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Review Article

Tribulus terrestris: A Revisit to a Promising Herbal Diuretic

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ABSTRACT

Background: Standard diuretics are essential for managing fluid as well as electrolyte overload and hypertension but are frequently associated with adverse effects such as electrolyte imbalances, renal dysfunction, and metabolic disturbances. This has prompted increased interest in safer, plant-based alternatives. *Tribulus terrestris*, a medicinal herb used as a diuretic agent in traditional systems, has shown promising diuretic activity in recent experimental studies. **Objective:** To provide an outline and assess the reported diuretic effects of *Tribulus terrestris*, including its phytochemical profile, mechanisms of action, and findings from in vivo, in vitro, and in silico studies. **Methods:** An extensive literature survey was performed on the PubMed, Scopus, ScienceDirect, and Google Scholar databases for studies published between 2000 and 2025. The inclusion criterion was original articles evaluating the diuretic activity of *Tribulus terrestris*. Articles without diuretic activity were excluded. Data extraction included the plant part used, extract type, dosage, model used and observed effects. **Results:** This review highlights the diuretic properties and phytoconstituents of *Tribulus terrestris*. Most studies have used aqueous or ethanolic extracts of fruits or whole plants and reported significant increases in urine output and urinary sodium excretion, which are often comparable to those of standard diuretics such as furosemide. **Conclusion:** This review highlights the preclinical diuretic activity of *Tribulus terrestris*. It has shown effective and well-tolerated diuretic potential in preclinical and human subjects. It is a promising, likely herbal-based diuretic, natural alternative or complement, adjunct to conventional diuretics, which warrants further investigation through clinical studies.

Keywords: diuresis, diuretic agent, herbal medicine, Indian traditional medicine, Siddha system of medicine, *Tribulus terrestris*

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INTRODUCTION

Diuretics are pharmacologically active substances that promote the excretion of water and electrolytes, primarily sodium and chloride, through the kidneys, increasing urine output[1]. They play pivotal roles in modern clinical medicine, serving as first-line therapies for managing various cardiovascular, renal, and hepatic conditions, such as hypertension, congestive heart failure, nephrotic syndrome, chronic kidney disease, and liver cirrhosis, where fluid overload and blood pressure regulation are of paramount importance. Conventional diuretics such as thiazides, loop diuretics, potassium-sparing agents, osmotic diuretics, and carbonic anhydrase inhibitors have proven highly effective in managing such clinical conditions. However, despite their efficacy, these agents are not without limitations, and they exhibit a wide array of adverse effects, including electrolyte imbalances (e.g., hypokalemia, hyponatremia), dehydration, hypotension, metabolic disturbances (e.g., hyperuricemia, hyperglycemia), renal dysfunction, and ototoxicity, which significantly hamper long-term compliance and quality of life in vulnerable (especially elderly) populations[2-4].

The adverse drug reaction profile of conventional diuretics has prompted a need for safer, equally effective, and more holistic alternatives. The World Health Organization (WHO) has emphasized the integration of traditional medicine into national health systems, recognizing the potential of herbal drugs in preventive and therapeutic healthcare[5]. Numerous medicinal plants have been studied in this context for their diuretic potential[6-8]. One plant that has drawn considerable attention is *Tribulus terrestris* (*TT*), an herbaceous plant widely distributed in tropical and subtropical regions across Asia, Africa, Europe, and Australia[9]. It has long held a revered place in various traditional medicine systems, including Ayurveda, Traditional Chinese Medicine (TCM), Siddha and Unani, and its use has been indicated in the treatment of urinary tract infections, edema, sexual dysfunction, kidney stones, and inflammation[10,11].

TT contains a rich repertoire of phytochemicals, including saponins, flavonoids, alkaloids, tannins, and glycosides, many of which are biologically active and are associated with diuretic properties. In particular, its fruit and root extracts have demonstrated notable renal and cardiovascular effects in preclinical studies. The therapeutic potential of plants as natural diuretic lies in its efficacy, favorable safety profile, and additional antioxidant, anti-inflammatory, and adaptogenic activities. These multifaceted actions may contribute synergistically to its diuretic potential, making it a strong candidate for integration into evidence-based herbal therapeutics[12-18].

