

## **The Impact of High Temperature to the Occurrence of Urine Crystallization at CV Alumunium Mandiri Palembang, South Sumatra**

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**Abstract—** *Hottest temperatures make body adapting by excreting excessive sweating. CV Alumunium Mandiri Palembang manufacture in making fan and pot that is fire furnace causing hottest temperatures. When the body loses fluid without being accompanied by the consumption of replacement fluids for a long time, it will cause the urine to be concentrated (supersaturation) which will then form crystals in the urine. This study aims to analyze the influence of heat on the production section of the work environment towards the occurrence of urine crystallization in CV Alumunium Mandiri Palembang. Methods: This research used a proportional simple random sampling study design. The sample was workers CV Alumunium Mandiri Palembang and there were 35 respondents. The data analysis that was done was bivariate and univariate data. Bivariate analysis used Chi-Square Test. Result: The results showed that variabel The influence of heat (P-value=0,013; 95% CI= 1,140-60,625), age (P-value =0,091; 95% CI= 0,916-11,146), working period (P-value =0,039; 95% CI= 1,055-19,192), consumption of drinking water (P-value =0,018; 95% CI= 1,016-54,095). Prevalence of urine crystallization in the amount of 22.9% or 8 toward workers. Conclusion: Therefore it could be concluded that urine crystallization was not related to age but was influenced by the temperature of heat in the work environment, working period and consumption of drinking water.*

**Keywords:** *heat, work environment, urine crystallization*

### I. INTRODUCTION

The physical condition of the work environment must be considered because the poor physical condition of the work environment will affect the safety and health of workers. A work environment with a neutral temperature (thermoneutral) provides a sense of comfort so that the work will be better. The individual comfortable temperature at work is 20-27o and humidity is 35-60%. High temperatures encourage workers to get tired, sleepy, dehydrated, decreased productivity to result in work accidents<sup>1</sup>.

Data from the National Institute for Occupational Safety and Health in 2011 shows that in a period of 15 years (1992 to 2006) 423 deaths had occurred in workers due to hot working environment temperatures resulting in workers sweating excessively and losing Na ions resulting in severe dehydration and death<sup>2</sup>.

Research on male workers in the steel industry and exposure to high temperatures in Brazil shows that a hot work environment causes the occurrence of bladder stones (urinary lithiasis) and proves that workers in hot work environments are 9 times more likely to get kidney stones compared to workers which is at room temperature<sup>3</sup>. The condition of the work environment with hot temperatures, makes the body adapt to the way of excessive sweating. Loss of body fluids in large amounts affects the fluid and electrolyte balance, and causes decreased urine production, and the urine becomes concentrated. If this condition is left for a long time it causes supersaturation. Changes in salt and electrolyte concentrations in urine are affected by food metabolism and fluid intake.

High temperature working environment conditions Loss of large amounts of liquid affects fluids and electrolytes, causing urine production to decrease, resulting in concentrated urine If this condition is left for a long time, it causes supersaturation. Changes in salt and electrolyte concentrations in nutrient solutions in the blood. Decreased salt concentration causes changes in urine pH and body temperature. Furthermore, there will be a deposition of salt in the urine to form crystals<sup>4</sup>. In Indonesia, water consumption is still relatively low.

The results of research<sup>5</sup> from The Indonesian Regional Hydration Study (THIRST) showed that 49.1% of research subjects experienced less water or hypovolemia, in adults by 42.5%. Hot work led to the occurrence of bladder stones (urinary lithiasis) and proved that workers in hot work environments are 9 times more likely to develop kidney stones than those at room temperature<sup>3</sup>.

CV Alumunium Mandiri Palembang is a home-based factory which is engaged in making cauldrons and crockery. In the process of using a furnace for smelting iron and aluminum. The heat produced by the furnace radiates to the worker. The worker's body adapts to excessive sweating and does not use complete clothing to cool the body.

Appropriate building ventilation conditions and unavailability of drinking water facilities cause acclimation to the body must work hard. Drinking

water consumption is only done when workers feel thirsty to support the minimal intake of replacement fluids. Based on these conditions, a study was carried out aimed at analyzing the effect of the working environment heat temperature in the aluminum industrial production section on the incidence of urine crystallization in workers.

**II. METHOD**

The study design was cross-sectional to analyze the effect of high temperatures in the work environment in the production section of CV Mandiri Aluminum Palembang South Sumatra on the incident of crystallization of workers' urine. The sample is workers in the production section with a total of 35 respondents. Sampling was done by simple random sampling, while the data were analyzed bivariate using the Chi-Square test.

