Available online on 15.09.2025 at http://jddtonline.info

Journal of Drug Delivery and Therapeutics

Open Access to Pharmaceutical and Medical Research

Copyright © 2025 The Author(s): This is an open-access article distributed under the terms of the CC BY-NC 4.0 which permits unrestricted use, distribution, and reproduction in any medium for non-commercial use provided the original author and source are credited

Open Access Full Text Article

Research Article

In-Vitro Antibacterial Evaluation of Hawan Ash: A Traditional Material with Emerging Therapeutic Potential

Happy Patel [1*], Deepika Chandawat [2], Mahek Patel [3]

[1] Hemchandracharya North Gujarat University, Patan, Gujarat, India- 431004

[2] Gujarat Arts and Science College, Ahmedabad, Gujarat University, India - 431004

[3] Smt. S. S. Patel Nootan College, Sankadchand Patel University, Visnagar, Gujarat, India - 431004

Article Info:

Article History:

Received 16 June 2025
Reviewed 30 July 2025
Accepted 23 August 2025
Published 15 Sep 2025

Cite this article as:

Patel H, Chandawat D, Patel M, In-Vitro Antibacterial Evaluation of Hawan Ash: A Traditional Material with Emerging Therapeutic Potential, Journal of Drug Delivery and Therapeutics. 2025; 15(9):55-60 *DOI: http://dx.doi.org/10.22270/jddt.v15i9.7354*

*For Correspondence:

Happy Patel, Hemchandracharya North Gujarat University, Patan, Gujarat, India- 431004

Abstract

Ash derived from ritualistic fire offerings has been traditionally considered to possess medicinal properties, yet its antibacterial potential remains scientifically unexplored. The lack of systematic evaluation necessitates an in-depth investigation of its efficacy. This study comprehensively examines the antibacterial activity of Hawan ash, assessing the influence of ash type, solvent selection, and dosage on bacterial inhibition to provide insights into its potential as a natural antimicrobial agent. Hawan ash extracts were prepared using different ash types (HA-1, HA-2 and HA-3) and solvents and tested at various concentrations against multiple bacterial species. Antibacterial activity was evaluated using the agar well diffusion method by measuring the zone of inhibition (ZOI). Results revealed significant variability in antibacterial activity depending on ash type, solvent, and dosage. Although standard antibiotic (Neomycin 30µg/disc) as a positive agent exhibited the highest ZOI (23.21 ± 0.06 mm), confirming the effectiveness of conventional antibiotics. Methanol ash extracts showed stronger activity than aqueous extracts ($p < 0.05$) with the highest inhibition against *S. typhi* (18.33 ± 0.29 mm at 0.6g/mL, HA-2). Aqueous extracts exhibited moderate activity with *P. vulgaris* being the most susceptible (10.00 ± 0.51 mm at 0.6g/mL, HA-1). These findings highlight the antibacterial potential of Hawan ash, influenced by extraction parameters. The observed variability underscores the need for advanced phytochemical profiling to identify bioactive constituents and optimize formulations for therapeutic applications.

Keywords: Hawan ash, Antibacterial activity, Well diffusion method, ZOI, Therapeutic potential

1. INTRODUCTION

The growing threat of antibiotic-resistant bacteria has intensified the search for novel antimicrobial agents, pushing researchers to explore traditional and natural remedies. Among these, ash-based formulations have been historically utilized in various cultures for their purported healing and antimicrobial properties. Hawan ash, a by-product of ritualistic fire ceremonies, has long been valued in Ayurveda and other traditional healing systems for its medicinal benefits, including antibacterial, antifungal, and antiviral activities[1].