This review aims to systematically explore and synthesize existing scientific literature on the diuretic properties of *TT*, focusing on its phytochemical composition, mechanisms of action, experimental outcomes, and potential clinical relevance. We hope to contribute to the growing discourse on plant-

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based interventions for renal and cardiovascular health by comparing them to conventional diuretic agents and highlighting their therapeutic promise.

Standard diuretics and their uses

Diuretics are broadly classified into thiazide, loop, potassium sparing, osmotic diuretic and carbonic anhydrase inhibitors. Each class offers specific therapeutic benefits and is selected according to the clinical condition being treated[2-4,19]. The details are listed below in Table 1.

Adverse effects of standard diuretics

Despite their critical role in clinical practice, the long-term use of standard diuretics is frequently accompanied by a broad spectrum of adverse effects. These side effects vary depending on the class of diuretic, the dosage, the duration of therapy, and the individual patient's comorbid conditions. The most notable adverse effects affect fluid and electrolyte balance, renal function, metabolic processes, and, in some cases, hormonal pathways[32-34]. Understanding these side effects is essential for clinicians to ensure safe and effective therapy, monitor patients appropriately, and consider alternative therapies when needed (Table 2).

A. Electrolyte imbalance

- Hypokalemia: This disease commonly occurs with thiazide and loop diuretics due to increased sodium delivery to the distal tubule, which increases potassium excretion. This can lead to muscle weakness, arrhythmias, fatigue, and, in severe cases, paralysis or cardiac arrest[2,3,22,23,35-38].
- Hyponatremia: In particular, associated with thiazide diuretics, hyponatremia can cause confusion, seizures, and coma, especially in elderly individuals and individuals with low body mass[20-23,26].
- Hypomagnesemia: Loop diuretics may cause magnesium loss, leading to neuromuscular irritability, muscle cramps, and arrhythmias[36-40].
- Hyperkalemia: Seen with potassium-sparing diuretics (e.g., spironolactone, amiloride), especially in patients with renal impairment or those taking angiotensin-converting enzyme inhibitors or angiotensin receptor blockers. This can lead to dangerous cardiac conduction abnormalities[27].
- Hypercalcemia/hypocalcemia: Thiazides reduce calcium excretion and may lead to hypercalcemia, whereas loop diuretics increase calcium loss, potentially resulting in hypocalcemia and its associated symptoms (e.g., tetany, seizures)[20-23,26].
- Volume Depletion and Dehydration: Excessive diuresis, especially with loop diuretics, can lead to significant intravascular volume depletion and dehydration. This may manifest as hypotension, dizziness, orthostatic hypotension, prerenal azotemia, or even acute kidney injury in susceptible individuals, such as elderly individuals or those with preexisting renal impairment[32-34].

B. Metabolic Abnormalities

- Hyperuricemia: Diuretics, especially thiazides and loop agents, compete with uric acid for excretion in the renal tubules, increasing serum uric acid levels. This may precipitate gout attacks in predisposed individuals[20-24,26,35,41].
- Hyperglycemia and glucose intolerance: Thiazide diuretics can impair insulin sensitivity and glucose tolerance, contributing to new-onset diabetes mellitus or worsening of preexisting diabetes[20-23,26].
- Dyslipidemia: Thiazides may cause mild increases in total cholesterol, LDL cholesterol, and triglycerides, although the clinical significance of these increases remains debated[2-4,20-22].

C. Ototoxicity: Loop diuretics, especially at high doses or when administered intravenously too rapidly, can cause ototoxicity, leading to reversible or irreversible hearing loss and tinnitus. The risk is increased when these drugs are used in combination with other ototoxic drugs (e.g., aminoglycosides)[2-4,35,42,43].

D. Hormonal and endocrine effects

- Gynecomastia, Impotence, Menstrual Irregularities: Seen with spironolactone, a potassium-sparing diuretic that also antagonizes androgen receptors. Eplerenone, a more selective aldosterone antagonist, has a lower risk of such side effects (27).
- Menstrual Irregularities and Breast Tenderness: These may also occur with spironolactone in females because of its antiandrogenic activity[27].
- Allergic reactions and hypersensitivity: Most thiazides and loop diuretics are sulfonamide derivatives and may cause skin rashes, photosensitivity, and, rarely, Stevens-Johnson syndrome in sensitive individuals[20,21,35].

