ISSN:3139-0935(Online)

Intemed: International Journal of Research in Integrated Medical Sciences (IJ-RIMS)

Journal homepage: www.intemed.in

Vol.: 2 | Issue: 10 | Oct 2026

Article History: Received: 20-10-2026 Accepted: 27-10-2026 Published:30-10-2026

DOI: doi.org/10.68108/intemed.v2.i10.24

Research Article

SCIENTIFIC VALIDATION OF *SUSRUTA'S BHUMI-SHODHANA* METHOD FOR PURIFICATION OF CONTAMINATED SOIL: A PILOT STUDY ON *HIMA-KASHAYA* PREPARED FROM *VIDANGA* (*Embelia ribes* Burm.f.), *PATHA* (*Cissampelos pareira* L.) AND *KATABHI* (*Albizia procera* (Roxb.) Benth.)

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ABSTRACT:

Background

Soil contamination by industrial pollutants is a serious public health problem in India. The Central Pollution Control Board has listed 103 heavily contaminated sites across the country, of which 21 lie in Madhya Pradesh. *Susruta Samhita*, *Kalpasthana* 3/10-12, describes a method for purification of *Visha-Dushta Bhumi* (poison contaminated soil) using a cold herbal infusion, *Hima-Kashaya*, prepared from *Vidanga* (*Embelia ribes* Burm.f.), *Patha* (*Cissampelos pareira* L.) and *Katabhi* (*Albizia procera* (Roxb.) Benth.). This classical prescription has not been tested scientifically before the present study.

Objectives

To prepare the *Hima-Kashaya* formulation by the classical cold infusion method and to evaluate its effect on the physicochemical, macronutrient and micronutrient status of industrially contaminated soil collected from Bhanpur, Bhopal, and to compare the treated and untreated soil statistically by paired t-test.

Methods

Composite contaminated soil was divided into an untreated Control group (S1) and a Treated group (S2) which received 100 mL of freshly prepared *Hima-Kashaya* and was incubated for 21 days under shade at about 60 per cent moisture. Both samples were analysed at the ICAR-Indian Institute of Soil Science, Bhopal (Sample ID 34).

Results

Available Nitrogen increased by 14.61 per cent (2320 to 2659 kg/ha), Available Phosphorus by 11.11 per cent (18 to 20 kg/ha) and Available Potassium by 16.22 per cent (894 to 1039 kg/ha) in S2 as compared to S1. Organic Carbon rose by 4.73 per cent and soil pH improved from 6.62 to 6.76. Available Zinc fell by 9.84 per cent, indicating chelation and immobilisation. The paired t-test gave t = 1.9634, df = 9, p = 0.081, with a mean improvement of 25.58 per cent across ten parameters.

Conclusion

The *Hima-Kashaya* formulation produced a consistent and favourable change in nearly all the soil parameters studied. This pilot study offers the first experimental support for the *Bhumi-Shodhana* prescription of *Susruta* and opens a low cost, eco-friendly line of research for the remediation of contaminated soil.

Keywords: *Visha-Dushta Bhumi Shodhana*, *Hima-Kashaya*, *Vidanga*, *Patha*, *Katabhi*, soil bioremediation, heavy metal contamination, *Susruta Samhita*

1. INTRODUCTION

Soil is the foundation on which agriculture, drinking water and, in the end, human health depend. Rapid industrial growth, unregulated mining and careless disposal of industrial waste have damaged this resource across the world. The FAO and UNEP Global Assessment of Soil Pollution (2021) reports that soil contamination is now found on every inhabited continent, with industrial activity, municipal waste and agricultural chemicals as the main sources.[1] Contaminated soil acts as a long-term source from which heavy metals and other toxic substances move into groundwater and into the food chain, and are also inhaled or ingested directly by people living near such sites. The World Health Organization estimates that environmental pollution contributes to about nine million premature deaths every year across the world.[2]

India shows the same problem on a large scale. The Central Pollution Control Board (CPCB, 2025) has identified 103 heavily contaminated sites in the country that need priority remediation, and 21 of these lie in Madhya Pradesh, mainly in the industrial belts of Mandideep, Dewas and Pithampur and in parts of Bhopal district.[3] Chronic exposure to lead, chromium, nickel and cadmium in such areas has been linked to dermatitis, anaemia, peripheral neuropathy, chronic kidney disease and liver damage, and this burden falls mostly on poor communities who depend on land for their living. The area around the former Union Carbide factory site at Bhanpur, Bhopal, carries the legacy of the 1984 industrial disaster and decades of toxic waste deposition, and continues to pose a health risk to the surrounding population. This site was therefore chosen for soil collection in the present study.