Hawan ash has been utilized for a range of dermatological applications, including wound healing, eczema treatment, and skin protection. It has been reported to possess antibacterial, antiviral, antifungal, and anti-inflammatory properties, making it a potential candidate for treating conditions such as acne vulgaris[2]. Similarly, studies on Agnihotra ash which is related form of sacred ash suggest its efficacy in reducing multidrug-resistant *Escherichia coli* populations, highlighting its potential in combating waterborne infections [3,4]. Moreover, Agnihotra ash also removes water pathogens of sewage and purifies it [5,6]

Beyond traditional medicine, research has demonstrated that ash from various sources can exhibit significant antimicrobial effects. For instance, wood biomass ash has been shown to reduce bacterial populations by 83–89% in controlled laboratory conditions and by 40–53% in large-scale applications, suggesting its relevance in sewage sludge treatment[7]. Additionally, extracts from *Parthenium hysterophorus* ash have displayed inhibitory activity against *Salmonella enterica* and *Staphylococcus epidermidis*, reinforcing the notion that plant-derived ashes could serve as effective antimicrobial agents [8]. The antimicrobial efficacy of ash is often attributed to its mineral composition and alkaline pH, which can disrupt microbial cell walls and inhibit growth. For instance, purified coal fly ash has exhibited significant antibacterial activity against both Gram-positive and Gram-negative bacteria, with studies showing up to 59.89% growth reduction in *Bacillus cereus*[9].The high alkalinity of ash worked as natural antibacterial agent for commercial disinfectant of egg shells which can be replaced by chemical disinfectant showed[10].

This study aims to evaluate the antibacterial activity of Hawan ash extracts against selected Gram-positive and Gram-negative bacterial strains. By employing both

aqueous and methanolic extraction methods, we seek to determine the efficacy of these extracts and assess the impact of purification treatments on their antimicrobial properties. The outcomes of this research could offer valuable insights into the development of ash-based natural antimicrobials and lay the foundation for their therapeutic exploration in topical or environmental applications[11].

2. MATERIAL AND METHODS

2.1 Collection of Hawan Ash Samples

Hawan ash samples were collected from three ritual sites in the Mehsana district of Gujarat, India: Ladol (23.6167° N, 72.7333° E), Khanusa (23.660° N, 72.7629° E), and Changod (23.5615° N, 72.7276° E), corresponding to Mahavishnuyag, Maharudrayag, and Deviyag, respectively. The samples were designated as HA-1, HA-2, and HA-3. To ensure the removal of coarse particles and potential contaminants, the ash was sieved through a 100-micron mesh before further utilisation.

2.2 Pre-preparation of Hawan Ash Samples

For purification, a measured amount of ash was suspended in double-distilled water (DDW) at a 1:10 (w/v) ratio, stirred for 20 minutes to dissolve soluble impurities and then filtered using Whatman No. 1 filter paper. The washed ash was dried in a hot air oven at 100–120°C until completely moisture-free[12].

Antimicrobial analysis

2.3 Bacterial Strains

Gram-negative *Escherichia coli* (ATCC 25922), Gram-negative *Proteus vulgaris* (ATCC 133150), Gram-negative *Salmonella typh*i (ATCC 6539), Gram-negative *Pseudomonas aeruginosa* (ATCC 27853), Gram-positive *Bacillus subtilis* (ATCC 6633) were used to assess the antibacterial activity of the Hawan ash extracts.

2.4 Preparation of Ash extracts

Preparation of Aqueous Hawan Ash Extracts

Extracts of all three Hawan ashes (HA-1, HA-2 and HA-3) were prepared using maceration and sonication with distilled water as the extraction solvent. Briefly, 150 g of ash was suspended in 700 mL of solvent and subjected to intermittent shaking by using auto- shaker (10 minutes at 3-hour intervals, repeated three times) at room temperature to enhance extraction efficiency. The mixture was then filtered through muslin cloth to remove insoluble residues, and the filtrate was concentrated under reduced pressure at 40°C using a rotary evaporator**.** The dried extracts were stored at 4°C for further experimentation

Preparation of Methanolic Hawan Ash Extracts

Methanolic extractions of (HA-1, HA-2 and HA-3) was conducted by suspending 150 g of ash with 700 mL of methanol, followed by intermittent shaking by using auto- shaker for 15 minutes at 3-hour intervals, repeated three times. After 24 hours of incubation, the liquid extract was decanted, and the residue was re-extracted with 500 mL of fresh methanol by shaking for 2 hours. The combined extracts were filtered through muslin cloth, concentrated by boiling, and evaporated to dryness using a hot air oven. The dried extracts were stored at 4°C for further analysis.