Need for Alternative Diuretics

Despite the well-established clinical efficacy of conventional diuretics in managing a variety of cardiovascular and renal disorders, their use

Table 1. Classification of Standard Diuretics and their Key Uses

Class	Examples	Site of Action	Primary Clinical Uses
Thiazide diuretics	Hydrochlorothiazide, indapamide	Distal convoluted tubule	Hypertension, mild edema, kidney stones, osteoporosis (20–23)
Loop diuretics	Furosemide, torsemide	Thick ascending loop of Henle	Pulmonary edema, CHF, renal failure, hypercalcemia (24–26)
Potassium-sparing diuretics	Spironolactone, amiloride	Collecting ducts/distal nephron	CHF, hyperaldosteronism, hypokalemia prevention (27,28)
Carbonic anhydrase inhibitors	Acetazolamide, dorzolamide	Proximal convoluted tubule	Glaucoma, altitude sickness, and metabolic alkalosis (29)
Osmotic diuretics	Mannitol	Glomerulus → entire nephron	Cerebral edema, acute angle-closure glaucoma, prophylaxis for acute renal failure (30,31)

Table 2. Common adverse effects of different diuretic groups

Diuretic Class	Common Adverse Effects
Thiazide diuretics	Hypokalemia, hyponatremia, hypercalcemia, hyperuricemia, hyperglycemia, dyslipidemia (20,21,23)
Loop diuretics	Hypokalemia, hypocalcemia, ototoxicity, dehydration, hyperuricemia, renal dysfunction (26,35)
Potassium-sparing diuretics	Hyperkalemia, gynecomastia (spironolactone), menstrual irregularities (27)
Carbonic anhydrase inhibitors	Metabolic acidosis, hypokalemia, drowsiness, paresthesia (29)
Osmotic diuretics	Volume overload (in renal failure), electrolyte imbalance, headache, nausea, dehydration (30)

is often limited by significant adverse effects. As mentioned earlier, conventional diuretics are frequently associated with electrolyte imbalances, metabolic disturbances, renal impairment, ototoxicity, and hormonal side effects, particularly with long-term therapy. Due to these side effects/risks associated with their use, continuous monitoring is needed, and additional medications are needed to manage those side effects, which affects patient compliance, especially with elderly individuals and individuals with multiple comorbidities. The burden of regular biochemical monitoring to detect electrolyte abnormalities and renal function deterioration adds to healthcare costs and patient burden[36-41,44,45]. Therefore, interest in identifying and validating safer alternatives that could either complement or substitute conventional diuretics, especially in the management of mild to moderate fluid retention, early-stage hypertension, or as adjuncts in integrated care, is increasing.

Herbal diuretics: An evolving frontier

The use of plant-based diuretics is not new. Traditional systems of medicine, such as Ayurveda, Siddha, TCM, Unani, and various indigenous practices, have long recognized certain herbs for their ability to promote diuresis, reduce edema, and support kidney function. Herbal medicines, which are derived from natural sources and used in lower, physiologically compatible doses, are generally perceived to have a better safety profile. Moreover, many medicinal plants contain a broad spectrum of bioactive compounds that exert multiple therapeutic effects simultaneously, such as anti-inflammatory, antioxidant, and renoprotective effects, which may collectively increase their utility in clinical settings[7,46-50]. In recent years, there has been a significant surge in scientific research aimed at exploring and validating the diuretic potential of herbal medicines. Among the most widely studied plants is *TT*, a plant with a rich history of use in traditional medicine and a promising phytochemical profile.

Tribulus terrestris

TT, commonly known as puncture vine, caltrop, Nerunjil (in Siddha) or Gokshura (in Ayurveda), is an herbaceous plant belonging to the Zygophyllaceae family that grows in dry climates. The botanical classification of the plant is given in Table 3.

The plant typically has small yellow flowers, pinnate leaves, and spiny fruits. It is considered a weed in many parts of the world but has attracted attention for its high content of pharmacologically active constituents[14,18,46,51,52].

Traditional uses of *Tribulus terrestris*

In Ayurvedic medicine, *TT* is classified as a mutravirechaniya dravya, meaning a substance that promotes urination[53], and in the Siddha system of medicine, it is popularly known as Nerunjil[10]. It is traditionally used for the treatment of dysuria, nephrolithiasis, edema, urinary tract infections, and oliguria[11,48,51,54]. These indications suggest its diuretic properties, which modern scientific investigations are beginning to explore and substantiate.

