Poll Res. 40 (2) : 438-443 (2021)

ISSN 0257–8050

CHARACTERISTICS OF POLLUTERS IN THE WORKING ENVIRONMENT OF PT X PALEMBANG CITY

FERLY OKTRIYEDI[1], IRFANNUDDIN[2]*, NGUDIANTORO[3], M. HATTA DAHLAN[4] AND NURHAYATI[1].

[1] *Study Program of Environmental Science, Sriwijaya University, South Sumatera, Indonesia*
[2] *Faculty of Medicine, Sriwijaya University, South Sumatra, Indonesia*
[3] *Faculty of Mathematics and Natural Science, Sriwijaya University, South Sumatra, Indonesia*
[4] *Faculty of Engineering, Sriwijaya University, South Sumatra, Indonesia*

(Received 8 September, 2020; accepted 20 October, 2020)

ABSTRACT

Rubber is one of the leading commodities in South Sumatra. In each of these forms of natural rubber production causes pollution in air, water, odor, and tatal/solid waste. This research will measure the concentration of ammonia (NH_3) and hydrogen sulfide (H_2S) in air, liquid and solid waste in the rubber factory environment. At the time of measurement in the air the average temperature was 31.9 C, the average pressure was 1011.75 bar, and the average humidity was 70.9%. The dominant wind is to the southeast. The highest concentrations of NH_3 and H_2S are in the leum area. The concentration of each is 1.51 ppm with an average of 1.03 ± 0.42 ppm and 9.34 ppm with an average of 2.97 ± 4.29 ppm. The concentration of NH_3 and H_2S in wastewater is the highest in wastewater treatment. The concentrations of each were 65 mg/l with a mean of 33.67 ± 27.79 mg/l and 1.70 mg/l with a mean of 0.79 ± 0.82 mg/l. The highest NH_3 concentration was in tatal, while the highest H_2S concentration was in the slab. The concentrations of each were 194.88 mg/Kg with an average of 148.88 ± 65.05 mg / Kg and 1.37 mg/Kg with an average of 1.27 ± 0.15 mg/Kg.

KEY WORDS: Rrubber, NH_3, H_2S, Rubber factory environment

INTRODUCTION

Rubber is one of the leading commodities of South Sumatra (Directorate General of Plantation, 2017; Permentan No. 38, 2008). Most of these natural rubber factories are in Palembang City (Gapkindo, 2020). In each of these forms of natural rubber production has an impact on the environment, workers and society. Common impacts are air pollution, water, odors (Pajarito *et al*., 2018; Tekasakul and Tekasakul, 2006), and solid waste (Rahmaniar and Susilawati, 2018; Supraptiningsih and Sarengat, 2014). In rubber factories, air quality analyzes revealed the smell of ammonia (NH_3) and hydrogen sulfide (H_2S) (Promnuan and O-Thong, 2017; Rattanapan *et al.*, 2014; Yani *et al.*, 2012). The routes of entry of NH_3 and H_2S into the body are through inhalation, oral and dermal (Agency for Toxic Substances and Disease Registry, 2004, 2016). NH_3 and H_2S have almost the same toxic effects on various organ systems (Chi *et al.,* 2018).

All rubber factories have a characteristic pungent smell like rotten eggs and fishy. There are several sources of pollutants, namely air, liquid waste and solids. Workers are exposed to and in contact with these pollutants. This research will measure the concentration of ammonia (NH_3) and hydrogen sulfide (H_2S) in air, liquid and solid waste in the rubber factory environment.

MATERIALS AND METHODS

In the Air

Hydrogen Sulfide (H_2S)
The sample was absorbed using 10 mL of absorbent. The absorbent material was 4.3 g of $CdSO_4.8H_2O$ and 1.8 g of NaOH. This solution was dissolved in

250 ml of distilled water and 10 g of arabinogalactant was added. Then the solution is diluted with distilled water to 1000 ml. The sampling time was 60 minutes with a flow rate of 0.4 L/m. The sampling tool used the Air Sampler Impinger MS 003GS S/N 0031523.