2.5 Sterility test of Ash extracts

To assess the sterility of the ash extracts, 100 µL of each tested concentration was aseptically streaked onto sterile nutrient agar plates. The plates were incubated at 37°C for 48 hours and subsequently examined for any signs of microbial contamination[13].

2.6 Activation of bacterial Culture

The bacterial strains were retrieved from laboratory stock by transferring into MHB (Mueller-Hinton broth) and incubated at 37°C for 18–24 hours under static conditions to obtain an actively growing culture(8). The bacterial suspensions were then adjusted to 0.5 McFarland standard (~1.5×10^8 CFU/mL) using sterile saline**,** ensuring uniform bacterial concentration for subsequent antibacterial assays.

2.7 Antibacterial susceptibility testing

Antibacterial activity of the Ash extracts was checked by Agar well diffusion method. The Mueller-Hinton agar (MHA) plates were prepared by pouring 20ml sterilized MHA and allowed to solidify before 0.1ml of bacterial suspension was evenly spread using a sterile cotton swab. A sterile cork borer (9 mm diameter) was used to punch wells into the agar, and each well was filled with 100 µl of the Hawan ash extract at different concentrations. As controls, a well was filled with a standard Neomycin (broad-spectrum antibiotic) solution (30 µg/well) as the positive control, while plain solvents (distilled water and methanol) served as negative controls. The plates were then incubated at 37°C for 18–24 hours, and the zone of inhibition (ZOI) around each well was measured in millimetres (mm) using a digital calliper[14,15].

2.8 Statistical analysis

The results were recorded as mean ± standard error mean of three independent replicates. Statistical analysis (ANOVA and Post hoc by Tukey's tests) was performed to determine significant differences between different extracts, concentrations, and controls[16].

3. RESULT & DISSCUSION

3.1 The antibacterial activity of three Hawan ash extracts

The antibacterial activity of three Hawan ash extracts {HA-1 (Table 1), HA-2 (Table 2), and HA-3 (Table 3)} was systematically evaluated against five bacterial strains using aqueous and methanolic solvents at varying concentrations. The efficacy of these extracts was compared to the standard antibiotic neomycin (30 µg/disc) and a negative control (plain solvent itself).

Table 1: Zone of Inhibition (mm) of HA-1 Extracts at Different Concentrations against Bacterial Strains.

Bacterial strains	Solvent type	Negative control	Zone of inhibition in mm against concentration in g/ml						Positive control
			0.1	0.2	0.3	0.4	0.5	0.6	
E.co	A	0.00 ± 0.00	0.00 ± 0.00	10.00 ± 0.00	11.23 ± 0.18	14.13 ± 0.56	15.06 ± 0.68	15.03 ± 0.12	23.21 ± 0.06
	M	0.00 ± 0.00	11.00 ± 0.26	12.03 ± 0.45	14.46 ± 1.00	15.60 ± 0.19	16.10 ± 0.43	16.00 ± 0.49	22.61 ± 0.42
Pro.	A	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	10.00 ± 0.51	13.80 ± 0.23	14.63 ± 0.11	15.63 ± 0.25	21.08± 0.53
	M	0.00 ± 0.00	11.82 ± 0.20	12.60 ± 0.31	14.16 ± 0.67	15.80 ± 0.28	15.31 ± 0.11	16.20 ± 0.40	21.00 ± 0.37
Pseu.	A	0.00 ± 0.00	0.00 ± 0.00	11.00 ± 0.68	15.22 ± 0.32	13.00 ± 0.19	13.60 ± 0.92	16.05 ± 0.22	21.91 ± 0.15
	M	0.00 ± 0.00	11.06 ± 0.58	12.50 ± 0.09	14.05 ± 0.41	15.15 ± 0.27	16.04 ± 0.37	16.37 ± 0.31	22.07 ± 0.41
Bac.	A	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	11.28 ± 0.17	13.16 ± 0.40	14.30 ± 0.25	14.72 ± 0.36	19.90± 0.37
	M	0.00 ± 0.00	10.12 ± 0.11	12.22 ± 0.32	13.12 ± 0.46	14.40 ± 0.26	15.52 ± 0.19	16.60 ± 0.19	20.67 ± 0.46
Sal.	A	0.00 ± 0.00	0.00 ± 0.00	10.24 ± 0.07	10.43 ± 0.29	13.24 ± 0.46	15.13 ± 0.76	16.00 ± 0.37	20.58 ± 0.09
	M	0.00 ± 0.00	10.00 ± 0.17	11.57 ± 0.32	12.10 ± 0.32	15.20 ± 0.28	15.29 ± 0.23	17.00 ± 0.62	21.33 ± 0.18