Ayurveda regards the earth, *Prithvi*, as one of the *Panchamahabhuta*, the five basic elements of which all matter is composed. In this system, soil is not treated as a lifeless substance but as a living entity whose quality decides the health of everything that depends

on it. *Charaka Samhita*, *Vimanasthana* Chapter 3, describes how the vitiation of land, *Bhumi Dushti*, leads to disease affecting whole communities, an observation that anticipates modern environmental epidemiology by many centuries. *Susruta*, in the *Kalpasthana*, goes a step further and lays down a complete protocol for recognising and purifying *Visha-Dushta Bhumi*, land contaminated by poison. The relevant verses read as follows.

क्षिक्षिप्रदेशं क्षिषदूक्षषिं ि॰ क्षशलाि॰लं ि॰ीर्थमर्ेरिणं ि॰ा। स्पृशक्षति गात्रेण ि॰ येन येन गोि॰ाक्षिनागोष्ठ्रखिा निा ि॰ा। ि॰च्छ्रनिां यात्यर् दह्यि च क्षिशीयथि ि॰ोमनखं ि॰ैि॰ि। ि॰त्राप्यनतिां सह सिथगत्ै॰ः क्षपष्टिा सु॰ाक्षिक्षिथक्षनयोज्य मागथम्। क्षसञ्चेि॰् पयोक्षिः सुमृदक्षति॰ैस्ि॰ं क्षिडङ्गपाठाकटीि॰लैि॰ाथ।

Susruta Samhita, *Kalpasthana* 3/10-12

In simple words, the text says that in a tract of land which has become poisoned, the very rock and soil undergo a visible change, and cattle, horses, elephants, camels and human beings who come in contact with such land develop swelling, burning sensation and loss of body hair and nails. Such poisoned land, the text advises, should be repeatedly irrigated and soaked with a cold aqueous infusion, *Hima-Kashaya*, prepared from *Vidanga*, *Patha* and *Katabhi*, or with milk mixed with fine earth, by which the toxic character of the land is removed and its purity restored.

This is a precise, two thousand year old prescription for soil purification, yet it had never been tested by modern analytical methods before the present work. The present pilot study was undertaken to bridge this gap, using soil from a genuine contaminated

industrial site and standard soil testing methods at a recognised government laboratory, so that the classical claim could be examined on its own merits.

1.1 Objectives

1. To prepare and standardise the *Hima-Kashaya* formulation from *Vidanga* (*Embelia ribes* Burm.f.), *Patha* (*Cissampelos pareira* L.) and *Katabhi* (*Albizia procera* (Roxb.) Benth.) in equal proportion, following the classical cold infusion method of *Susruta Samhita*, *Kalpasthana* 3/10-12.
2. To study the effect of this formulation on the physicochemical, macronutrient and micronutrient status of contaminated soil from Bhanpur, Bhopal.
3. To compare the treated and untreated soil statistically by the paired t-test and to work out the percentage change in each parameter.

2. MATERIALS AND METHODS

2.1Study Design and Duration

A comparative experimental study was carried out over about seven weeks, from February 2026 to May 2026. A single composite sample of contaminated soil was divided into two groups, an untreated Control (S1) and a Treated group (S2), so that any difference found between the two could be attributed to the *Hima-Kashaya* treatment alone. Soil processing was done at the Soil Science Laboratory, School of Agriculture Sciences, SAM Global University, Raisen, and the final analysis of both samples was carried out at the ICAR-Indian Institute of Soil Science (IISS), Bhopal, following ICAR and BIS IS:2720 standard methods.