**III. RESULTS**

Table 1 shows that 43.8% of workers in an environment with temperature > 26.7°C experienced urine crystallization while compared to workers in an environment with temperature ≤26.7 °C. Chi-Square results obtained a p-value of 0.013 (p-value <0.05) which shows the relationship between the influence of heat in the work environment in the production department with the incidence of crystallization of worker urine. Based on the calculation of the risk estimate it is known that the risk range (PR) is 8.313. This shows that workers who work in sections with temperatures > 26.7 °C have a risk of 8,313 times greater exposure to urine crystallization than workers in environments with temperatures ≤26.7 °C. In a population of 95%, it is believed that heat temperature is a risk factor for urine crystallization in the range of 1.140 to 60.625.

Table 1. Effect heat on the work environment at production department on the occurrence of crystallization of urine in CV Alumunium Mandiri

Heat temperature at production area	Urine Crystallization				Total		P-value	PR 95% CI
	Positive		Negative		N	%		
	n	%	n	%				
>26.7	7	43.8	9	56.2	16	100	8.313 (1,140 - 60,625)	
≤26,7	1	5.3	18	94.7	19	100		

The results also showed that 41.7% of workers aged > 40 years experienced more crystallization of urine than workers aged < 40 years (table 2). Chi square results obtained a p-value of 0.091 (p-value >0.05) which means there is no relationship between the age of the worker and the incidence of urine crystallization in the

work. Urine crystallization in the range of 1,140 to 60,625.

Table 2. Effect of age of workers who work in the production department on the occurrence of crystallization of urine in CV Alumunium Mandiri

Age (year)	Urine Crystallization				Total		P-value	PR 95% CI
	Positive		Negative		N	%		
	n	%	n	%				
>40	5	41.7	7	58.3	12	100	0.013 (0.916-11.146)	
≤40	3	13.0	20	87.0	23	100		

Table 3 shows that 42.9% of workers with > 10 years of service experience urine crystallization and workers with ≤10 years of service who experience 9.5% of urine crystallization. Chi-Square test results obtained a p-value of 0.039 (p-value < 0.05), which means there is a relationship between the work period and the incidence of urine crystallization in workers. Based on the calculation of Risk Estimate, the risk range (PR) of 4,500 is obtained. This means that workers with ten years of service > 4,500 times greater risk of being exposed to urine crystallization compared to workers with ten years of ≤10 years of service. In a population of 95%, it is believed that the service life is a risk factor for urine crystallization in the range of 1.055 to 19.192.

Table 3. Influence of the work period of workers in the production department on the occurrence of crystallization of urine in CV Alumunium Mandiri

Work Period (year)	Urine Crystallization				Total		P-value	PR 95% CI
	Positive		Negative		N	%		
	n	%	n	%				
>10	6	42.9	8	57.1	14	100	0.039 (1,055-19,192)	
≤ 10	2	9.5	19	90.5	21	100		

Table 4 shows that 41.2% of workers with poor drinking water consumption experienced urine crystallization and only 5.6% of workers had the awareness to consume drinking water so that they did not experience urine crystallization. Chi-Square test results obtained a p-value of 0.018 (p-value <0.05), which means there is a relationship between drinking water consumption and the incidence of urine crystallization. Based on the calculation of Risk Estimate, the range of risks (PR) is 7,412. Thus it is known that workers with poor drinking water consumption have a risk of 7,412 times greater exposure to urine crystallization compared to workers with good drinking water consumption. In a population of 95%, it is believed that drinking water

consumption is a risk factor for urine crystallization in the range of 1.016 to 54.095.

Table 4. Effect of drinking water consumption of workers in the production department on the occurrence of crystallization of urine in CV Aluminium Mandiri

Drinking Water	Urine Crystallization				Total		P-value	PR 95% CI
	Positive		Negative		N	%		
	n	%	n	%				
Bad	7	41.2	10	58.8	17	100	0.018	7.412 (1.016-54.095)
Good	1	5.6	17	94.4	18	100		

**IV DISCUSSION**

The results of temperature measurements show that several points in the production section have temperatures above the threshold value. The distribution of heat temperature frequencies between work environments >26.7°C and <26.7°C has a difference of 8.6%. Exposure to high temperatures caused 43.8% of positive workers to experience crystallization of urine. Urine crystallization can form slowly over a long time. If this condition is allowed to cause health problems such as urinary system disorders and other heat-related illnesses.