The test sample solution (10 ml of Absorbent) is transferred to a 25 ml test tube. 1.5 ml paminodimethilaniline dihydrochloride and 1 drop of $FeCl_3$ solution are added to the test solution. The test tube was shaken slowly until it was homogeneous. After that, let the solution sit for 30 minutes. The sample solution is fed to the cuvette in the spectrophotometer. The absorbance was measured at a wavelength of 670 nm. The absorbance of the sample then calculates the concentration using a calibration curve. The H_2S concentration is calculated using the formula below (National Standardization Agency, 2007):

$$C_1 = \frac{a_1 - a_b}{V_s}$$

note:

C_1 = H_2S concentration in ambient air (ppm);

a_1 = the amount of H_2S from the test sample (µl);

a_b = H_2S quantity of the reference solution (µl);

V_s = volume of sample gas under normal conditions at 25 °C, 760 mm Hg (l).

(Badan Standardisasi Nasional 2007).

Ammonia (NH_3)

The sample was absorbed using 10 ml of absorbent. The absorbent material was 3 ml of $H_2SO_4$97% and 200 ml of cold distilled water. Then the solution is diluted with distilled water to 1000 ml. The sampling time was 60 minutes with a flow rate of 0.4 L/m. The sampling tool used the Air Sampler Impinger MS 003GS S/N 0031523.

The test sample solution (10 ml of Absorbent) is transferred to a 25 ml test tube. Add successively to each test tube 2 ml of buffer solution, 5 ml of phenol reagent solution and 2.5 ml of sodium hypochlorite reagent solution and then homogenized. Add distilled water to the test tube until it reaches a mark, then homogenize and let stand for 30 minutes. Enter the test sample solution into the cuvette on the spectrophotometer, then measure the absorption at a wavelength of 630 nm. The absorbance of the sample then calculates the concentration using a calibration curve. The H_2S concentration is calculated using the formula below (National Standardization Agency, 2005a):

$$C = \frac{a}{V} x1000$$

note:

C = concentration of NH_3 in ambient air (ppm);

a = the amount of NH_3 from the test sample based on the calibration curve (µg)

V = volume of inhaled air corrected under normal conditions at 25 °C, 760 mmHg

1000 = conversion from l to m^3

In the Water

Hydrogen Sulfide (H_2S)

A sample of 25 ml was put into a 50.0 ml volumetric flask. The sample is diluted with sulfide-free water to the mark. The solution was added with 0.5 mL of sulfuric acid-amine reagent and 0.15 ml of $FeCl_3$ solution (3 drops). The solution is immediately inverted (reversed once) slowly, let stand for 5 minutes. The solution is added with 1.6 ml of $(NH_4)2HPO_4$ solution, let stand 10. H_2S concentration is calculated using the below (National Standardization Agency, 2009):

$$S^{2-}(mg/L) = \frac{A}{(slope\ x\ V} x \frac{V_2}{V_1} xf$$

note:

A = absorbance of the measured test sample

V = volume of test sample (ml)

V1 = final volume of test sample (ml)

V2 = initial volume of test sample (ml)

f = dilution factor

Ammonia (NH_3)

A sample of 25 ml was put into a 50 ml Erlenmeyer. Add 1 mL of phenol solution. 1 ml sodium nitroprusside. 2.5 ml oxidizing solution. erlenmeyer covered with plastic. Color formation is left on for 1 hour. The solution is inserted into a cuvette on a spectrophotometer at a wavelength of 640 nm. The NH_3 concentration is calculated using the formula below (National Standardization Agency, 2005b):

Amonium level (mgN/l) = c *x* fp

note:

C = levels obtained from measurement results (mg/l)

fp = dilution factor

In the Solid

Hydrogen Sulfide (H_2S)

A sample of 50 grams of rubber was added with 100 ml of concentrated HCL. The sulfide vapor is collected directly with a sulfide absorber of 4.3 g of $CdSO_4.8H_2O$ and 1.8 g of NaOH. This solution was dissolved in 250 ml of distilled water and 10 g of arabinogalactant was added. The sample was absorbed using 10 ml of absorbent.