METHODOLOGY

This review was conducted with the objective of synthesizing current knowledge on the diuretic properties of *TT* on the basis of available experimental and preclinical studies. A literature search was conducted using the various search engines, such as Scopus, ScienceDirect, Web of Science, PubMed, Embase and Google Scholar. The keywords used for the literature search included "*Tribulus terrestris* pharmacology", "*Tribulus terrestris* AND diuretics", "*Tribulus terrestris* AND diuretic activity", "*Tribulus terrestris* AND diuresis", "Phytochemicals of *Tribulus terrestris*", "GC-MS analysis AND *Tribulus terrestris*", "Bioactive compounds of *Tribulus terrestris*", "Network pharmacology AND *Tribulus terrestris*", "Molecular docking AND *Tribulus terrestris*" and other relevant terms.

The search was limited to studies published between 2000 and 2025 in the English language and included in silico, in vitro and in vivo experiments evaluating diuretic properties. The search was restricted to original research articles that specifically evaluated the diuretic effect of *TT* using animal, human, and cell models; in silico models; and comparisons with standard diuretics. Titles, abstracts and keywords were used for examination and identification of the collected manuscripts. Detailed information on the plant parts used (fruit, leaf, root, whole plant), types of extracts (aqueous, ethanolic, methanolic, etc.), dosages used, types of experimental models (human, rat, mouse, or in vitro), comparisons with standard diuretics, observed outcomes (urine output, electrolyte excretion, onset, duration), phytochemical constituents identified, and mechanisms of action (if mentioned using network pharmacology and molecular docking and simulation works) has been compiled using the databases mentioned earlier.

Table 3. Botanical Profile of TT

Kingdom	Plantae
Order	Zygophyllales
Family	Zygophyllaceae
Genus	*Tribulus*
Species	*terrestris*

RESULTS

Phytochemical composition

The therapeutic properties of *TT* are attributed to its rich phytochemical content[11,46,51,52,55-60], including the following:

- **Saponins:** Saponins are the principal bioactive agents responsible for many of the plant's pharmacological effects, including possible modulation of kidney function.
- **Flavonoids:** Flavonoids possess antioxidant and anti-inflammatory properties that may indirectly support renal perfusion and diuresis.
- **Alkaloids and glycosides:** May contribute to electrolyte modulation and fluid balance.
- **Tannins and phenolic compounds:** Known for their general protective effects on tissues, including the renal epithelium.

The search for alternative, plant-based diuretics has become a focal point in modern pharmacological research, driven by the need for effective yet safer therapeutic options. *TT*, with its historical use in traditional medicine, favorable safety profile, and phytochemically diverse composition, *TT* has emerged as a strong candidate for further scientific exploration. By bridging ethnopharmacology with modern pharmacodynamics, this review aims to critically analyze and consolidate the evidence regarding the diuretic activity of *TT* and to assess its potential as a natural substitute or adjunct to conventional diuretic therapies.

The table (Table 4) below summarizes the phytochemical profile data from the selected studies, including the type of extract, plant part used, groups of phytochemicals identified, and source reference.

Experimental Evidence for Diuretic activity

Emerging preclinical studies suggest that various extracts of *TT*, particularly aqueous extract of the fruit and aerial parts, demonstrate significant diuretic activity in animal models, which is often comparable to that of standard diuretics such as furosemide. Unlike conventional agents, this extract appears to cause minimal electrolyte disturbances and exhibits a broader safety margin[7,9,49,50,67,68]. Only a handful of studies