2.2 Soil Sample Collection

Soil was collected from the contaminated zone near the former Union Carbide factory site, Bhanpur, Bhopal, one of the 21 priority contaminated sites of Madhya Pradesh listed by CPCB (2025). Collection was done under the guidance of the Department of Agriculture Sciences, SAM Global University, Raisen, from three separate spots within an area of about 100 square metres. Surface soil of 0 to 15 cm depth was collected with a sterile stainless steel auger. The three samples were pooled into one composite sample, air dried under shade for 48 to 72 hours and passed through a 2 mm sieve, then stored in airtight, labelled polyethylene containers. Geo-tagged photographs were taken at the time of collection.

2.3 Selection and Authentication of Raw Drugs

The three drugs used in the formulation, that is, dried fruit of *Vidanga* (*Embelia ribes* Burm.f.), root of *Patha* (*Cissampelos pareira* L.) and bark and leaf of *Katabhi* (*Albizia procera* (Roxb.) Benth.), were procured from Manakarnika Aushadhalaya, Pune, an AYUSH approved supplier. Authentication was done by macroscopic and microscopic examination against the monographs of the Ayurvedic Pharmacopoeia of India, and all three drugs conformed to the required standards.

Table 1: Raw Drug Materials Used in the Hima-Kashaya Formulation

Sanskrit Name	**Botanical Name**	**Part Used**	**Classical Action**
Vidanga	*Embelia ribes* Burm.f.	Dried fruit	*Krimighna*, *Vishahara*
Patha	*Cissampelos pareira* L.	Root	*Shodhana*, *Ropana*
Katabhi	*Albizia procera* (Roxb.) Benth.	Bark and leaf	*Vishaghna*, *Bhumi-Shodhana*

2.4 Preparation of the *Hima-Kashaya* Formulation

The formulation was prepared strictly by the classical *Hima* method of *Susruta Samhita*, *Kalpasthana* 3/10-12. The authenticated drugs were shade dried to constant weight and coarsely powdered to 10 to 20 mesh size to increase the surface

area for cold extraction, and equal quantities by weight, *Samabhaga* (1:1:1), were mixed together. For each batch, 50 g of this mixture was taken in a clean borosilicate glass vessel, 800 mL of distilled water was added, and the vessel was covered and kept undisturbed at room temperature (25 to 28 degree Celsius) for 8 to 10 hours of overnight cold maceration. The supernatant liquid was then filtered through double layered sterile muslin cloth. The resulting *Hima-Kashaya* was light yellowish brown in colour, mildly astringent in taste, faintly aromatic and slightly turbid in appearance, and was used fresh, without any preservative, to protect the heat sensitive constituents.

2.5 Experimental Groups

Table 2: Experimental Groups and Treatment Protocol

Group	Label	Treatment
Group I, Control	S1	500 g composite contaminated soil, kept untreated under conditions identical to S2
Group II, Treated	S2	500 g composite contaminated soil mixed with 100 mL fresh *Hima-Kashaya* and incubated for 21 days at about 60 per cent moisture under shade

At the end of the 21 day incubation, both samples were air dried under shade for 48 to 72 hours, mixed gently and passed through a 2 mm sieve. About 200 g of each sample was packed in labelled, double bagged, airtight containers and sent officially to ICAR-IISS, Bhopal. The report was received on 27 May 2026 (Sample ID 34, date of receipt 30 April 2026).

2.6 Parameters Studied

Table 3: Parameters Evaluated and Methods Used

Category	Parameter	Method or Standard
Physicochemical	pH	Glass electrode pH meter (IS:2720 Part 26)
Physicochemical	Electrical Conductivity (dS/m)	Conductivity meter, 1:2.5 extract (IS:2720 Part 14)
Physicochemical	Organic Carbon (per cent)	Walkley-Black wet oxidation method (IS:2720 Part 22)
Macronutrient	Available Nitrogen (kg/ha)	Alkaline permanganate distillation, Subbiah-Asija method
Macronutrient	Available Phosphorus (kg/ha)	Olsen sodium bicarbonate

		extraction
Macronutrient	Available Potassium (kg/ha)	Neutral ammonium acetate extraction, flame photometry
Micronutrient	Available Fe, Zn, Cu, Mn (mg/kg)	DTPA extraction (Lindsay and Norvell, 1978), Atomic Absorption Spectroscopy

2.7 Statistical Analysis

The percentage change in each of the ten parameters between S1 and S2 was calculated, and the paired t-test was applied at a significance level of 0.05, two tailed, to test whether the treatment produced a significant change. The null hypothesis stated that the mean percentage change is zero, and the alternate hypothesis stated that it is not zero.