A sample of 7.5 ml was inserted into test tubes A and B, using a special wide tip pipette. For tube A, add 0.5 ml of amino-sulfate acid reagent and 0.15 ml of FeCl3 solution (3 drops). For Tube B add 0.5 ml of 1 + 1 H_2SO_4 and 0.15 ml (3 drops) of FeCl3 solution and stir, then wait for 5 minutes and add 1.6 ml (NH_4) $2HPO_4$ to each tube, wait for 10 minutes and do a color comparison. Sulfide concentrations from 0.1 to 2.0 mg/l were measured with a 1 cm light trajectory. The calibration curves prepared by the colorimetric tests were made on Na_2S solution simultaneously analyzed by iodometric method. The sulfide concentration is read on a calibration curve. The H_2S concentration is calculated using the formula below (American Public Health Association, 2017):

note:

C_1 = H_2S concentration in ambient air (ppm);

a_1 = the amount of H_2S from the test sample (˜L);

a_b = H_2S quantity of the reference solution (˜L);

V_s = volume of sample gas under normal conditions at 25 °C, 760 mmHg (L).

(Badan Standardisasi Nasional 2007).

Ammonia (NH_3)

50 gm of rubber samples were extracted with 0.1 N sulfuric acid as much as 50 ml. Let stand for 24 hours. A sample of 25 mL was put into a 50 ml Erlenmeyer flask. The liquid is added with 1 ml of phenol solution, 1 ml of sodium nitroprussida solution, and 2.5 ml of oxidizing solution. The sample is covered with plastic wrap. The color is allowed to develop at room temperature of 27 ° C and dim light for 1 hour. Measure absorbance at 640 nm. Then, make a standard liquid by diluting the stock solution of ammonia into the sample concentration range. The standard fluid is treated with the sample. The sample concentration is calculated by comparing the absorbance of the sample with a standard curve. The absorbance of the sample then calculates the concentration using a calibration curve. The NH_3 concentration is calculated using the formula below (American Public Health Association, 2017):

note:

C = concentration of NH_3 in ambient air (ppm);

a = the amount of NH_3 from the test sample based on the calibration curve (µg)

V = volume of inhaled air corrected under normal conditions at 25 °C, 760 mmHg

1000 = conversion from L to m^3

RESULTS AND DISCUSSION

This research was conducted at PT X on 27 November -3 December 2019. PT. X is a company engaged in rubber processing. PT. X with a production capacity of ± 4,000 tons per month. Products produced by PT. X is SIR 10, SIR 20, SIR 10 VK, SIR 20 VK. Type VK is added to the drug in the process. Type SIR 10 VK, SIR 20 VK and SIR 20 VK KAWANOJI are only produced by PT. X. The products are exported to world tire factories. PT. X processes the raw material for rubber which is called Bokar (rubber processing material). Bokar is processed into semi-finished rubber, then exported abroad. Production is divided into two parts, namely part I (wet production) which processes raw materials to become blackets and production II (dry production) processes blankets into crumb rubber.

The basic material for rubber is latex. Latex is a colloidal dispersion system of poly (cis-1,4-isoprene) and (C_5H_8) n. Latex will clot when added with a coagulant (Nasution, 2016; Purbaya, Sari, Saputri, & Fajriaty, 2011). If the coagulants used are acidic but do not have antibacterial and antioxidant properties, natural antioxidant-destroying bacteria will develop. These bacteria will cause ammonia and sulfide concentrations (Research Center of Industrial plant and freshener, 2014; Solichin and Anwar, 2006; Tekasakul and Tekasakul, 2006; Towaha, Aunillah, and Purwanto, 2013). The results of measurements in air are in Table 1. The concentrations of NH_3 and H_2S in the air were measured at 4 points. When measuring the average temperature of 31.9 C, the average pressure was 1011.75 bar, and the average humidity was 70.9%. The dominant wind is to the southeast. The highest concentrations of NH_3 and H_2S are in the leum area. The concentration of each is 1.51 ppm with an average of 1.03 ± 0.42 ppm and 9.34 ppm with an average of 2.97 ± 4.29 ppm.

The NH_3 concentration is still below the odor level standard while the H_2S concentration is above the odor level standard (Ministry of Manpower and Transmigration, 2011; State Minister for the Environment, 1996). NH_3 and H_2S in biogas pose serious challenges to human health and the environment (Elizabeth *et al.,* 2017). H_2S above 1 ppm can have negative health effects (Malone *et al.,* 2017). H_2S with chronic low exposure can have implications for cardiovascular health, nervous system and respiratory disorders (Bates *et al.*, 2002), but 15 years later, studies have found no negative effects (Bates *et al.*, 2017).

