

Ethnomedicinal Approaches to Kidney Stone Management: A Systematic Review of Traditional and Pharmacological Insights

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Abstract—Kidney stone disease (urolithiasis) is a recurring metabolic disorder with significant global morbidity. The resurgence of interest in ethnomedicinal therapies reflects a shift toward natural, cost-effective, and safer alternatives to conventional treatment. This systematic review synthesizes evidence from fifteen scientific papers (2009–2025), exploring traditional and pharmacological insights into antiurolithiatic plants. Key species such as *Phyllanthus niruri*, *Boerhaavia diffusa*, *Crataeva nurvala*, and *Orthosiphon stamineus* exhibit multifaceted mechanisms—enhancing diuresis, inhibiting calcium oxalate crystallization, and protecting renal tissue from oxidative stress. Despite strong preclinical support, the lack of standardized clinical validation remains a critical limitation. Integrating ethnobotanical wisdom with molecular pharmacology could pave the way for sustainable phytotherapeutic strategies in kidney stone prevention and management.

Index Terms—Ethnomedicine, Urolithiasis, Phytotherapy, Herbal pharmacology, Kidney stones, Nephroprotection, Traditional medicine

I. INTRODUCTION

Kidney stone disease (urolithiasis) is a metabolic disorder characterized by the formation and retention of crystalline aggregates in the urinary system (Nirumand, Hajialyani, & Rahimi, 2018). Though modern interventions such as extracorporeal shockwave lithotripsy (ESWL) and ureteroscopy have revolutionized management, their high recurrence rates (up to 50% within five years) emphasize the need for preventive strategies (Allam, El-Dessouki, & El-Shiekh, 2025).

Ethnomedicinal practices form an integral part of traditional health systems like Ayurveda, Unani, and Traditional Chinese Medicine (TCM), utilizing plants

with diuretic, anti-inflammatory, and antioxidant properties (Soni & Pandey, 2024). Among the numerous botanicals documented, *Phyllanthus niruri*, *Boerhaavia diffusa*, and *Crataeva nurvala* stand out for their well-researched antiurolithiatic effects. This systematic review aims to bridge ethnobotanical heritage and modern pharmacology by highlighting bioactive compounds, validated mechanisms, and therapeutic prospects of such plants in urolithiasis prevention and treatment.

II. METHODOLOGY

A structured review methodology was adopted, covering scientific databases including PubMed, Scopus, Science Direct, and Google Scholar. The keywords “ethnomedicinal plants,” “urolithiasis,” “kidney stone,” and “Phytotherapy” were used to screen studies published between 2009–2025.

Inclusion criteria:

1. Peer-reviewed articles with ethnobotanical or pharmacological focus.
2. Studies on plants traditionally used for kidney stones.
3. Experimental validation through in vivo, in vitro, or clinical research.

Fifteen studies meeting the criteria were included, encompassing ethnopharmacological surveys, molecular mechanism analyses, and clinical observations (Beldar, Sidat, & Jadhao, 2022; Akram & Idrees, 2019).

III. ETHNOMEDICINAL DIVERSITY AND DISTRIBUTION

Ethnobotanical documentation reveals over 200 plants globally used in urolithiasis therapy, predominantly in tropical Asia, Africa, and South America. India

contributes the largest ethnomedicinal diversity, with 85 species recorded (Lavate, 2021).

Common preparations include decoctions, juices, and powders of roots, leaves, or whole plants administered orally for 2–8 weeks. Major plants, their traditional uses, and pharmacological actions are summarized in Table 1.

Plant Name	Family	Traditional System	Pharmacological Property	Key Reference
<i>Phyllanthus niruri</i>	<i>Phyllanthaceae</i>	Ayurveda	Antilithic, diuretic	Beldar et al., 2022
<i>Boerhaavia diffusa</i>	<i>Nyctaginaceae</i>	Ayurveda	Antioxidant, nephroprotective	Allam & Sabra, 2024
<i>Crataeva nurvala</i>	<i>Capparaceae</i>	Ayurveda	Smooth muscle relaxant	Balkrishna et al., 2024
<i>Orthosiphon stamineus</i>	<i>Lamiaceae</i>	Malay–Indonesian	Calcium oxalate inhibitor	Zakaria et al., 2023
<i>Tribulus terrestris</i>	<i>Zygophyllaceae</i>	Siddha	Renal tonic	Chinnappan et al., 2023
<i>Aerva lanata</i>	<i>Amaranthaceae</i>	Ayurveda	Diuretic, antioxidant	Beldar et al., 2022
<i>Madhuca longifolia</i>	<i>Sapotaceae</i>	Unani	Calcium chelator	Chanchal & Sharma, 2024

IV. PHARMACOLOGICAL INSIGHTS

4.1 Experimental Validation

Pharmacological studies demonstrate that *Phyllanthus niruri* extracts significantly inhibit calcium oxalate crystal formation and promote magnesium and citrate excretion (Nirumand et al., 2018). *Boerhaavia diffusa* possesses punarnavine and rotenoids that restore renal function by lowering oxidative stress and serum urea (Allam & Sabra, 2024; Gupta & Kanwar, 2018).

