Research Paper

Correlation of Surface Ammonia Concentration on a Rotting Corpse to the Degree of Decomposition

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ABSTRACT

Background: Ammonia is toxic at high concentrations, and those who handle corpses should be cautious about the ammonia produced by decomposition. However, there is a dearth of reports showing an appropriate index for the ammonia level of corpses.

Methods: The progression of decomposition was divided into four stages based on easily visible changes in appearance, namely, skin discoloration and soft tissue destruction. Ammonia was quantified in the liquid decomposition products on the surface of the corpse and in the air surrounding it.

Results: During moderate to severe decomposition, ammonia concentrations rose to levels that could cause serious damage to the respiratory system and ocular mucosa due to chemical irritation. However, as decay progressed and bone became exposed, ammonia concentration decreased.

Conclusion: This study revealed that ammonia levels can be predicted from the visual stage of corpse decomposition. We believe that these results can guide the safe handling of bodies.

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Introduction

Soft tissues in a rotting corpse decompose and liquefy, escaping from the body through the nasal cavity, mouth, urethra, and anus [1, 2]. Skin and muscle tissue also decompose, releasing large amounts of liquid decomposition products through tissue defects. These liquid decomposition products contain high concentrations of ammonia, as shown in Figure 1, which volatilize and release ammonia gas into the surrounding area [3-5]. As both liquid and gaseous ammonia are known to be toxic to humans [6, 7], it is important to conduct a detailed investigation of ammonia concentrations around a rotting corpse. However, this topic has not been a focus of much research. We previously measured putrefactive amines produced by decomposing corpses and reported that ammonia around the rotting corpse often reaches toxic levels after death [8]. However, the ammonia concentration on each post-mortem day varies widely, possibly due to differences in various conditions, making it difficult to define the criteria clearly.

In this study, we quantified ammonia in the putrefactive fluid and in the air surrounding a rotting corpse at each stage of decomposition, aiming to clarify the risk of exposure to the corpses. The results of this study are expected to be useful for disease prevention and health management for people who come into contact with putrefactive corpses.

Materials and Methods

This study focused on rotting corpses from October 2018 to September 2025, during which the average daily temperature between death and discovery was higher than 20°C. Forty-two bodies were analyzed in an advanced state of decomposition, excluding mummified bodies, bodies with high levels of toxic substances, and bodies with suspected infectious diseases. The analysis primarily relied on full autopsies and toxicological analysis to determine the cause and date of death (Table 1).

The degree of decomposition of cadavers was classified into the following four stages based on easily visible changes in appearance, namely, skin discoloration and soft tissue destruction:

Mild stage: The skin was discolored, typically greenish-reddish-brown (Figure 2A).

Moderate stage: Skin and soft tissue loss was less than 50% of the body surface area (Figure 2B).

Severe stage: Skin and soft tissue loss was more than 50% of the body surface area (Figure 2C).

Later stage: Almost all bones are exposed and nearly ossified (Figure 2D).

The corpse was placed in an unventilated area for several minutes, and a clean spoon was used to collect approximately 2 g of liquid decomposition products from the face, neck, and upper thorax to analyze the liquid decomposition (Figure 3A). Assuming that the corpse would be handled 50 cm from the worker's face in practice, the tip of an air detector tube was attached approximately 50 cm from the corpse's chest (Figure 3B) according to the following method.

Ammonia in the liquid decomposition product was analyzed by the indophenol method. One gram of the collected liquid from decomposed samples was diluted 10-fold with distilled water. The precipitate was removed by centrifugation, and the supernatant was supplemented with phenol and sodium nitroprusside and then made alkaline. Then, sodium hypochlorite was added for oxidation, and the absorbance of the generated indophenol blue was measured spectrophotometrically at 630 nm to quantify the ammonia concentration. Ammonia gas was measured using a gas detector tube (No.105SE or No.105SB manufactured by Komyo Rikagaku Kogyo Co., Ltd. Kanagawa, Japan).