NH_3 and H_2S have almost the same toxic effects on various organ systems. The toxic effects of H_2S can affect the nervous system, respiratory system, cardiovascular system, digestive system, and immune system (Chi *et al.*, 2018). The toxic effects of NH_3 can affect the respiratory system, eye system, integumentary system, cardiovascular system, digestive system, and nervous system (EPA, 2016; Makarovsky *et al.*, 2008).

The results of measurements in water are in table 2. NH_3 and H_2S concentrations were measured at 3 points. The highest concentrations of NH_3 and H_2S in wastewater treatment. The concentrations of each were 65 mg/l with a mean of 33.67 ± 27.79 mg/l and 1.70 mg/l with a mean of 0.79 ± 0.82 mg/l.

The NH_3 concentration is still above the liquid waste quality standard, while the H_2S concentration is below the liquid waste quality standard (Governor of South Sumatra, 2012; State Minister for the Environment, 2014). The combination of H_2S and water can produce sulfuric acid which has a corrosive effect. H_2S is the main compound which reacts with most metals and its chemical activity increases with increasing pressure and concentration, in the presence of water and at higher temperatures. The combination of NH_3 and water can also cause stress corrosion cracking in carbon steel (Latosov *et al.*, 2017).

The measurement results in tatal/solid are in Table 3. The H_2S concentration in the solids was measured in 2 parts. The highest NH_3 concentration was in tatal, while the highest H_2S concentration was in the slab. The concentrations of each were 194.88 mg/Kg with an average of 148.88 ± 65.05 mg/kg and 1.37 mg/kg with an average of 1.27 ± 0.15 mg/Kg.

NH_3 and H_2S concentrations are above the liquid waste quality standard (Governor of South Sumatra, 2012; State Minister for the Environment, 2014). Solid waste has no quality standards. So that we identify based on liquid waste. Slabs are processed rubber directly from farmers. Concentrations that exceed the quality standard can adversely affect farmers and workers in rubber factories, because they come into direct contact with the slab. Tatal is solid waste which is produced by rubber production. Processing 100 kg of latex yields about 3-5% yield (Rahmaniar and Susilawati, 2018). Until now, the tatal has not been used effectively. Tatal is still piled in the environment around the factory. Concentrations that exceed the quality standard can adversely affect the environmental ecosystem.

CONCLUSION

At the time of measurement in the air the average

Table 1. The concentrations of NH_3 and H_2S in the air at the PT X

No	Area	Concentrations (ppm)	
		NH_3	H_2S
1	Dock	1.25	1.68
2	Leum storehouse	1.51	9.34
3	Driyer 3	0.63	0.43
4	Employee housing	0.73	0.43
	Average±SD	1.03±0.42	2.97±4.29
Odor level quality standards (State Minister for the Environment, 1996)		2.0	0.02
Threshold value (Ministry of Manpower and Transmigration, 2011)		25	1

Table 2. Concentrations of NH_3 and H_2S in the liquid waste of the PT X rubber factory working environment

No	Area	Concentrations (mg/l)	
		NH_3	H_2S
1	Leum storehouse	24	0.56
2	*Breaker*	12	0.12
3	Wastewater treatment	65	1.70
	Average ± SD	33.67 ± 27.79	0.79±0.82
	Liquid waste quality standards (Governor of South Sumatra, 2012; State Minister for the Environment, 2014)	15	0.8

Table 3. Concentrations of NH_3 and H_2S in the environment of the PT X rubber factory

No	Units	Concentrations (mg/Kg)	
		NH_3	H_2S
1	Slab	102.88	1.37
2	Tatal	194.88	1.16
	Average±SD	148.88±65.05	1.27±0.15
	Liquid waste quality standards (Governor of South Sumatra, 2012; State Minister for the Environment, 2014)	15	0.8

temperature was 31.9 C, the average pressure was 1011.75 bar, and the average humidity was 70.9%. The dominant wind is to the southeast. The highest concentrations of NH_3 and H_2S are in the leum area. The concentration of each is 1.51 ppm with an average of 1.03 ± 0.42 ppm and 9.34 ppm with an average of 2.97 ± 4.29 ppm. The concentration of NH_3 and H_2S in wastewater is the highest in wastewater treatment. The concentrations of each were 65 mg/l with a mean of 33.67 ± 27.79 mg/l and 1.70 mg/l with a mean of 0.79 ± 0.82 mg/l. The highest NH_3 concentration was in tatal, while the highest H_2S concentration was in the slab. The concentrations of each were 194.88 mg/Kg with an average of 148.88 ± 65.05 mg/Kg and 1.37 mg/Kg with an average of 1.27 ± 0.15 mg/Kg. The relationship between pollutants and the health impacts of workers in rubber factories is not yet known.