"Zone of inhibition (mean ± SEM, mm) of aqueous (A) and methanolic (M) extracts. E.co = *Escherichia coli*, Pro. = *Proteus vulgaris*, Pseu. = *Pseudomonas aeruginosa*, Bac. = *Bacillus subtilis*, Sal. = *Salmonella typhi*. Neomycin (30µg/well) as a positive control."

Table 2: Zone of Inhibition (mm) of HA-2 Extracts at Different Concentrations Against Bacterial Strains.

Bacterial strains	Solvent type	Negative control	Zone of inhibition in mm against concentration in g/ml						Positive control
			0.1	0.2	0.3	0.4	0.5	0.6	
E.co	A	0.00 ± 0.00	0.00 ± 0.00	10.66 ± 0.41	12.70 ± 0.38	16.21 ± 0.23	16.36 ± 0.14	17.01 ± 0.22	21.31 ± 0.25
	M	0.00 ± 0.00	10.30 ± 0.26	12.00 ± 0.21	14.52 ± 0.10	15.86 ± 0.03	17.33 ± 0.41	17.87 ± 0.10	21.96 ± 0.10
Pro.	A	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	10.77 ± 0.22	14.06 ± 0.62	15.24 ± 0.10	15.08 ± 0.68	21.07 ± 0.38
	M	0.00 ± 0.00	10.92 ± 0.33	12.76 ± 0.22	13.62 ± 0.11	13.99 ± 0.11	16.10 ± 0.36	15.98 ± 0.61	21.84 ± 0.60
Pseu.	A	0.00 ± 0.00	0.00 ± 0.00	11.34 ± 0.16	12.10 ± 0.19	13.23 ± 0.14	13.99 ± 0.21	14.77 ± 0.21	20.64 ± 0.22
	M	0.00 ± 0.00	10.71 ± 0.68	10.98 ± 0.36	13.73 ± 0.25	15.36 ± 0.28	18.01 ± 0.62	18.00 ± 0.17	22.10 ± 0.18
Bac.	A	0.00 ± 0.00	0.00 ± 0.00	12.03 ± 0.52	12.30 ± 0.31	14.10 ± 0.36	14.00 ± 0.68	15.12 ± 0.36	20.01 ± 0.37
	M	0.00 ± 0.00	10.00 ± 0.08	12.95 ± 0.71	13.96 ± 0.12	15.77 ± 0.34	15.66 ± 0.51	15.67 ± 0.10	19.87 ± 0.10
Sal.	A	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	11.10 ± 0.36	12.00 ± 0.10	13.97 ± 0.31	16.13 ± 0.51	20.54 ± 0.37
	M	0.00 ± 0.00	0.00 ± 0.00	10.90 ± 0.32	12.88 ± 0.71	15.26 ± 0.42	16.44 ± 0.36	18.33 ± 0.29	21.97 ± 0.34

"Zone of inhibition (mean ± SEM, mm) of aqueous (A) and methanolic (M) extracts. E.co = *Escherichia coli*, Pro. = *Proteus vulgaris*, Pseu. = *Pseudomonas aeruginosa*, Bac. = *Bacillus subtilis*, Sal. = *Salmonella typhi*. Neomycin (30µg/well) as a positive control."

Table 3: zone of inhibition (mm) of HA-3 extracts at different concentrations against bacterial strains.