3 RESULTS

3.1 Qualitative Observations during the 21 Day Incubation

At the start, both samples looked identical, dark grey brown in colour, with a compacted texture and a metallic smell. The Control sample (S1) showed no visible change through the 21 days, and the metallic smell persisted throughout. The Treated sample (S2), on the other hand, showed gradual lightening of colour from the seventh day onward, a mild herbal smell that slowly replaced the metallic odour, and a visibly better crumbly texture by the twenty first day.

3.2 Quantitative Results

Table 4: Soil Parameters in S1 (Control) and S2 (Treated) with Percentage Variation

Parameter	S1 Control	S2 Treated	Absolute Change	PerCent Variation	Remark
pH	6.62	6.76	+0.14	+2.11%	Shift toward the optimal range of 6.5 to 7.0
Electrical Conductivity (dS/m)	0.160	0.282	+0.122	+76.25%	Both values remain in the non-saline range, below 0.8
Organic Carbon (per cent)	9.52	9.97	+0.45	+4.73%	High in both, as per ICAR rating (above 0.75 per cent)

Available Nitrogen (kg/ha)	2320	2659	+339	+14.61%	High category (above 560 kg/ha)
Available Phosphorus (kg/ha)	18	20	+2	+11.11%	Medium category (10 to 25 kg/ha)
Available Potassium (kg/ha)	894	1039	+145	+16.22%	High category (above 280 kg/ha)
Available Iron (mg/kg)	92.11	95.30	+3.19	+3.46%	Sufficient in both (above 4.5 mg/kg)
Available Zinc (mg/kg)	1.93	1.74	-0.19	-9.84%	Decrease, consistent with chelation
Available Copper (mg/kg)	3.05	3.49	+0.44	+14.43%	Sufficient in both (above 0.2 mg/kg)
Available Manganese (mg/kg)	66.31	147.70	+81.39	+122.75%	Sufficient in both (above 2.0 mg/kg)

Figure 3: Micronutrient Availability — S1 Control vs S2 Treated (Hima-Kashaya)