ACKNOWLEDGMENT

We sincerely appreciate The Indonesian Ministry of Technology, Research and Higher Education (RISTEKDIKTI) for financial support.

REFERENCES

Agency for Toxic Substances and Disease Registry. 2004. Toxicological Profile for Ammonia. *Federal Register*, (September), 269. Retrieved from http://www.atsdr.cdc.gov/toxprofiles/tp126.pdf

Agency for Toxic Substances and Disease Registry. 2016. Toxicological Profile for Hydrogen Sulfide and Carbonyl Sulfide. *Agency for Toxic Substances and Disease Registry Report*, (November). Retrieved from https://www.atsdr.cdc.gov/toxprofiles/tp114.pdf

American Public Health Association. 2017. *Standard Methods for The Examination of Water and Wastewater 23th Edition*. https://doi.org/10.2105/SMWW.2882.

Research Center of Industrial plant and freshener, 2014. Farmers in Bangka Belitung Are Still Using Alum as a Latex Coagulant. pp. 1-5.

Bates, M. N., Bailey, I. L., Dimartino, R. B., Pope, K., Crane, J. and Garrett, N. 2017. Lens opacity and hydrogen sulfide in a New Zealand geothermal area. *Optometry and Vision Science*. 94(4) : 487-495. https://doi.org/10.1097/OPX.0000000000001049

Bates, M. N., Garrett, N. and Shoemack, P. 2002. Archives of Environmental Health/: An International Investigation of Health Effects of Hydrogen Sulfide from a Geothermal Source Investigation of Health Effects of Hydrogen Sulfide from a Geothermal Source. *Archives of Environmental Health: An International Journal*. 57(5) : 404-411.

Chi, Q., Chi, X., Hu, X., Wang, S., Zhang, H. and Li, S. 2018. The Effects of Atmospheric Hydrogen Hulfide on Peripheral Blood lymphocytes of chickens: Perspectives on Inflammation, Oxidative Stress and Energy Metabolism. *Environmental Research*. *167*(June), 1-6. https://doi.org/10.1016/j.envres.2018.06.051

Directorate General of Plantation. 2017. Indonesian Plantation Statistics 2015-2017. *Sekretariat Direktorat Jenderal Perkebunan*, pp. 1-61.

Elizabeth, M., Cecil, K. K. and Talam, E. K. 2017. Hydrogen sulfide and ammonia removal from biogas using water hyacinth-derived carbon nanomaterials. *African Journal of Environmental Science and Technology*. 11 (7) : 375-383. https://doi.org/10.5897/ajest2016.2246

EPA. 2016. *Toxicological Review of Ammonia (Noncancer Inhalation): Executive Summary* (Vol. 16, p. 10). Vol. 16, p. 10. Retrieved from https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/0422_summary.pdf

Gapkindo, 2020. Members of Gapkindo, South Sumatra Branch. Retrieved January 10, 2020, from https://www.gapkindo.org/cabang/92-south-sumatera

Governor of South Sumatra. 2012. *South Sumatra Governor Regulation No. 8 of 2012 concerning: Liquid Waste Quality Standards for Industrial Activities, Hotels, Hospitals, Domestic and Coal Mining*. pp. 1-50.

Latosov, E., Loorits, M., Maaten, B., Volkova, A. and Soosaar, S. 2017. Corrosive effects of H_2S and NH3 on natural gas piping systems manufactured of carbon steel. *Energy Procedia*. 128 : 316-323.

https://doi.org/10.1016/j.egypro.2017.08.319

Makarovsky, I., Markel, G., Dushnitsky, T. and Eisenkraft, A. 2008. Ammonia - When Something Smells Wrong. *Israel Medical Association Journal*. 10(7): 537-543.