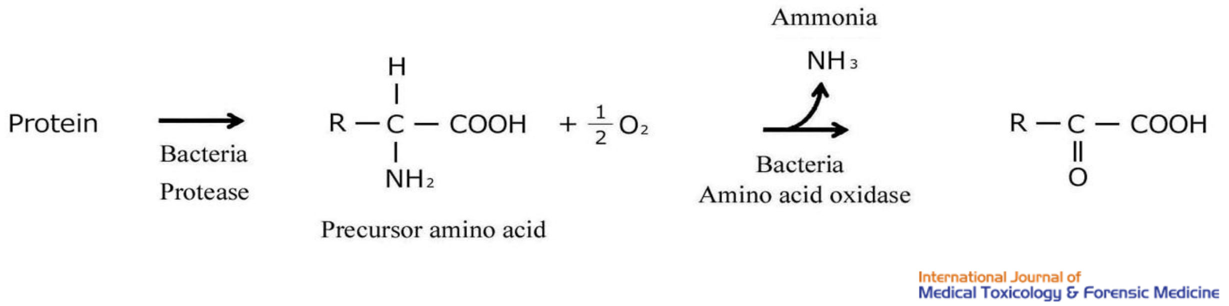

Figure 1. Pathways of ammonia production. Ammonia is produced from the action of bacterial amino acid oxidase on precursor amino acids generated by protein degradation in the human body.

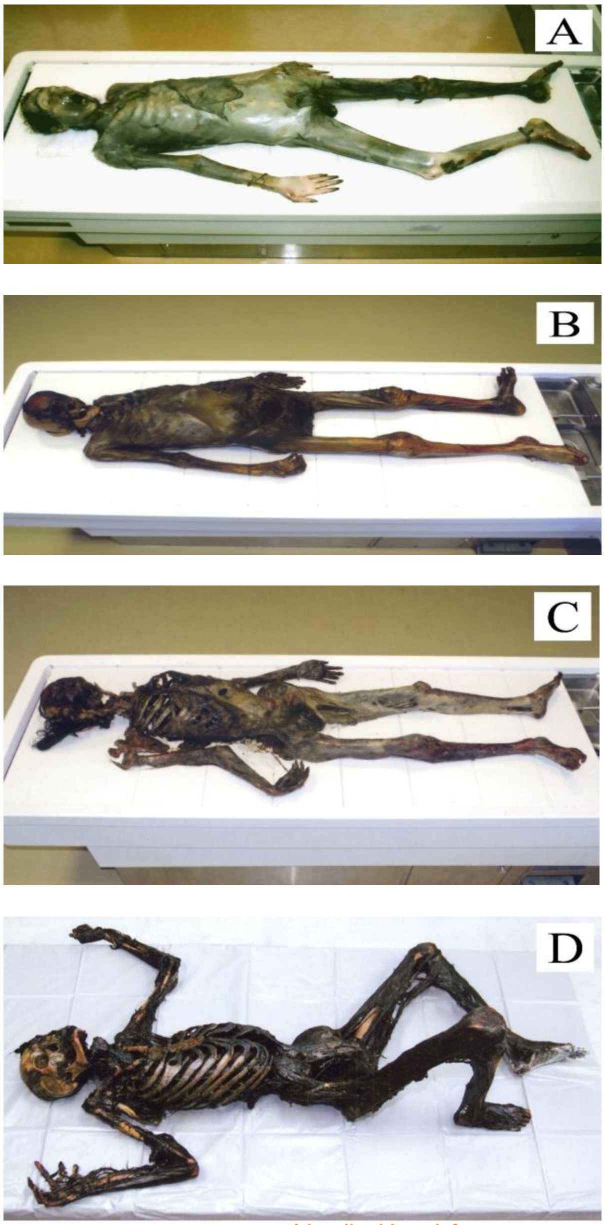

Figure 2. Degree of corpse decomposition. The degree of corpse decomposition was classified into four stages based on external changes. (A) Mild stage, (B) moderate stage, (C) severe stage, and (D) the later stage where almost all bones are exposed and nearly ossified. See the text for details.