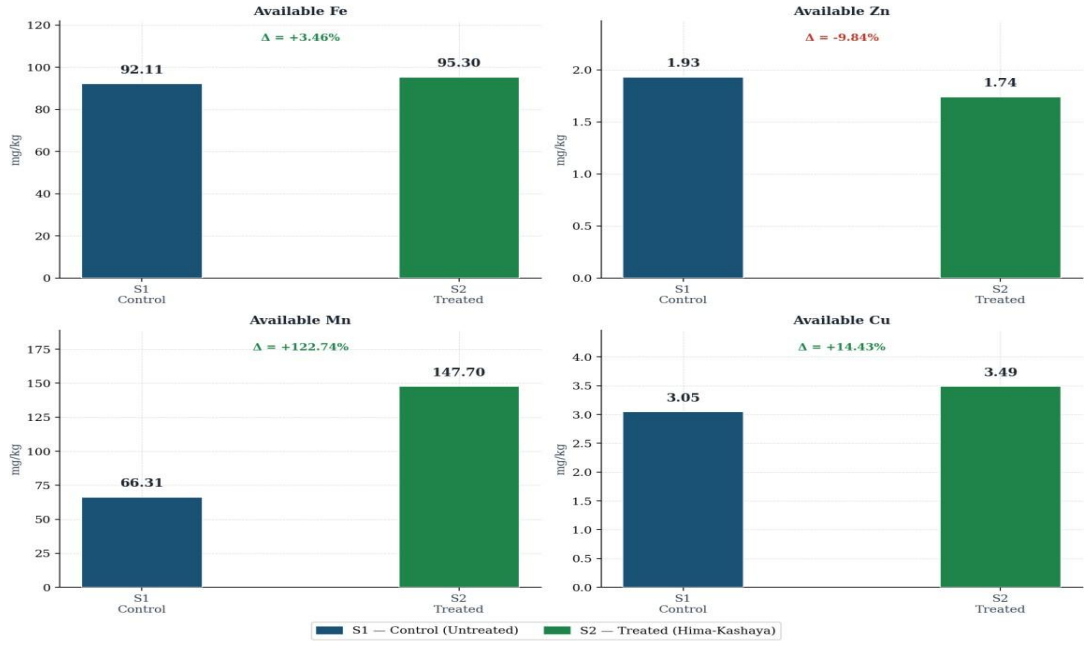


Figure 3: Micronutrient Availability, S1 Control versus S2 Treated

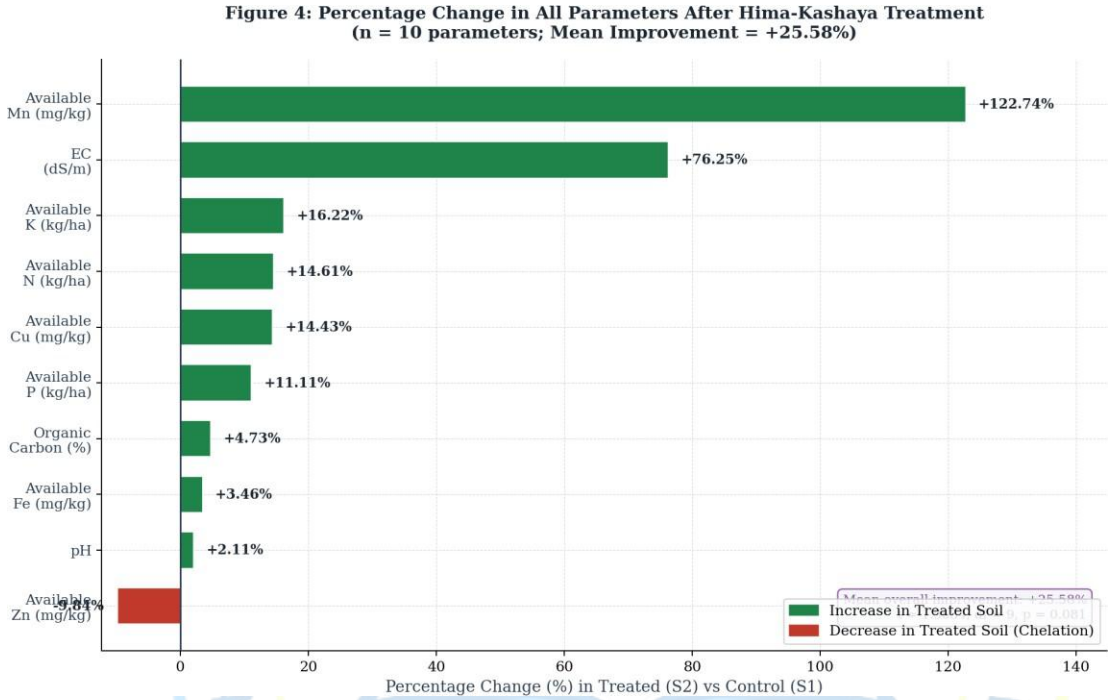


Figure 4: Per Cent Change in All Ten Parameters after Hima-Kashaya Treatment

3.3 Statistical Analysis

The mean percentage change across the ten parameters was 25.58 per cent, with a standard deviation of 41.20 per cent and a standard error of 13.03 per cent. The paired t-test gave t = 1.9634 at df = 9. The critical value of t at α = 0.05 (two tailed) is 2.262 and at α
= 0.10 (two tailed) is 1.833. The approximate two tailed p-value obtained was 0.081.