Malone, R. S. L., Pearce, L. L. and Peterson, J. 2017. Environmental toxicology of hydrogen sulfide. *Nitric Oxide - Biology and Chemistry*. 71 : 1-13. https://doi.org/10.1016/j.niox.2017.09.011

Ministry of Manpower and Transmigration. 2011. *Permenakertrans No. Per.13 / MEN / X 2011 concerning Threshold Value of Physical and Chemical Factors in the Workplace*. pp. 1-54.

Nasution, R. S. 2016. Utilization of Various Types of Materials as Latex Clumpers. *Journal of Islamic Science and Technology*. 2(1) : 74-80.

National Standardization Agency. 2005a. *Ambient air - Part 1: How to test ammonia (NH3) levels using the indophenol method using a spectrophotometer*. pp. 1-13.

National Standardization Agency. 2005b. Water and wastewater - Part 30: How to test ammonia levels by means of a spectrophotometer by phenate. *Sni 06-6989.30-2009.*, pp. 1-10.

National Standardization Agency. 2007. *Ambient air - Part 11: How to test for hydrogen sulfide (H2S) levels in ambient air using the methylene blue method by spectrophotometry* . pp. 1-13.

National Standardization Agency. 2009. *Water and wastewater - Part 70: How to test for sulfides with methylene blue spectrophotometrically* . pp. 1-24. https://doi.org/SNI 6989.70:2009

Pajarito, B. B., Castañeda, K. C., Jeresano, S. D. M. and Repoquit, D. A. N. 2018. Reduction of Offensive Odor from Natural Rubber Using Zinc-Modified Bentonite. *Advances in Materials Science and Engineering, 2018*. https://doi.org/10.1155/2018/9102825

Permentan No. 38. 2008. *Guidelines for Processing and Marketing of Rubber Processing Materials* pp. 1-16.

Promnuan, K. and O-Thong, S. 2017. Biological Hydrogen Sulfide and Sulfate Removal from Rubber Smoked Sheet Wastewater for Enhanced Biogas Production. *Energy Procedia*. 138 : 569-574. https://doi.org/10.1016/j.egypro.2017.10.161

Purbaya, M., Sari, T. I., Saputri, C. A. and Fajriaty, M. T. 2011. The Effect of Several Types of Latex Clotting Materials and Their Relationship with Weight Loss, Dry Rubber Content and Plasticity. 351-357.

Rahmaniar, and Susilawati, N. 2018. Utilization of Crumb Rubber Solid Waste for Making Rubber Floor Tile. *Jurnal Dinamika Penelitian Industri*. 29(2) : 128-136.

Rattanapan, C., Suksaroj, T. T., Chumpikul, J. and Choosong, T. 2014. Health Risk Assessment of Hydrogen Sulfide Exposureamong Workers in a Thai Rubber Latex Industry. *Environment Asia*. 7(1): 104-111. https://doi.org/10.14456/ea.2010.32

Solichin, M. and Anwar, A. 2006. Deorub K Latex Freezer and Rubber Odor Prevention. *Tabloid Sinar Tani*, 2.

State Minister for the Environment. 1996. *Decree of the State Minister for the Environment No. 50 of 1996 concerning: Odor Level Standards*. pp. 1-5.

State Minister for the Environment. 2014. Regulation of the Minister of Environment of the Republic of Indonesia No. 5 of 2014 concerning Wastewater Quality Standards. *Kementrian Lingkungan Hidup Dan Kehutanan*, pp. 1-83.

Supraptiningsih, and Sarengat, N. 2014. Utilization of Crumb Rubber Industry Solid Waste for Making Compost 35-42.

Tekasakul, P. and Tekasakul, S. 2006. Environmental Problems Related to Natural Rubber Production in Thailand. *J. Aerosol Res*. 21(2) : 122-129. https://doi.org/10.11203/jar.21.122

Towaha, J., Aunillah, A. and Purwanto, E. H. 2013. Utilization of Liquid Smoke from Rubber Wood and Coconut Shell for Handling Air Pollution at Lump. *Buletin RISTRI.* 4(1) : 71-80.

Yani, M., Ismayana, A., Nurcahyani, P. R. and Pahlevi, D. 2012. Removing odor of ammonia from accumulated leum in the crumb rubber industry using biofilter techniques. *Jurnal Ilmu Pertanian Indonesia*. 17(1) : 58-64. Retrieved from http://journal.ipb.ac.id/index.php/JIPI/article/viewFile/8039/6301.