The No.105SE tube was used in the range of 1 ppm to 200 ppm of ammonia gas, and No.105SB was used in the range of 50 ppm to 900 ppm. A gas sampling pump (AP-20, manufactured by Komyo Rikagaku Kogyo Co., Ltd., Kanagawa, Japan) was connected to the base of the detector tube. The tip of the detector tube was fixed 50 cm above the chest for the reasons stated above. A gas sampling pump drew 100 ml of sampling air through the detector tube. The ammonia concentration was obtained by reading the color change range of the detector tube. In the case of high concentrations, 50 ml of sampling air was collected and the measurement value doubled to yield the ammonia gas concentration. These measurements were

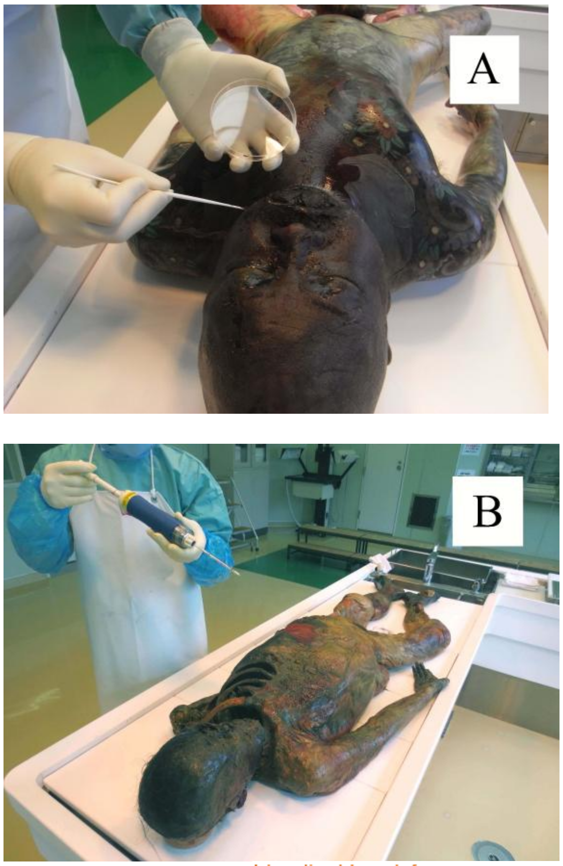

Figure 3. Sample collection. (A) Liquid decomposition samples were taken from the surface of the rotting corpse using a clean disposable spoon at the autopsy unit. (B) Air was aspirated with a detector tube approximately 50 cm above the chest of the corpse.

performed twice, and the average value of the concentrations was used as the data for plotting or statistical analysis.

Data are expressed as mean ± SE. Differences between each group were tested for statistical significance using one-way analysis of variance and Fisher post hoc test. A *P*-value of less than 0.05 denoted the presence of a statistically significant difference.

This study has been approved by the Research Ethics Committee of University of Occupational and Environmental Health Japan under the registration number R02-027.

Results

Table 1 shows the number of cases by sex, place of death, cause of death, and number of days until autopsy. A total of 42 people died, aged between 41 and 93 years (average 68.6 years); 34 of these deaths occurred indoors and 8 outdoors. The causes of death were illness (natural causes) for 34, asphyxiation for 2, heat stroke for 3, drowning for 2, and head injury for 1. The period from death to autopsy ranged from 3 to 48 days (average 19.8 days). There were 12 corpses in the mild stage, 15 in the moderate stage, 11 in the severe stage, and 4 in the later stage.

The ammonia concentration in the liquid decomposition products increased as the stage progressed as shown in Figure 4A (mild: 2.89±0.88 mg/g, moderate: 8.90±0.87 mg/g, severe: 15.04±1.61 mg/g) but showed a decreasing trend in the later stage (12.23±2.00 mg/g). Similarly, the ammonia gas concentration around the corpse also increased as the stage progressed (mild: 117.9±30.5 ppm, moderate: 305.3±30.9 ppm, severe: 700.9±99.2 ppm), but decreased significantly in the later stage (285.0±228.6ppm) as shown in Figure 4B.