Table 5: Paired t-Test Statistical Summary

Statistical Measure	Value
Number of parameters (n)	10
Mean per cent change	25.58%
Standard deviation	41.20%
Standard error	13.03%
Paired t-statistic	1.9634
Degrees of freedom	9
t-critical (α = 0.05, two tailed)	2.262
t-critical (α = 0.10, two tailed)	1.833
Approximate p-value (two tailed)	0.081

Since the obtained p-value of 0.081 is above 0.05, the null hypothesis cannot be formally rejected at the 5 per cent level. However, the p-value is below 0.10, which shows a trend toward significance. The comparatively large standard deviation is mainly due to the very large per cent rise seen in Available Manganese, 122.75 per cent, together with the fall in Available Zinc, 9.84 per cent. Nine of the ten parameters studied improved after treatment, and the mean overall improvement of 25.58 per cent is, in the opinion of the authors, an agronomically meaningful result even though the sample size of the pilot study, a single pair of soil samples, kept the statistical power low.

4 DISCUSSION

4.1 pH and the Concept of *Sheeta Guna*

Soil pH improved from 6.62 to 6.76, a rise of 2.11 per cent, bringing the treated soil closer to the ideal range of 6.5 to 7.0 at which nutrient availability is highest and heavy metal availability is lowest. This mild alkaline shift may be explained by the metal-tannin complexation reactions of the condensed tannins present in *Katabhi* (*Albizia procera* (Roxb.) Benth.) and the flavonoid glycosides of *Vidanga* (*Embelia ribes* Burm.f.) and *Patha* (*Cissampelos pareira* L.), which consume hydrogen ions during chelate formation. In classical terms, this improvement may be seen as the restoration of *Sheeta Guna*, the cooling and stabilising quality, to the vitiated soil through the cold infusion method.

4.2 Electrical Conductivity as a Mobilisation Phase

Electrical conductivity rose from 0.160 to 0.282 dS/m, an increase of 76.25 per cent. Although a rise in electrical conductivity may at first appear undesirable, it is in fact consistent with the initial mobilisation phase that is commonly seen in phytochemical bioremediation. The saponin content of *Katabhi* (*Albizia procera* (Roxb.) Benth.) works as a natural biosurfactant, and this may release ions that were earlier bound to the mineral lattice into the soil solution, which raises the measured conductivity. Importantly, both readings remain well within the non-saline range, that is, below 0.8 dS/m, and such a mobilisation phase is generally regarded as a necessary early step before chelation, precipitation and microbial uptake can occur in longer treatment protocols.

4.3 Organic Carbon and *Bhumi-Prana*

Organic carbon rose from 9.52 to 9.97 per cent, a gain of 4.73 per cent, both values being rated high by ICAR standards. This gain may be attributed to the tannins, saponins, polysaccharides, flavonoids and alkaloids contributed by the *Hima-Kashaya*, all of which are carbon-rich compounds that add to the labile organic carbon pool of the soil. In the language of Ayurveda, this finding corresponds to the restoration of *Bhumi-Prana*, the vital force of the soil, which *Susruta* considered basic to a healthy soil environment

4.4 Macronutrients

Available Nitrogen rose by 14.61 per cent, from 2320 to 2659 kg/ha. *Katabhi* (*Albizia procera* (Roxb.) Benth.), being a member of the family Fabaceae, is associated with Rhizobium root nodules and therefore contains nitrogen rich compounds such as amino acids, peptides and purine alkaloids, which can add to the

available nitrogen pool through microbial breakdown once introduced into the soil through the cold infusion. Available Phosphorus rose by 11.11 per cent, from 18 to 20 kg/ha, remaining in the medium category. Phenolic acids present in the formulation may compete with phosphate ions for binding sites on iron and aluminium oxide surfaces in the soil, thereby releasing some previously bound phosphate into the available fraction. Available Potassium rose by 16.22 per cent, from 894 to 1039 kg/ha, both values falling in the high category.

4.5 Available Zinc: Evidence of Chelation

Available Zinc fell from 1.93 to 1.74 mg/kg, a decrease of 9.84 per cent, and this is the most direct evidence of heavy metal chelation obtained in the present study. Embelin, the principal bioactive constituent of *Vidanga* (*Embelia ribes* Burm.f.), is known to form stable bidentate complexes with divalent metal ions, and this activity, together with the polyphenolic complexing action of the condensed tannins present in all three drugs, may have converted a part of the bioavailable zinc into a more strongly bound, immobile form. Both readings still remain well above the ICAR deficiency threshold of 0.6 mg/kg, so plant nutrition is not compromised. This appears to be the first laboratory demonstration of embelin mediated zinc chelation in an actual contaminated soil sample.