Bacterial strains	Solvent type	Negative control	Zone of inhibition in mm against concentration in g/ml						Positive control
			0.1	0.2	0.3	0.4	0.5	0.6	
E.co	A	0.00 ± 0.00	0.00 ± 0.00	10.31 ± 0.25	12.12 ± 0.32	14.85 ± 0.12	16.06 ± 0.10	16.00 ± 0.15	22.03 ± 0.40
	M	0.00 ± 0.00	10.23 ± 0.03	12.02 ± 0.01	14.31 ± 0.43	16.00 ± 0.33	18.10 ± 0.30	17.12 ± 0.31	22.94 ± 0.21
Pro.	A	0.00 ± 0.00	0.00 ± 0.00	12.00 ± 0.02	13.60 ± 0.20	15.10 ± 0.28	17.01 ± 0.33	17.46 ± 0.17	20.60 ± 0.28
	M	0.00 ± 0.00	10.77 ± 0.36	12.85 ± 0.60	14.28 ± 0.31	14.99 ± 0.37	16.97 ± 0.40	17.90 ± 0.30	21.86 ± 0.03
Pseu.	A	0.00 ± 0.00	0.00 ± 0.00	10.10 ± 0.44	12.06 ± 0.40	12.47 ± 0.10	14.66 ± 0.12	15.33 ± 0.19	20.00 ± 0.12
	M	0.00 ± 0.00	0.00 ± 0.00	11.76 ± 0.34	13.69 ± 0.21	13.90 ± 0.22	15.69 ± 0.50	16.80 ± 0.48	20.91 ± 0.45
Bac.	A	0.00 ± 0.00	0.00 ± 0.00	13.01 ± 0.21	13.22 ± 0.15	15.00 ± 0.02	16.20 ± 0.70	16.12 ± 0.10	19.36 ± 0.22
	M	0.00 ± 0.00	10.61± 0.24	12.97 ± 0.30	14.41 ± 0.37	16.89 ± 0.31	17.49 ± 0.11	17.81 ± 0.50	20.78 ± 0.38
Sal.	A	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	12.00 ± 0.27	14.20 ± 0.40	16.04 ± 0.38	16.16 ± 0.64	20.10 ± 0.61
	M	0.00 ± 0.00	0.00 ± 0.00	10.36 ± 0.19	13.94 ± 0.18	15.76 ± 0.18	16.88 ± 0.17	17.78 ± 0.21	20.90 ± 0.37

"Zone of inhibition (mean ± SEM, mm) of aqueous (A) and methanolic (M) extracts. E.co = *Escherichia coli*, Pro. = *Proteus vulgaris*, Pseu. = *Pseudomonas aeruginosa*, Bac. = *Bacillus subtilis*, Sal. = *Salmonella typhi*. Neomycin (30µg/well) as a positive control."

3.2 Comparative Antibacterial Efficacy of Hawan Ash Extracts

The box plot in Fig. 1 (aqueous solvent) and Fig. 2 (methanol solvent) summarize the inhibition zones (in mm) observed for each ash type across different bacterial strains, highlighting variations in antibacterial activity based on solvent type. A dose-dependent response was observed, as higher concentrations led to larger inhibition zones. Methanol extracts showed stronger activity than aqueous extracts ($p < 0.05$) with the highest inhibition against *S. typhi* (18.33 ± 0.29 mm at 0.6g/mL, HA-2). Aqueous extracts exhibited moderate activity, with *P. vulgaris* being the most susceptible (10.00 ± 0.51 mm at 0.6g/mL, HA-1). Among the tested species and Ash extracts, *B. subtilis* showed the highest resistance. HA-2 exhibited the steepest concentration-dependent response than HA-1 and HA-3. At lower concentrations (0.1g/mL) the antibacterial activity of HA-3 was minimal reinforcing its lower efficacy.

3.3 Comparison with Standard Antibiotics

Although the antibacterial activity of Hawan ash extracts did not exceed that of the positive control—**Neomycin (30 µg/disc)**, which exhibited inhibition zones ranging from 19 to 23 mm—the presence of significant antimicrobial activity validates the therapeutic potential of these natural ash-based formulations. Particularly, methanolic extracts from HA-2 demonstrated promising inhibition against key Gram-negative pathogens, underscoring their potential as adjunct or alternative antimicrobial agents.