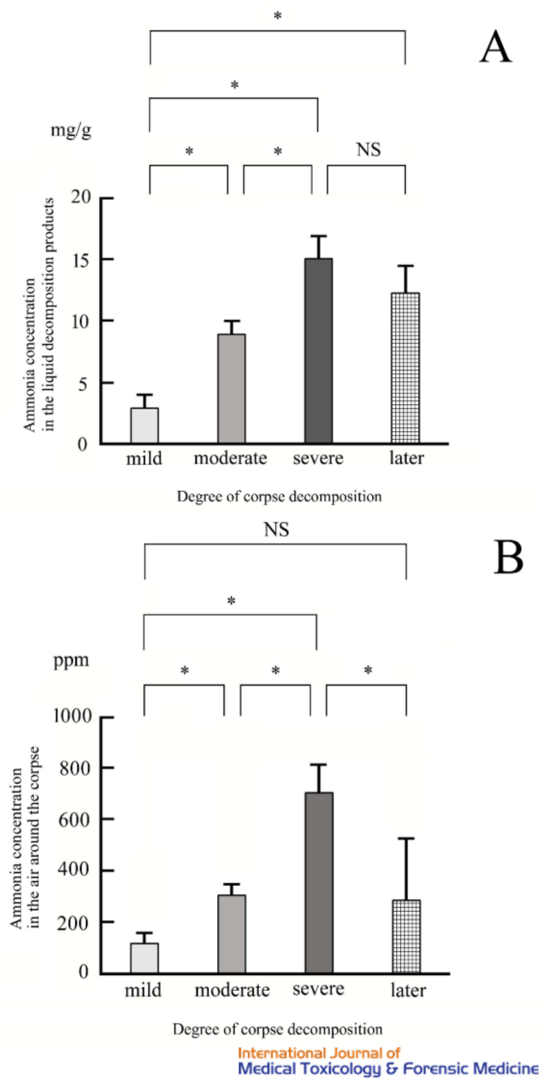

Figure 4. Changes in ammonia concentration at each decomposition stage. As decomposition progressed, the ammonia concentration increased but decreased in the later stages. (A) Concentration in the liquid decomposition products. (B) Concentration in the air around the corpse. Data are shown as mean ± SE. *P < 0.05, and NS means not significant between each stage.

Discussion

The decomposition of soft tissues occurs due to autolysis, bacterial activity, and feeding by insects or vertebrate scavengers [1]. The soft tissues decompose into liquid decomposition products containing ammonia [3]. These liquid decomposition products in the body flow out through the nasal passages, mouth, urethra, and anus, and adhere to the surface of the rotting corpse [1, 2]. The volatile nature of ammonia enables its diffusion as a gas from the liquid decomposition products on the skin into the air surrounding the rotting corpse. Tanaka et al. analyzed the gases generated around rotting pig corpses and detected ammonia, methyl mercaptan, hydrogen sulfide, methyl sulfide, methyl disulfide, and trimethylamine [9]. The concentration of ammonia was the highest, ranging from 10 to 100 times that of the other gases [9]. The strong odor components in putrid gases have been reported to be putrescine and cadaverine, both of which are aliphatic amines [10]. While ammonia gas is present in high concentrations, it has little effect on the putrid odor. Microbial proteases degrade the proteins within a corpse into amino acids [11] following which microbial amino acid oxidases remove amino groups from these amino acids, resulting in the production of ammonia [7]. Although we did not examine microorganisms in liquid decomposition products in this study, many of the microorganisms responsible for corpse decomposition originate from the normal flora in a human body [1] and can oxidize amino acids [12]. Amino acid oxidase degrades all types of amino acids to produce ammonia [7] as shown in Figure 1. We hypothesize that ammonia gas concentrations are higher than those of other gases because numerous microorganisms decompose l arge amounts of amino acids within corpses. However, we had not found any correlation between the postmortem interval and the ammonia gas concentration around the corpse [8]. Various factors, including temperature, humidity, pH, and nutritional status, can influence the growth and activity of microbes in a corpse [1, 13]. Furthermore, feeding by insects and vertebrate scavengers is thought to reduce the protein content of the corpse, thereby affecting ammonia production. We speculate that the lack of correlation between the time elapsed since death and the ammonia concentration may be due to the effects of the surrounding environment of the corpse on ammonia production.

Table 1. Classification of the cases.