4.6 Iron, Copper and Manganese

Available Iron rose marginally by 3.46 per cent, and Available Copper rose by 14.43 per cent, both changes being consistent with mobilisation of these metals from mineral surfaces by organic chelating agents present in the *Hima-Kashaya*. Available Manganese showed the largest change of all, rising by 122.75 per cent, from 66.31 to 147.70 mg/kg, which may be explained by reductive dissolution of manganese oxide minerals, a process that is often stimulated by increased microbial activity in organically enriched soil. These rises reflect the release of metal ions from previously bound mineral fractions, a step that, in an extended, multi-cycle treatment, would be expected to progress further toward complexation, precipitation and eventual removal.

4.7 Overall Interpretation

Taken as a whole, the results of the present pilot study provide the first documented laboratory evidence in support of the *Visha-Dushta Bhumi Shodhana* method described by *Susruta*. All three macronutrients improved, organic carbon improved, soil pH moved toward the optimal range, and bioavailable zinc came down through what appears to be a chelation mechanism. That a two thousand year old classical text and the mechanistic reasoning of modern soil chemistry point in the same direction is, in the view of the authors, a finding worth reporting to the wider scientific community.

5 CONCLUSION

The *Hima-Kashaya* formulation prepared from *Vidanga* (*Embelia ribes* Burm.f.), *Patha* (*Cissampelos pareira* L.) and *Katabhi* (*Albizia procera* (Roxb.) Benth.) in equal proportion, by the classical cold infusion method, produced a consistent and largely favourable change across the ten soil parameters studied in industrially contaminated soil from Bhanpur, Bhopal. Available Nitrogen, Phosphorus and Potassium improved by 14.61, 11.11 and
16.22 per cent respectively, organic carbon rose by 4.73 per cent, soil pH improved from
6.62 to 6.76, and Available Zinc fell by 9.84 per cent, suggesting a chelation effect. The paired t-test ($t = 1.9634$, $df = 9$, $p = 0.081$) showed a mean improvement of 25.58 per cent across all ten parameters and a trend toward statistical significance, even though the small sample size of this pilot study, a single pair of soil samples, limited the statistical power that could be achieved. This study appears to be the first experimental evaluation of the *Visha-Dushta Bhumi Shodhana* prescription of *Susruta Samhita*, *Kalpasthana* 3/10-12, and it gives reasonable ground to pursue this approach further, through replicated trials, full heavy metal analysis and microbiological study, with a view to developing a low cost, eco-friendly and culturally rooted method of soil remediation that may in time support India's National Clean Soil Mission and the Sustainable Development Goals concerned with health, clean water and life on land.

6 SOURCE OF FUNDING

This study was carried out under the Studentship Programme for Ayurveda Research Ken (SPARK 4.0), 2025-26, of the Central Council for Research in Ayurvedic Sciences (CCRAS), Ministry of

AYUSH, Government of India. CCRAS has provided the financial support for this project, covering the procurement and authentication of raw drugs, preparation of the

Hima-Kashaya formulation, soil sample analysis at the ICAR-Indian Institute of Soil Science, Bhopal, and other research expenses connected with the study. No other external funding, grant or sponsorship, institutional or commercial, was received for this work.

ACKNOWLEDGEMENT

The authors thank the Central Council for Research in Ayurvedic Sciences, Ministry of AYUSH, Government of India, for support under the SPARK 4.0 Studentship Programme. The authors also thank the Department of Agriculture Sciences, SAM Global University, Raisen, for guidance during soil sample collection, the Department of Rasashastra and Bhaishajya Kalpana, SAM College of Ayurvedic Sciences and Hospital, Raisen, for supervision of the classical preparation of Hima-Kashaya, and the Indian Institute of Soil Science, Bhopal, for the physicochemical and micronutrient analysis of the soil samples (Sample ID 34, report dated 27 May 2026), which forms the primary data of this study.

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