The statistically significant differences (**$p < 0.05$**) between solvent systems highlight the importance of extraction methodology in enhancing bioactive compound yield. These findings support the potential integration of Hawan ash into topical or environmental antimicrobial applications and warrant further studies focusing on isolation of active constituents, mechanism of action, and formulation development.

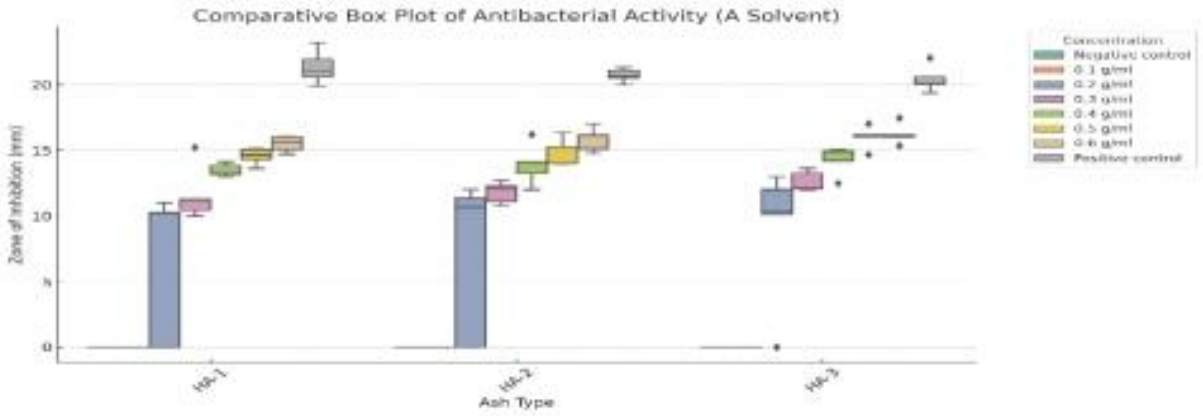


Figure 1: Comparative Box Plot of Antibacterial Activity of Hawan Ash Extracts (Solvent A)

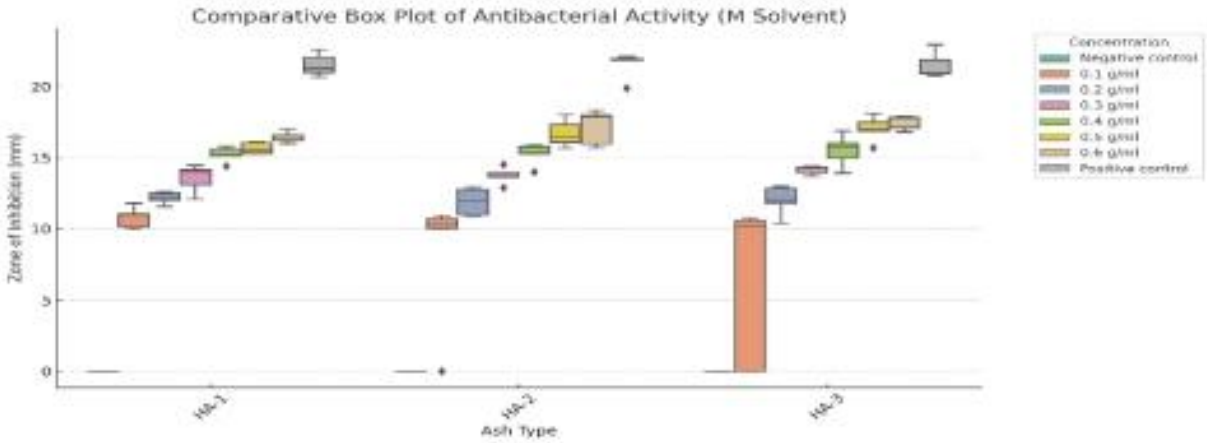


Figure 2: Comparative Box Plot of Antibacterial Activity of Hawan Ash Extracts (Solvent M)

3.4 Factors Influencing Antibacterial Variability

The observed variability in the zones of inhibition (ZOI) among the three Hawan ash samples—HA-1, HA-2, and HA-3—can be attributed to differences in their elemental composition, pH, and availability of bioactive compounds. The alkaline nature of ash, coupled with the presence of metal oxides and trace minerals, plays a critical role in microbial inhibition. These inorganic constituents may interfere with microbial cell wall integrity, enzymatic function, or ion exchange mechanisms, thereby exerting antimicrobial effects.