		Total (*n*=42)	Mild (*n*=12)	Moderate (*n*=15)	Severe (*n*=11)	Later (*n*=4)
Sex						
	Men	28	6	11	9	2
	Women	14	6	4	2	2
Place of Death						
	Indoor	34	8	12	11	3
	Outdoor	8	4	3	0	1
Cause of Death						
	Natural Death	34	7	13	10	4
	Suffocation	2	0	2	0	0
	Heat Stroke	3	2	0	1	0
	Drowning	2	2	0	0	0
	Head injury	1	1	0	0	0
Time from Death to Autopsy						
	4–9 days	8	6	1	1	0
	10–19 days	15	5	6	2	2
	20–29 days	7	1	2	3	1
	30–39 days	9	0	3	5	1
	40–48 days	3	0	3	0	0

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The transformation of a corpse is known to comprise five stages: fresh, bloated, decay, post-decay, and skeletal [1]. In this study, we focused primarily on the bloated, decay, and post-decay stages, which are considered to be the most active phases of microbial decomposition in a corpse. During these phases, various changes occur, including skin discoloration, skin blister, skin slippage, and destruction of tissues caused by autolysis, bacterial activity, and feeding by insects or vertebrate scavengers [1]. We classified the degree of corpse decomposition into four stages: mild, moderate, severe, and later (almost skeletonized), based on easily visible external discoloration (ranging from reddish-green to nearly black) and destruction of skin and soft tissue. The classification is simple and easy for non-forensic pathologists to use when determining the stage of decomposition based on appearance. The degree of corpse decomposition was strongly linked to the concentrations of liquid and gaseous ammonia, which increase as the decomposition progresses. We believe this classification is appropriate for scientifically demonstrating the progression of decomposition of a corpse. In the mild stages, there was no destruction of the skin. Hence, decomposition occurred mainly inside the body, and the ammonia detected was derived from putrefactive fluids leaking from the tissues, including those of the mouth and nose. The early stages of soft tissue decomposition were associated with low concentrations of liquid and gaseous ammonia. During the moderate to severe stages, soft tissue decomposition progressed, resulting in high levels of ammonia being detected in the liquid decomposition products and the surrounding air. Ammonia gas, vaporized from liquid decomposition products generated in large quantities within the body, diffused through skin and muscle defects, resulting in the detection of high concentrations. In the later stage, the concentrations of liquid and gaseous ammonia exhibited a decreasing trend. This may be because nearly all soft tissues have been decomposed by bacteria, resulting in a decrease in ammonia production. The loss of liquid decomposition products, which are the source of ammonia gas, could explain the significant decrease in its concentration.

Liquid ammonia can cause damage to skin and mucous membranes. Even the ingestion of small amounts can cause damage to the gastrointestinal mucosa [14]. Ammonia gas is highly soluble and undergoes an exothermic reaction upon contact with moist skin or mucous membranes, producing ammonium hydroxide and heat [6]. Exposure to high concentrations of ammonia gas immediately causes severe irritation and burns to the mucous membranes of the eyes, skin, mouth, and respiratory tract. The severity of the injury is directly related to the concentration of ammonia gas [15]. Odors are noticeable at 53 ppm, and exposure to 100 ppm can be tolerated for several hours. However, eye irritation occurs at 140 ppm, pharyngeal mucosal irritation at 408 ppm, eye mucosal damage at 698 ppm, laryngeal spasm and pulmonary edema at 1500 ppm, and death occurs within 30 minutes at 2500–4500 ppm [15-17].

According to this study, mild decomposition is sufficient to cause odor and eye irritation, moderate decomposition irritates the mucous membranes of throat, while severe decomposition causes damage to the eye mucosa. The high concentration in the severe decomposition stage (700.9 ± 99.23 ppm) approaches a level that can cause serious damage to the respiratory system and poses a severe risk to people with highly sensitive respiratory mucosa. In particular, when near rotting corpses in moderate to severe stages of decomposition, it is necessary to wear a mask to prevent irritation of the respiratory mucosa. When near corpses in severe stages of decomposition, it is necessary to wear goggles to protect the eye mucosa from damage. The concentration of ammonia in the air surrounding a rotting corpse in an enclosed space is likely to be even higher, increasing the risk of health problems for living humans. Therefore, large-scale disaster sites with numerous casualties are likely to contain a significantly high concentration of ammonia gas. When coming into contact with a rotting corpse in moderate or severe stages of decomposition, precautions should be taken to prevent skin or mucous

Membrane damage from both liquid and gaseous ammonia, as well as to avoid inhaling ammonia gas.