Table 4. Showing the phytochemical profile of different parts of *TT*

Plant Part	Extract type	Phytochemical groups	References
Aerial parts	Methanolic extract	Aromatic compounds, carboxylic acids and derivatives, terpenoids, aliphatic hydrocarbons and aldehydes	2024 (55)
Fruits	Hydroalcoholic extract	Steroidal saponins, sapogenins, flavonoids, flavonoid glycosides, phytosterols, alkaloids, and amides	2024 (61)
Whole plant	Methanolic extract	Steroidal saponins, flavonoids, flavonoid glycosides, alkaloids, amino acids, nucleobases, phenolic acids, and terpenoids	2023 (62)
Whole plant	Methanolic extract	Myricetin, liquitrigenin, physcion, protodioscin, and rutin	2022 (57)
Fresh fruit	Petroleum ether, and chloroform	Steroids, triterpenoids, reducing sugars, alkaloids, saponins, tannins, and flavonoids	2022 (58)
Fresh fruit	Benzene	Steroids, triterpenoids, reducing sugars, saponins, and tannins	2022 (58)
Fresh fruit	Ethanol	Steroids, triterpenoids, reducing sugars, alkaloids, saponins, and tannins	2022 (58)
Fresh fruit	Aqueous	Saponins, and tannins	2022 (58)
Leaf and seeds	Ethanol	Nuatigenin	2021 (59)
Fruits	Gross saponin of *TT* fruit	Steroidal saponins, flavonoids, alkaloids, amides and phytosterols	2020 (63)
Fruits	Total saponin extract	Flavonoid glycosides, saponins, phenolic acids, and other glycosides	2020 (64)
Seeds	Ultrasonic extract	Steroid saponins, rutin, dioscin, furostanol saponins (protodioscin, prototribestin and pseudoprotodioscin)	2011 (65)
Dried fruit	Petroleum ether, and chloroform	Steroids, triterpenoids, reducing sugars, alkaloids, saponins, tannins, and flavonoids	2011 (66)
Dried fruit	Benzene	Steroids, triterpenoids, reducing sugars, saponins, and tannins	2011 (66)
Dried fruit	Ethanol	Steroids, triterpenoids, reducing sugars, alkaloids, saponins, and tannins	2011 (66)
Dried fruit	Aqueous	Reducing sugars, saponins, and tannins	2011 (66)

have explored the diuretic potential of *TT* and compared its efficacy to that of standard diuretics such as furosemide, hydrochlorothiazide, or spironolactone. Table 5, Figures 1 and 2 summarizes the results of preclinical and human tests of *TT* with respect to its diuretic effect.

Strengths of *TT*

In all of the above studies, the extracts of *TT* appeared to produce diuresis, which is similar to that of furosemide. These findings reassure the diuretic potential of *TT* extracts and their potential use in the management of urolithiasis, fluid overload, hypertension, urinary tract infections and urinary stone management and in nephroprotection in cases of urolithiasis.

Limitations

These studies did not reveal or determine exactly how *TT* is able to produce the diuretic effects. Further investigations are needed to shed light on the diuretic effects of the extracts of *TT*. There were no isolation of the compounds which were responsible for the diuretic activity and it's in silico diuretic evaluation were not assessed. Moreover, the studies were done on small sample sizes, different extracts, lack of dose standardization, and no large scale randomized clinical trials were conducted. All of these need to be addressed properly to evaluate the diuretic activity of *TT*.

CONCLUSION

This review specifically evaluated the diuretic activity of *TT* using various experimental models and human studies. The selected studies varied in terms of the plant parts used, extract type, models used, dosing and the standard drugs used to compare the effects.

TT contains a wide variety of phytochemicals; no single compound has been conclusively identified as the one responsible for diuretic activity. Almost all the studies reported a significant increase in urine output and urinary sodium (Na^+) and chloride (Cl^-) excretion, indicating effective diuretic action.

This evidence indicates that *TT* possesses notable diuretic potential mediated by multiple phytochemical constituents. Its probable multitarget action, minimal adverse effects, and complementary systemic benefits make it an attractive candidate for further investigation in preclinical and clinical settings. However, large-scale human trials, standardizations of extracts, and dose–response relationships need to be established before routine therapeutic use can be advocated.

TT is a promising natural alternative to conventional diuretics because of its low incidence of side effects, and additional pharmacological benefits, such as hepatoprotection[71,72], anti-inflammatory effects[55,57,64,73], antioxidant effects[17,57,74,75], nephroprotection[61,69], and neuroprotection[76-78], are few to mention. Although only a few studies support the claim of its diuretic property, it is widely used in traditional medicine as a diuretic agent[10].

FUTURE DIRECTIONS

Further in-depth analysis of the diuretic activity of *TT* through the identification and isolation of bioactive compounds, and their variations according to the region where they are grown is needed with respect to their diuretic property needs to be evaluated. The synergistic effect of these drugs with standard diuretics has yet to be evaluated. Clinical trials and pharmacodynamic evaluations are necessary to validate its therapeutic potential and safety profile. With growing interest in plant-based therapeutics, *TT* may offer a complementary or standalone approach for fluid retention and mild hypertensive states.