Orthosiphon stamineus (“Java tea”) contains sinensetin and rosmarinic acid—potent antioxidants preventing crystal adhesion to epithelial cells and improving urinary output (Zakaria et al., 2023). *Tribulus terrestris* and *Crataeva nurvala* exhibit spasmolytic and anti-inflammatory properties, aiding stone expulsion (Chinnappan et al., 2023).

The triterpenoids madhucic acid and betulinic acid in *Madhuca longifolia* act as calcium chelators, preventing microcrystal aggregation (Chanchal & Sharma, 2024). Collectively, these pharmacological findings validate ethnomedicinal wisdom with molecular precision.

4.2 Phytochemical Diversity and Biochemical Targets
Ethnomedicinal plants share overlapping biochemical targets:

- Oxalate metabolism inhibition: Flavonoids like quercetin and kaempferol downregulate glycolate oxidase, reducing oxalate synthesis.
- Crystal inhibition: Alkaloids enhance urinary citrate and magnesium, which prevent calcium binding.
- Renal protection: Polyphenols like Gallic and caffeic acids neutralize free radicals (Akram & Idrees, 2019).

4.3 Synergistic Formulations

Ayurvedic formulations such as Cystone, Pashanabheda, and Varunadi Kwatha integrate multiple herbs for dual litholytic and diuretic effects. Experimental data confirm that combined extracts outperform single-plant therapies in crystal reduction (Lavate, 2021).

V. MECHANISMS OF ACTION

5.1 Diuretic and Litholytic Effects

Plants like *Phyllanthus niruri* and *Boerhaavia diffusa* enhance diuresis via renal aquaporin modulation and prostaglandin-mediated glomerular filtration (Allam et al., 2025). *Tribulus terrestris* facilitates litholysis by reducing urinary viscosity and relaxing ureteric muscles (Nimavat et al., 2022).

5.2 Antioxidant and Anti-inflammatory Mechanisms
Oxidative stress-induced renal injury promotes crystal adhesion. Polyphenols such as ellagic acid and rosmarinic acid suppress NF- κ B activation, lowering inflammatory cytokine expression (Nirumand et al., 2018; Zakaria et al., 2023).

5.3 Calcium and Oxalate Regulation
Polyphenols in *Boerhaavia diffusa* inhibit glycolate oxidase, decreasing oxalate production, while triterpenoids in *Madhuca longifolia* bind free calcium, preventing precipitation (Gupta & Kanwar, 2018).

5.4 Nephroprotective Action
Triterpenoids stabilize renal epithelial membranes, reducing lipid peroxidation. Histopathological studies show preserved tubule architecture in *B. diffusa* treated models (Chanchal & Sharma, 2024).

VI. CLINICAL AND TOXICOLOGICAL EVIDENCE

6.1 Clinical Findings
Clinical trials on *Phyllanthus niruri* decoctions have shown up to 75% reduction in stone size over 12 weeks, with significant improvements in urinary pH and citrate excretion (Allam & Sabra, 2024). *Orthosiphon stamineus* users reported reduced recurrence rates (Zakaria et al., 2023). Systematic reviews (Akram & Idrees, 2019) affirm consistent improvements in renal biomarkers, although most studies remain observational.

6.2 Toxicology
Safety profiles are favorable; *Phyllanthus niruri* and *Aerva lanata* show no hepatotoxicity at 2000 mg/kg (Maharana & Dadhich, 2015). However, *Madhuca longifolia* may cause mild hepatic strain at higher doses, necessitating dose regulation (Chanchal & Sharma, 2024).

6.3 Research Gaps
Despite strong ethnobotanical backing, critical gaps persist:

1. Lack of large-scale randomized clinical trials (Soni & Pandey, 2024).
2. Phytochemical variability affecting reproducibility.

3. Inadequate data on herb–drug interactions with diuretics or ACE inhibitors.
4. Limited exploration of molecular pathways (MAPK, Nrf2, and TGF- β).

Future studies should integrate metabolomics, molecular docking, and bioassay-guided isolation for standardization.

VII. FUTURE PROSPECTS

Advanced tools like metabolomics, nanocarrier formulations, and AI-assisted compound screening may enhance the efficacy and bioavailability of herbal treatments. Cross-disciplinary research linking traditional healers with modern pharmacologists could enable standardized, clinically validated herbal formulations for urolithiasis.

VIII. CONCLUSION

Ethnomedicinal plants offer immense potential in managing kidney stone disease through multidimensional actions: diuresis, antioxidation, and crystal inhibition. Consistent preclinical data validate the use of *Phyllanthus niruri*, *Boerhaavia diffusa*, and *Orthosiphon stamineus*, among others, as viable alternatives to conventional drugs. Integrating traditional botanical knowledge with clinical research can advance the development of globally accessible phytopharmaceuticals for nephrolithiasis.

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