The types of urine crystallization found in workers are oxalate crystals and urate crystals. Oxalate crystals can form due to multifactorial, congenital processes and are most often caused by metabolic disorders. The body cannot metabolize oxalate and is excreted by the body through the kidneys. Oxalate crystals form when the kidneys are disturbed, whereas urate crystals are usually present in people > 60 years old. Urate crystals in young people usually occur in young people who are obese or overweight<sup>6</sup>.

Based on observations, workers sweat excessively but are not accompanied by the consumption of drinking water and electrolyte liquids as a substitute for lost salt. Excessive sweating makes blood pressure increase, pulse increases and the modulating system in the brain will respond to various mechanisms of convection, conduction, radiation, and evaporation to maintain body heat. Body water decreases due to late drinking, causing increased osmolality of body fluids and urine becomes concentrated. It takes a while for a thirst to appear after the body lacks water. Observation results indicate that the number of dispensers is small and tends to be far from the work area making workers tend to be lazy to take water even though they feel thirsty due to ambient heat.

Thermoregulation mechanism functions to maintain body temperature due to decreased peripheral blood flow. This action called peripheral vasoconstriction, and moves blood to the body's core, an increase in

central blood volume makes the brain not detect a decrease in blood volume so more fluid intake is not considered necessary, even when fluid is needed<sup>7,8</sup>. This activity stimulates central volume receptors to stimulate the release of AVP (Arginine Vasopressin Plasma) and causes a decrease in thirst and the kidneys get a signal to conserve fluids thereby decreasing urine output<sup>9</sup>.

Workers are often not aware that they are deficient in fluids. Fluid is mostly released through urine or digestive tract, as well as other parts through the skin and lungs as a result of air dryness. The fluid that is lost and not replaced causes the plasma volume to decrease and there is a decrease in the physical and cognitive abilities of workers<sup>10</sup>.

It is stated that there is a relationship between drinking water consumption and the relationship between drinking water consumption and the occurrence of urine crystallization in the Furnace process plant Department employees at PT. Vale Indonesia Tbk<sup>12</sup>. Adequate water consumption maintains health, prevents dehydration due to excessive sweating and urine output. Dehydration affects fatigue, impaired concentration, even decreased consciousness<sup>10</sup>. The risk of crystallization of urine increases by 7.64 times when not consuming water according to the needs of the body shown to RSI Sultan Agung Semarang workers<sup>13</sup>. If the exposure to heat is left continuously the body will experience fatigue. Increased blood vessel capacity causes a decrease in blood pressure and excessive drainage of fluid and salts that encourage muscle spasms.

Based on the results of interviews with workers in the printing and thinker section often experience spasms in the upper arms and legs of the calf. This condition shows another effect of the effect of heat called heat cramps. Heat cramps are painful, brief muscle cramps. Muscles may spasm or jerk involuntarily. Heat cramps can occur during exercise or work in a hot environment or begin a few hours later. Hot temperatures exposed to workers can cause physiological and psychological disorders.

Urine crystallization is related to heat stress. Heat pressure occurs due to interactions of air temperature, humidity, and the speed of air movement associated with the production of heat from the body's metabolic output<sup>14</sup>. It is known that there is a relationship between the temperature of the work environment and the incidence of urine crystallization (p-value = 0.002) for workers at PT Hok Tong Palembang<sup>15</sup>. Workers who work in hot environments are 9 times at risk of experiencing crystallization of urine compared to workers who work at room temperature<sup>16</sup>

Research shows there is no relationship between

the age of the worker and the incidence of urine crystallization. Exposure to heat temperatures as a factor in the occurrence of heat strains is felt by workers from both age groups, but not significantly in causing crystallization of urine. This is supported by research 8.9 which states that there is no significant relationship between the age of the respondents with the incidence of urine crystallization.

High heat stress with the highest temperature of 32.1°C produced by the furnace that is felt by all workers. This condition makes the distribution of body temperature responses in the two age groups not seen significantly. There were 3 people from 8 workers who tested positive for urine crystallization aged  $\leq 40$  years. These three workers experienced urine crystallization influenced by factors other than age, namely the body's metabolic process is slow and workers are obese or overweight which affects the body's slow process of acclimatizing temperature to temperature in the environment.