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Table 5. List of studies on the diuretic activity of *Tribulus terrestris* in comparison with the standard diuretics

Author (Year)	Year	Country	Plant and part used	Extract Type	Experimental Model	Species	Sample Size	Sex	Dose	Route	Comparator Drug	Dose	Route	Duration of study	Key Outcomes
Sudheendran, et al. (67)	2021	India	*Tribulus terrestris* roots and fruits	Crude aqueous extract	Lipschitz Test	*Wistar* rats	24	Male/ Female	8.64 ml/kg	Oral	Furosemide	20 mg/kg	Oral	5 hours	The *TT* root and fruit extracts increased urinary output in the treated animals. The root extract significantly increased the urine K^+ and Cl^- levels compared to the normal control.
Hanna Rachel, et al. (69)	2017	India	Sirupeelai Samoola Kudineer (SK) containing *Aerva lanata* (whole plant), *Crataeva nurvala* (root), *Tribulus terrestris* (fruit) and *Pavonia odorata* (root)	Crude aqueous extract	Ethylene Glycol-induced Renal Calculus	*Sprague-Dawley* rats	30	Male	4.5, 9 and 18 ml/kg	Oral	Furosemide	30 mg/kg	Oral	21 days	SK significantly increased the urine output, Na^+, K^+, Mg^{2+}, and PO^{3-}_4 excretion. It also reduced plasma and urine calcium and oxalate levels, reduced calcium and oxalate deposition in the tissues of the kidneys, and urinary excretion of urea, creatinine, and total proteins. Normalized the markers of renal function tests, reduced oxidative stress, leading to the effective reduction in urolithiasis.
Arasaratnam, et al. (70)	2010	Sri Lanka	*Tribulus terrestris* leaves, flowers and fruits	Aqueous extract	Urolithiasis	Humans (normal subjects and urolithic patients)	43	Not specified	10 mL	Oral	NA	NA	NA	7 days	Decreased serum uric acid level, increased the urine output, and serum Ca^{2+}, Mg^{2+}, and inorganic phosphate levels. Urinary excretion of citrate, oxalate, and inorganic phosphate also increased.
Nalwaya, et al. (68)	2009	India	UNEX capsules containing the extracts of *Boerhaavia diffusa* and *Tribulus terrestris*		Lipschitz Test	*Wistar* rats	24	Male/ Female	600 and 800 mg/kg	Oral	Furosemide	20 mg/kg	Oral	5 hours	UNEX capsules demonstrated dose-dependent diuretic activity, but the effect was less than furosemide with a slower onset of action. It also increased the excretion of Na^+, K^+ and Cl^-
Al-Ali M, et al. (9)	2003	Iraq	*Tribulus terrestris* leaves and fruits	Crude extract	Not specified	*Wistar* rats	30	Male	5 g/kg	Oral	Furosemide	120 mg/ kg	Oral	24 hours	Slightly stronger diuretic than furosemide, also increased the excretion of Na^+, K^+ and Cl^-