Moreover, the variability in bacterial susceptibility can be linked to structural differences in their cell wall architecture. Gram-negative bacteria, with their thinner peptidoglycan layers and outer membranes, often exhibit different susceptibility profiles compared to Gram-positive bacteria, which may influence the observed results.

3.5 Statistical Analysis

Statistical validation using ANOVA confirmed significant differences ($p < 0.05$) in antibacterial activity among the three ashes. Tukey's test further revealed that HA-2 had significantly higher inhibition zones than HA-1 and HA-3 reinforcing its superior antibacterial potential. Pearson correlation analysis demonstrated a strong positive correlation ($r > 0.85$) between concentration and inhibition zone (ZOI) for all bacterial strains and solvents confirming its highly dose-dependent antibacterial response. Furthermore, linear regression analysis revealed a statistically significant relationship ($p < 0.05$) between concentration and ZOI for all bacterial strains with R^2 values ranging from 0.85 to 0.97 reinforcing a strong dose-response relationship.

4. CONCLUSION

This study highlights the antibacterial potential of Hawan ash extracts. The findings indicate that methanolic extracts are more effective than aqueous extracts. A concentration-dependent response was evident, with higher concentrations exhibiting increased antibacterial activity. Although Hawan ash extracts showed significant antibacterial effects, their efficacy was lower than {Neomycin (30µg/disc)}. The variations in efficacy across different ash samples suggest that elemental composition, pH, and bioactive compound availability play a crucial role in antibacterial effectiveness. Given the promising antibacterial activity of Hawan ash, future research should focus on identifying active constituents, evaluating toxicity, and understanding mechanisms of action, to explore Hawan ash as a potential natural antimicrobial agent for pharmaceutical and therapeutic applications. This study lays a foundational framework for the integration of Hawan ash into evidence-based natural product drug discovery pipelines.

Author Contributions:

Happy Patel: Conceptualization, Methodology, Writing- Original Draft Preparation, Data curation.

Deepika Chandawat: Visualization, Writing- Reviewing and Editing.

Mahek Patel: Reviewing, Supervision.

Funding Source: The authors sincerely acknowledge SHODH - Scheme of Developing High-Quality Research, Education Department, Gujarat State, India for financial support.

Acknowledgments: We extend our appreciation to Smt. S. S. Patel Nootan College, Visnagar, Gujarat, India for providing the necessary research facilities and laboratory support essential to this research.

Declaration of Interest Statement: The authors declare no conflict of interest.

Informed Consent Statement: Not applicable.

