INTEGRATED BIOMONITORING OF BENZENE EXPOSURE AND DNA DAMAGE among Landfill Worker and Populations Living near an Open Dumpsite, Indonesia

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ABSTRACT

Open dumpsites may expose workers and nearby communities to benzene, a known human carcinogen. This cross-sectional study examined associations between benzene exposure, oxidative DNA damage, and genotoxicity around the Sarimukti dumpsite, Indonesia. Participants included landfill workers (n = 30), scavengers (n = 4), residents (n = 10), and controls (n = 9). Urinary S-phenyl mercapturic acid (S-PMA) and 8-hydroxy-2′-deoxyguanosine (8-OHdG) in urine and blood were analyzed using LC-MS/MS, while DNA damage was assessed using the alkaline Comet assay. Mean urinary S-PMA was 5.23 ± 5.78 µg/g creatinine, with significantly higher levels among residents than workers. Blood 8-OHdG correlated positively with %Tail DNA (r = 0.40) ($p<0.05$). Exposed groups exhibited greater DNA damage than controls. Alcohol consumption was associated with %Tail DNA (OR = 7.12; 95% CI: 1.06–48.03; $p<0.05$). These findings support complementary biomarker monitoring, although larger studies are needed to clarify associations and potential confounding.

Keywords: Occupational exposure, public health, S-phenyl mercapturic acid, 8-OHdG, Sarimukti open dumpsite.

INTRODUCTION

Open dumpsites may release benzene, a human carcinogen that can induce oxidative stress and DNA damage (Qin et al., 2025). Previous research at the Sarimukti open dumpsite, Indonesia, identified benzene as the predominant contributor to BTEX-related health risks (Rahman et al., 2026). Urinary S-phenyl mercapturic acid (S-PMA) reflects internal benzene exposure, while 8-hydroxy-2′-deoxyguanosine (8-OHdG) and Comet assay (%Tail DNA) indicate oxidative DNA damage and DNA strand breaks, respectively (Boogaard, 2022).



However, studies integrating these biomarkers across occupational and residential exposure groups near open dumpsites remain limited. This study integrates S-PMA, 8-OHdG, and %Tail DNA to investigate associations between internal benzene exposure and DNA damage among landfill workers, scavengers, nearby residents, and controls around Sarimukti, Indonesia.

METHODOLOGY

Study Area and Respondents

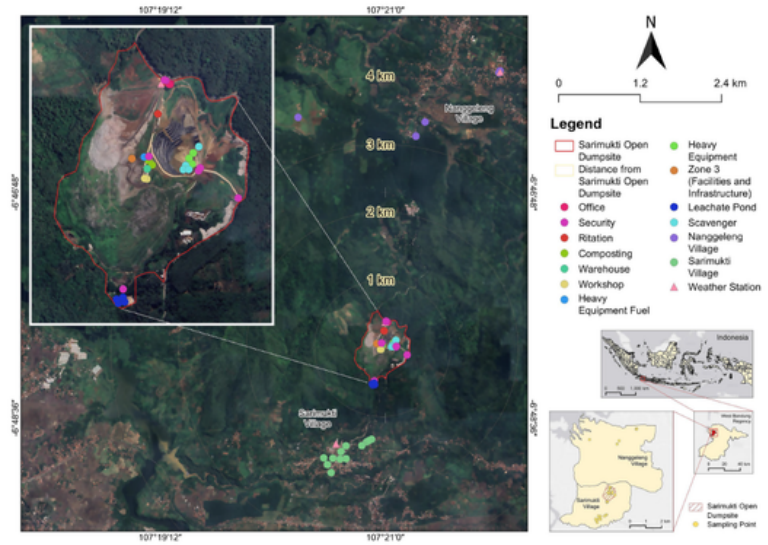


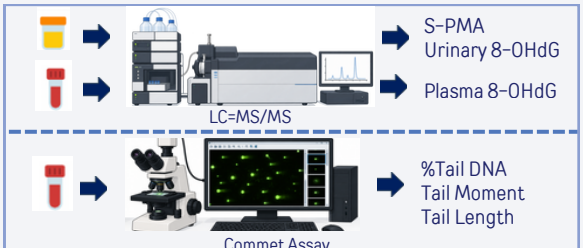
Fig.1 Study Area and Sampling Point

This study was conducted at Sarimukti open dumpsite in Cipatat District, West Bandung Regency, West Java, Indonesia (107°20′59″ E, 6°48′03″ S; **Fig. 1**). A total of 53 participants were included in the study: landfill workers (LW; n = 30), scavengers (S; n = 4), residents (R; n = 10), and controls (C; n = 9). Landfill worker comprised personnel of landfill management. Scavengers as informal waste pickers which worked at the dumpsite and resided within the site. Residents lived in Sarimukti Village (1-2 km), while controls lived in Nanggeleng Village (>3 km) north of the site.