The results of the study stated that there is a relationship between a work period and urine crystallization in workers which are categorized into two namely  $> 10$  years and  $\leq 10$  years. Workers with  $> 10$  years of service experience urine crystallization by 42.9% (6 people). There is a difference in the distribution of tenure by 20% in workers with  $> 10$  years of service compared to workers with ten years  $< 10$  years. Workers who tested positive for urine crystallization were 7 people with a tenure of 10-27 years, only one worker who tested positive for urine crystallization with a work period of 2 years. Based on the results of the interview, workers felt disturbed by the heat from the furnace. Workers who have worked for 10 years often feel stuffy and shortness of breath due to heat. To reduce the burning sensation, male workers do not wear clothes when working.

The worst conditions are felt during high production and the weather in the dry season, so workers have difficulty breathing and red rashes on the skin of workers (salt hungry). According<sup>14</sup> if this condition is left in a long time it can cause other health problems, namely heat rash. Heat rash occurs when sweat cannot evaporate freely from the skin, arising from a hot and humid environment. This hot rash can be annoying during work because it will feel prickling on the skin and make workers uncomfortable. Research<sup>12,17,18</sup> states that there is a significant relationship between work period and the incidence of urine crystallization related to age categories.

The effects that affect the body are slow in the process of acclimatizing temperature to temperature in the environment. The longer the worker is at the site of heat exposure has an impact on the increased

incidence of urine crystallization. Exposure to high temperatures from a furnace and poor ventilation conditions expose workers to hot temperatures exceeding the threshold value. Exposure to heat can be overcome by natural acclimatization of the body, but continuous heat exposure for  $> 10$  years affects the body's normal function to adapt. To minimize the temperature of the heat felt by the body of workers CV Aluminium Mandiri Palembang  $> 8$  hours need to be allowed to be outside the building to normalize body temperature.

The results showed there was a relationship between workers' drinking water consumption and the incidence of urine crystallization in CV Aluminium Mandiri Palembang. Workers' drinking water consumption is categorized into two, which is good if  $> 4$  liters/day and not good  $\leq 4$  liters/day. Workers with poor drinking water consumption experienced urine crystallization of 41.2%. The frequency distribution of drinking water consumption among workers contained a difference of 2.8% with workers in drinking water consumption good ( $> 4$  Liter).

Observations show there is no dispenser for workers to fill/take drinking water. In general, workers feel lazy to consume drinking water even though they are thirsty because of work demands. Some workers during the break choose to drink coffee, tea or beverage packaging and smoking compared to water consumption. Consumption of water containing sugar is needed by the body to replace lost electrolyte replacement fluids, but the consumption of sugar water, especially bottled drinks, causes the body's metabolism to become heavy in regulating the combustion system. Excessive consumption of sugar water causes obesity or obesity which accelerates urate crystals.

The lack of drinking water consumption is indicated by the urine of light yellow and dark yellow workers. Drinking water consumption causes an increase in urine volume and prevents the formation of oxalate crystals in the urine. Explanation<sup>19</sup> states that fluid intake, especially the consumption of large amounts of water, is the most powerful and economical deterrent against the formation of kidney stones (nephrolithiasis).

This opinion is supported by<sup>12,13,16,20</sup> which states that there is a significant relationship between workers' drinking water consumption and the risk of urine crystallization, and this incidence increases by 7.64 times when not consuming water according to the body's needs with a p-value of 0.001, ( $p < 0.05$ ). Research<sup>20</sup> confirms that the heat stress factor is associated with the occurrence of crystallization of urine in laundry and kitchen workers of Hotel X,

Medan. Consumption of drinking water with categories  $> 3\text{Liter} / \text{day}$  and  $\leq 3\text{Liter} / \text{day}$  has an impact on the crystallization of urine with a p-value of 0.003. Research<sup>21</sup> states the amount of drinking water that must be consumed by active and passive workers with hot working environment temperature conditions is 4-10 liters per day.

Therefore, the longer the workers of CV Aluminum Mandiri Palembang are exposed to heat and excessive sweating must be offset by the consumption of 250-300 ml of drinking water per 30 minutes to prevent the crystallization of urine. Consumption of sugar water, especially bottled drinks, causes the body's metabolism to be heavy in regulating the combustion system. Excessive consumption of sugar water causes obesity or obesity which accelerates urate crystals.

