules that are easily soluble in fat[6]. It is assumed that toxins with high solubility in fat (adipose) show low concentration in the body. This can be considered a protection mechanism. So, it was concluded that there was low benzene toxicity in obese people rather than lean people.

Detoxification of Benzene by Foods Rich in CYP2E1 Enzyme, Sulfation, and Glutation

YP2E1, Sulfation, and glutathione are enzymes that work in stage 2 of biotransformation[7]. Sulfation is one of a number of liver detoxification pathways, specifically phase II detoxification. Detoxification sulfate poison, it is a powerful antioxidant compound and detoxifying agent that is produced in the cytoplasm of every cell of the human body[8,9]. Antioxidant enzymes related to glutathione are involved in the metabolism and detoxification of cytotoxic and carcinogenic compounds and reactive oxygen species [10].

The best approach to detoxification must be to adopt a complete, healthy, complete, complete diet [11]: Various fruits and vegetables, best for including vegetables, coriander, garlic, and citrus fruits, fats and oils with medium - Chain fatty acids (Avocados, coconuts, olive oil), Proteins from lean meat, eggs, and vegetable sources (for example tofu, tempeh), complex carbohydrates from seeds such as brown rice, quinoa, millet, soba, legumes such as peas, beans, and lentils, which are rich in soluble and insoluble fiber.

Phase 1 and 2 of the detox system are complex processes and vegetables, fruits, grains, soybeans, garlic, rooibos tea and turmeric have been reported to maintain and support the detoxification phase that occurs in the liver, making it easier to work[7]. The two additional nutrients needed by the liver are zinc and choline. Zinc, which can be found in food and contains the most pork, crab, beef and oysters, has been shown to help detoxify the body from alcohol. Choline is needed to make phosphatidylcholine which is used by the liver to produce VLDL cholesterol types. Choline can be found in wheat germ, chicken, beef liver, and eggs[12].

Avocados contain various healthy nutrients such as vitamin A, vitamin C, vitamin E, vitamin K1, folate, vitamin B-6, niacin, pantothenic acid, and bioactive phytochemicals, such as carotenoids, terpenoids, and D-mannoheptulose, which have been reported to help fight cancer[13]. Avocados are rich in monounsaturated fatty acids (MUFA), which increase the bioavailability (absorption) of nutrients and phytochemicals. A study published in the American Journal of Clinical Nutrition, consuming high amounts of monosaturated fatty acids was found to reduce LDL cholesterol ('bad' cholesterol) by 14% and reduce the risk of cardiovascular disease[14]. Avocados also contain glutathione, an important factor in protecting against toxicity and disease[15].

Conclusion

Intake of foods containing the enzyme CYP2E1 (beef liver), sulfation (chicken), and glutathione (avocado) is expected to increase detoxification of benzene. Each individual has a different amount of cost per individual. This depends on the effective dose, benzene concentration, weight, and duration of work. In addition to diet, adopting a lifestyle that can minimize exposure to poisons and improve detoxification pathways is equally important. These lifestyle components include: Avoid environmental toxins, such as heavy metals, persistent organic pollutants, and electromagnetic radiation, mobilize and eliminate toxins through weight loss, use

of saunas, exercise, and chelating supplements such as Chlorella. Maintain optimal intestinal health through diet and probiotics, drink enough water to maintain optimal hydration, reduce emotional stress and maintain healthy relationships, ensure adequate sleep and relaxation.

Conflicts of Interest : All authors have no conflict interest to declare.

Source of Funding : The source of the research cost from self.

Ethical Clearance: The study was approved by the Ethics Committee Faculty of Public Health, Airlangga University.

Reference

1. IPCS. benzene. Geneva: World Health Organization; 1993.
2. IARC. Benzene. In: Some industrial chemicals and dyestuffs. Monogr Eval Carcinog Risk Chem to Humans. 1982;
3. s.j. Genius. Elimination of Persistent Toxicants from the Human Body., Hum. Exp. Toxicol. 2011;
4. D L, M L, D.S J. Detoxification and biotransformational imbalances. 2006;
5. Permenakertrans. No. 13/MEN/X/2011 About the Threshold Value of Physical Factors and Chemical Factors in the Workplace. 2011.
6. Mukono. The Environmental Toxicology. Surabaya: Airlangga University Press; 2005.
7. Hodges RE. MD. Modulation of Metabolic Detoxification Pathways Using Foods and Food-Derived Components: A Scientific Review with Clinical Application. J Nutr Metab. 2015;
8. Cook S. Oral Availability Of Glutathione Does The Research Dispel Previously Held Beliefs? Nat Med J Res Guid. 2017;
9. Pietryka J. Sulphation, Detoxification, and ASD. 2014;
10. Ates NA. Glutathione S-transferase gene polymorphisms in presbycusis. US Natl Libr Med Natl Institutes Heal. 2005;
11. Cline JC. Nutritional aspects of detoxification in clinical practice, Altern. Ther Heal Med. 2015;
12. Roizen, M. F., M.D., & Oz, M. C. M. You, The Owner's Manual. New York: Harper Collins Books; 2013.
13. Dreher, M. L., & Davenport AJ. Hass Avocado Composition and Potential Health Effects. Critical Reviews in Food Science and Nutrition. 2013;
14. Kris-Etherton PM, Pearson TA, Wan Y, Hargrove RL, Moriarty K, Fishell V ET. High-monounsaturated fatty acid diets lower both plasma cholesterol and triacylglycerol concentrations. Am J Clin Nutr. 1999;
15. Pastore, A., Federici, G., Bertini, E., & Piemonte F. Analysis of glutathione: implication in redox and detoxification. Clin Chim Acta. 2003;