Data Collection



Sample Analysis



(Oginawati et al., 2023; Ladeira et al., 2024)

RESULTS AND DISCUSSIONS

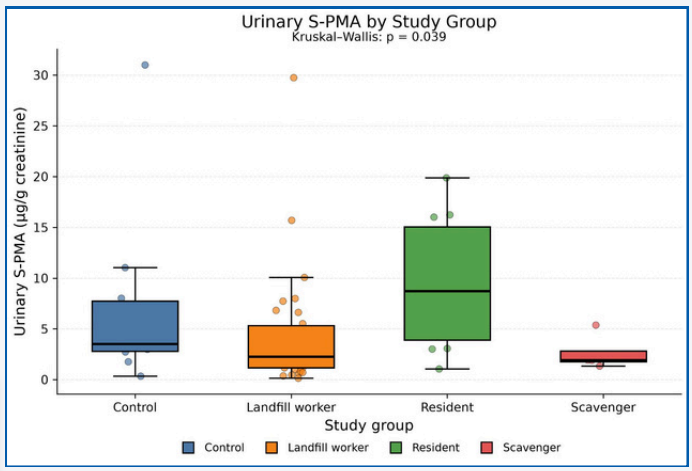


Fig.2 Urinary S-PMA by Study Group

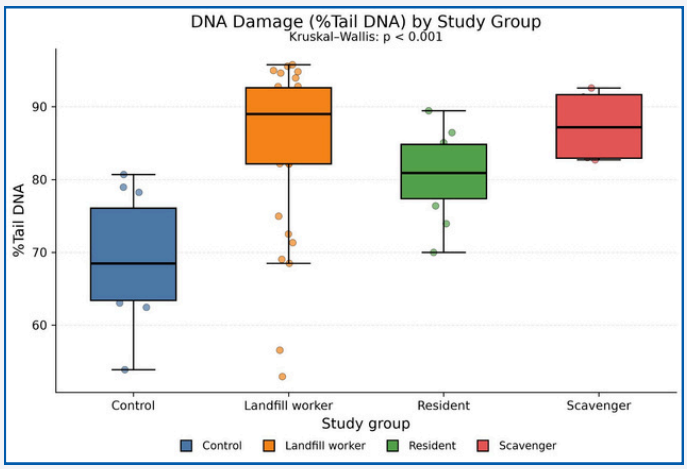


Fig.3 %Tail DNA by Study Group

Mean urinary S-PMA was 5.23 ± 5.78 µg/g creatinine (**Fig.2**), with significantly higher levels in nearby residents than landfill workers ($p < 0.05$) and in smokers than non-smokers (mean rank: 29.19 vs. 9.83; $p = 0.004$). DNA damage was significantly greater in exposed groups than controls ($p < 0.05$) (**Fig.3**), while blood 8-OHdG was positively correlated with %Tail DNA ($r = 0.40$, $p < 0.05$). Alcohol consumption was significantly associated with DNA damage in multivariable analysis (OR = 7.12; 95% CI: 1.06–48.03; $p = 0.044$). Alcohol may contribute to genotoxicity through acetaldehyde-induced DNA adduct formation, oxidative stress, and lipid peroxidation (Thomas & Hopkinson, 2024).

CONCLUSION

Exposed populations around the Sarimukti dumpsite exhibited greater DNA damage than controls. The positive correlation between blood 8-OHdG and %Tail DNA supports the complementary assessment of oxidative DNA damage and genotoxicity. Integrating exposure and effect biomarkers may strengthen environmental health surveillance, although larger studies are needed to confirm these associations.

REFERENCES

1. Boogaard, P. J. (2022). Human biomonitoring of low-level benzene exposures. Critical Reviews in Toxicology, 52(10), 799–810.
2. Ladeira, C., Møller, P., Giovannelli, L., Gajski, G., Haveric, A., Bankoglu, E. E., Azqueta, A., Gerić, M., Stopper, H., Cabêda, J., Tonin, F. S., & Collins, A. (2024). The Comet Assay as a Tool in Human Biomonitoring Studies of Environmental and Occupational Exposure to Chemicals—A Systematic Scoping Review. Toxics, 12(4), Article 270.
3. Oginawati, K., Nathanael, R. J., Chazanah, N., Suharyanto, Prabandari, D., Basuki, M. F., Oclandhi, B., Santoso, M., Febriana, S. A., Nugrahaningsih, D. A., Suhartini, S., Prakoeswa, C. R. S., & Tanziha, I. (2023). Occupational lead exposure health risk assessment and heme biosynthesis: A study on batik artisans in Yogyakarta, Indonesia. Heliyon, 9(9), Article e19994.
4. Rahman, I. N., Oginawati, K., Rahardyan, B., Santoso, M., Purnama, D. S., Fahimah, N., & Amin, M. (2026). Health risk assessment of benzene, toluene, ethylbenzene, and xylene among occupational and residential populations at landfill, Indonesia. Frontiers in Sustainable Cities, 8, Article 1912881.
5. Thomas, L. A., & Hopkinson, R. J. (2024). The biochemistry of the carcinogenic alcohol metabolite acetaldehyde. DNA Repair, 144, Article 103782.

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