## VI. CONCLUSION

Based on the results it can be concluded that

1. High temperatures in the work environment cause urine crystallization to workers in the production department.
2. Urine crystallization is more influenced by the length of time the worker is in the high-temperature area and lack of water consumption but is not affected by age
3. Prevalence of urine crystallization in the amount of 22.9% or 8 toward workers

## REFERENCES

1. Suma'mur. 2009. Corporate Hygiene and Occupational Health. Jakarta: PT.Toko Gunung Agung. Sagung Seto
2. Harrianto, R. 2009. Textbook on Occupational Health. Jakarta: EGC.
3. Atan, L, et al. 2005. High kidney stone risk in working in steel industry at hot temperature. Journal of Urology, Vol. 5, pp. 858-61. Available in <http://www.ncbi.nlm.nih.gov>.
4. Dano A, Rahim MR, Muis M. 2014. Factors Related to the Occurrence of Urine Crystallization in the Furnace Process Plant Department Employees at PT. Vale Indonesia Tbk Sorowako. Makassar: Faculty of Public Health, Hasanuddin University. Available in: <http://unhas.ac.id>.
5. Wilson J.W; Henry, W.K. 2001. Uronary Tract Infection in: Current Diagnosis and Treatment of Disease. Medical Book of New York 2001: 220-230.
6. Hardinsyah, Dodik Briawan, Et Al. Study of Drinking Habits and Hydration Status in Adolescents and Adults in Different Ecological Areas. Bogor: Association of Indonesian Nutrition and Food Enthusiasts (Persagi), Department of Community Nutrition, IPB Bogor, Danone Aqua Indonesia; 2009
7. Malisova O, Athanasatou A, Pepa A et all. Water Intake And Hydration Indices In Healthy European Adults: The European Hydration Research Study (EHRS). Nutrients 2016; 8-204.
8. Grandjean. Rolling Revision Of The Who Guidelines For Drinking-Water Quality Draft For Reviews And Comments (Not For Citation) Water Requirements, Impinging Factors, And Recommended Intakes. World Health Organization. 2004
9. Kenefick Rw, Hazzard Mp, Mahood Nv, Castellani Jw. Thirst Sensations And Avp Responses At Rest And During Exercise-Cold Exposure. Medicine and Science in Sports and Exercise. 2004: 36: 1528-1534
10. Andayani, K. Relationship between Liquid Consumption and Hydration Status in Male Industrial Workers [Thesis]. Diponegoro University. 2013
11. Moeljosoedarmo S. 2008. Industrial Hygiene. Jakarta: FKU Publisher Center
12. Ajief Achmad Z. Dano, Muhammad Rum Rahim, and Masyitha Muis. 2014. Factors related to the occurrence of crystallization of urine in Furnace Process Plant Department employees at PT. Vale Indonesia Tbk. Sorowako Available in: <http://repository.unhas.ac.id>.
13. Lina, Nur. 2008. Risk Factors for Male Urinary Tract Stone Events (Case Study of RSI Sultan Agung Semarang) [Thesis]. Semarang: Diponegoro University
14. Pandolf, K. B. 1997. Aging and Human Heat Tolerance. Experimental Aging Research
15. NCDOL. 2012. A Guide to Preventing Heat Stress and Cold Stress. USA: NC. Department of Labor Occupational Safety and Health. Available in: <http://nclabor.com>
16. Maslachah, Siti Chairul. 2009. Effect of Heat Pressure on the Formation of Worker Urine Crystals in Tofu Factory in Polokarto District, Sukoharjo. Surakarta: Div Program. Occupational Health Faculty of Medicine, Sebelas Maret University Surakarta. Available in: <http://repository.uns.ac.id>
17. Sumaryani, Dewi. 2002. Effect of Hot Work Environment on Crystallization of Gout in Workers at Hotel X, Jakarta [Thesis]. Jakarta: University of Indonesia
18. Borghi L, et al. 1993. Hot Occupation and

- nephrolithiasis. *Urol Journal*, Vol. 6, pp 1757-60. Available in: <http://www.ncbi.nlm.nih.gov>.
19. Triyanti, Firy. 2007. Relationship between Heat Stress Factors and the Incidence of Urine Crystallization in Laundry and Kitchen Workers Hotel X, Medan. Thesis. Medan: Occupational Health Study Program, Postgraduate School, University of North Sumatra. Available in: <http://repository.usu.ac.id>.
  20. Sawka M, Montain S, Latzka W. 2000. Fluid and Electrolyte Supplementation for Exercise-Heat Stress. *The American Journal of Clinical Nutrition*, Vol. 72, pp 562s-72s. Available in: <http://ajcn.nutrition.org>.