Conclusion

Ammonia levels can be predicted from the visual stage of corpse decomposition. When coming into contact with a rotting corpse in moderate or severe stages of decomposition, goggles, a mask, and rotective clothing should be worn to prevent skin or mucous membrane damage from both liquid and gaseous ammonia, as well as to avoid inhaling ammonia gas.

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Conflicts of Interest

The authors report there are no competing interests to declare.

References

[1] Lee Goff M. Early post-mortem changes and stages of decomposition in exposed cadavers. Exp Appl Acarol. 2009;49(1-2):21-36. [DOI: 10.1007/s10493-009-9284-9]

[2] Carter DO, Yellowlees D, Tibbett M. Cadaver decomposition in terrestrial ecosystems. Naturwissenschaften. 2007;94(1):12-24. [DOI: 10.1007/s00114-006-0159-1]

[3] Yu Q, Zhou R, Wang Y, Su W, Yang J, Feng T, et al. Carcass decay deteriorates water quality and modifies the nirS denitrifying communities in different degradation stages. Sci Total Environ. 2021;785(1):147185. [DOI: 10.1016/j.scitotenv.2021.147185]

[4] Statheropoulos M, Spiliopoulou C, Agapiou A. A study of volatile organic compounds evolved from the decaying human body. Forensic Sci Int. 2005;153(2-3):147-55. [DOI: 10.1016/j.forsciint.2004.08.015]

[5] Vass AA, Barshick SA, Sega G, Caton J, Skeen JT, Love JC, et al. Decomposition chemistry of human remains: a new methodology for determining the postmortem interval. J Forensic Sci. 2002;47(3):542-53. [Link]

[6] Verberk MM. Effects of ammonia in volunteers. Int Arch Occup Environ Health. 1977;39(2):73-81. [DOI: 10.1007/BF00380887]

[7] Rice SL, Eitenmiller RR, Koehler PE. Biologically active amines in food: A review. J Food Protect. 1976;39(5):353-8. [Link]

[8] Sato H, Umehara T, Kimura S, Tanaka T, Kim SE. Determination of putrefactive amine and ammonia concentrations around decomposed corpses. J Toxicol Sci. 2025;50(2):75-81. [DOI: 10.2131/jts.50.75]

[9] Tanaka Y, Osada T, Yonaga M, Yamashita T, Ogino A. Intensity and characteristics of malodor emission from swine carcasses. The Japanese journal of animal hygiene. 2013;38(4):157-63. [Link]

[10] Hussain A, Saraiva LR, Ferrero DM, Ahuja G, Krishna VS, Liberles SD, et al. High-affinity olfactory receptor for the death-associated odor cadaverine. Proc Natl Acad Sci U S A. 2013;110(48):19579-84. [DOI: 10.1073/pnas.1318596110]

[11] Simpson RJ. Nomenclature on proteases, proteinases, and peptidases. CSH Protoc. 2007;Apr(1):pdb ip13. [DOI: 10.1101/pdb.ip13]

[12] Pollegioni L, Piubelli L, Sacchi S, Pilone MS, Molla G. Physiological functions of D-amino acid oxidases: from yeast to humans. Cell Mol Life Sci. 2007;64(11):1373-94. [DOI: 10.1007/s00018-007-6558-4]

[13] Silla Santos MH. Biogenic amines: their importance in foods. Int J Food Microbiol. 1996;29(2-3):213-31. [Link]

[14] Singh S, Malhotra P, Jain S, Varma S. Gastro-esophageal burns following domestic liquid ammonia ingestion: report of two cases. J Assoc Physicians India. 1999;47(6):647. [Link]

[15] Arwood R, Hammond J, Ward GG. Ammonia inhalation. J Trauma. 1985;25(5):444-7. [DOI: 10.1097/00005373-198505000-00014]

[16] Amshel CE, Fealk MH, Phillips BJ, Caruso DM. Anhydrous ammonia burns case report and review of the literature. Burns. 2000;26(5):493-7. [DOI: 10.1016/s0305-4179(99)00176-x]

[17] Latenser BA, Lucktong TA. Anhydrous ammonia burns: case presentation and literature review. J Burn Care Rehabil. 2000;21(1):40-2. [Link]