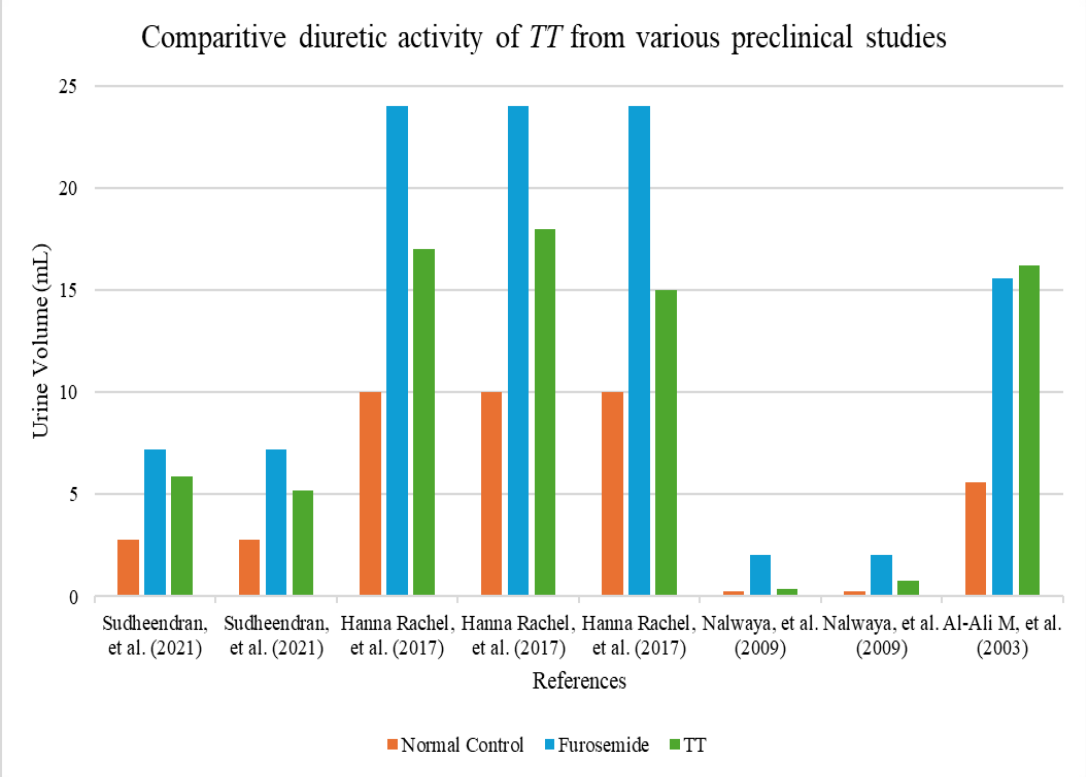

Figure 1. Effect of various extracts of *TT* on the urinary output when compared with the normal control and furosemide

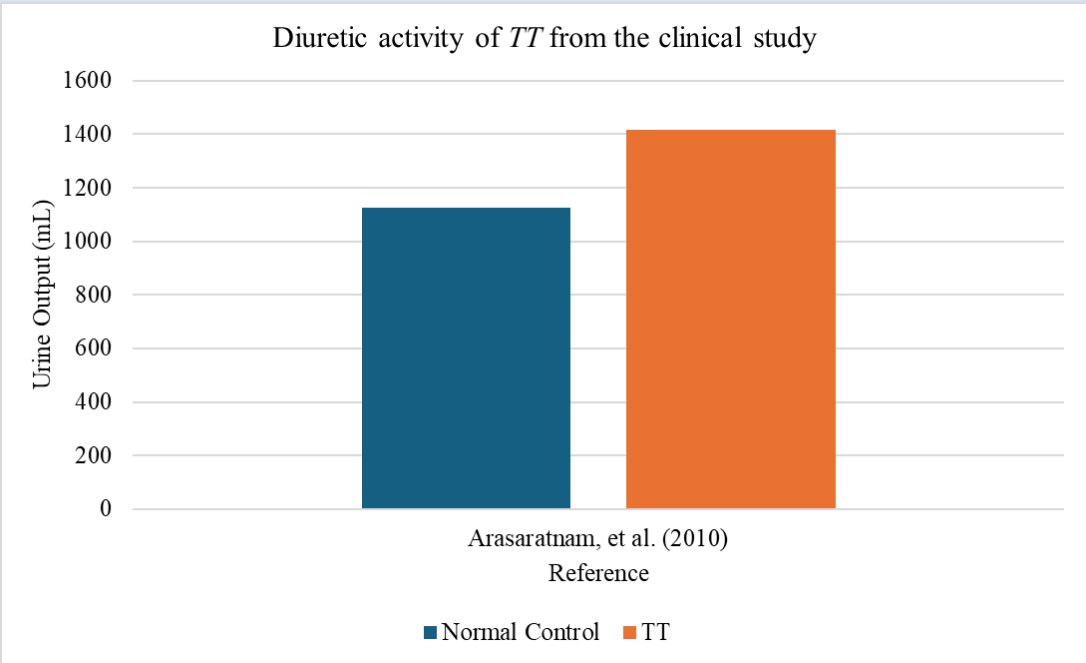

Figure 2. Effect of aqueous extract of *TT* on the urinary output in urolithiatic patients when compared with the normal subjects

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