REFERENCES

1. Pathade G, Abhang DrP. Scientific Study of Vedic Knowledge Agnihotra. Water Contamination Emergencies [Internet]. 2014 Mar 13 [cited 2025 Mar 9];165–71. Available from: https://papers.ssrn.com/abstract=2745964
2. Syal S, Pandit V, Ankalgi AD, Verma CPS, Ashawat MS. Formulation and Evaluation of Microsponges Gel of Havan Ash for the Treatment of Acne. Journal of Drug Delivery and Therapeutics [Internet]. 2020 Nov 15 [cited 2025 Feb 23];10(6):74–85. Available from: https://doi.org/10.22270/jddt.v10i6.4380
3. Tuladhar R, Maharjan BL, Sharma S, Singh A, Berk U. Effect of agnihotra ash on drug-resistant escherichia coli in water. Plant Biotic Interactions: State of the Art. 2019 Jan 1;243–51. Available from : https://doi.org/10.1007/978-3-030-26657-8_14
4. Thakare A, Ahmad M, Pande K, Metkari S. Purification of Water by using Cow Dung Ash. International Research Journal of Engineering and Technology. 2008;393(June). Available from: http://dx.doi.org/10.21275/SR23426233543
5. Ram R, Garg N, Priti. Response of agnihotra ash on the growth of pathogenic microorganisms. Journal of Eco-friendly Agriculture [Internet]. 2020 [cited 2025 Feb 24];15(2):118. Available from: https://doi.org/10.5958/2582-2683.2020.00014.3
6. Chen, Z., Yu, D., He, S., Ye, H., Zhang, L., Wen, Y., Zhang, W., Shu, L., & Chen, S. (2017). Prevalence of Antibiotic-Resistant *Escherichia coli* in Drinking Water Sources in Hangzhou City. *Frontiers in microbiology*, *8*, 1133.doi: 10.3389/fmicb.2017.01133. PMID: 28670309; PMCID: PMC5472731. Available from: https://doi.org/10.3389/fmicb.2017.01133
7. Wójcik M, Stachowicz F, Masłoń A. The Use of Wood Biomass Ash in Sewage Sludge Treatment in Terms of Its Agricultural Utilization. Waste Biomass Valorization. 2020;11(2). Available from : https://doi.org/10.1007/s12649-018-0518-0
8. Joshi SK, Semwal DK, Kumar A., Chauhan A. Antimicrobial activity of the water-soluble ash extract from the invasive weed Parthenium hysterophorus L. CURRENT MEDICAL AND DRUG RESEARCH. 2020 Nov 20;4(02). Available from Doi: 10.53517/CMDR.2581-5008.422020208
9. Alterary S, Marei NH. The Impact of Coal Fly Ash Purification on Its Antibacterial Activity. Minerals 2020, Vol 10, Page 1002 [Internet]. 2020 Nov 11 [cited 2025 Feb 23];10(11):1002. Available from: https://doi.org/10.3390/min10111002
10. Shithi KN, Saha A, Haque MN, Hossain I, Nooruzzaman M, Begum JA, Parvin R, Chowdhury EH. Use of ash filtrate as an alternative to chemical disinfectant and its antimicrobial efficacy. J Adv Vet Anim Res. 2024 Dec 28;11(4):1007-1016. doi: 10.5455/javar.2024.k851. PMID: 40013298; PMCID: PMC11855415
11. Pal D, Sahu CK, Haldar A. Bhasma : The ancient Indian nanomedicine. *Journal of advanced pharmaceutical technology & research*, *5*(1), 4–12. https://doi.org/10.4103/2231-4040.126980
12. Singh P, Sharda S, Cauhan SS. DOMESTIC WASTE WATER TREATMENT BY FLY AND WOOD ASH ALONG WITH ADDITIVES MATERIALS. INTERNATIONAL JOURNAL OF CIVIL ENGINEERING AND TECHNOLOGY (IJCIET) [Internet]. 2016 Mar 21 [cited 2025 Mar 2];7(2):67–75. Available from: https://iaeme.com/Home/article_id/IJCIET_07_02_005
13. Yadima SG, Muhammad M, Usman B. PHYTO-CHEMICAL SCREENING AND ANTIBACTERIAL ACTIVITIES OF AQUEOUS EXTRACTS OF DIOSPYROS MESPILIFORMIS, MITRAGYNA INERMIS, PILIOSTIGMA RETICULATUM AND TAMARINDUS INDICA IN NORTHERN NIGERIA. Arid Zone Journal of Engineering, Technology and Environment. 2017;13(3).
14. Gonelimali FD, Lin J, Miao W, Xuan J, Charles F, Chen M, et al. Antimicrobial properties and mechanism of action of some plant extracts against food pathogens and spoilage microorganisms. Front Microbiol [Internet]. 2018 Jul 24 [cited 2025 Feb 24];9(JUL):389103. Available from: https://doi.org/10.3389/fmicb.2018.01639
15. Chidiebere U. Evaluation of Antibacterial and Wound Healing Activity of Cocos nucifera (Coconut) Husk Ash Extract in Mice. Vol. 12, Journal of Food Processing & Technology 1 J Food Process Technol. 2021.
16. Rastogi V, Swami Krishnanand, Panwar RB, Chacko KM, Prem R, Vijay C, et al. Quality analysis, Anti-bacterial activity and Chemical Characterization of Ethnobotanical (Hawan) Medicinal Fumes. Interdisciplinary Journal of Yagya Research. 2022 Sep 2;5(1):01–19. Available from : https://doi.org/10.36018/ijyr.v5i1.79