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Research Article

Anantadi Yoga

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An analytical study on the efficacy of Anantadi Yoga in purifying contaminated soil and enhancing soil quality with special reference to physical parameters

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Soil contamination affects agricultural productivity and environmental sustainability, necessitating effective remediation methods. This study evaluates the efficacy of Anantadi Yoga, an Ayurvedic formulation from the Sushruta Samhita, in improving the physical properties of contaminated soil (Vishadushita Bhoomi). Ten soil samples were collected from agricultural and industrial areas in Himachal Pradesh and analyzed for physical parameters, including soil texture, bulk density, and particle density. Anantadi Yoga was applied to the samples, and changes in these parameters were monitored at 24, 36, and 72-hour intervals. The treatment resulted in noticeable improvements in soil structure, with changes in bulk density and particle density indicating enhanced aeration and porosity. These modifications suggest a potential role of Anantadi Yoga in restoring soil physical health. The findings support the potential of Anantadi Yoga in improving soil physical properties, which could contribute to better soil fertility and sustainability. Further research is recommended to explore its long-term impact on soil structure and its applicability in diverse soil conditions.

Keywords: Anantadi Yoga, Soil texture, Bulk density, Particle density, Soil remediation

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Introduction

Soil is a vital component of the Earth's lithosphere, supporting biodiversity, regulating water cycles, and serving as a foundation for agriculture. Composed of minerals, organic matter, water, and air, soil provides essential nutrients for plant growth and sustains human and animal life.**[1]** However, soil pollution has been a persistent issue throughout history, exacerbated by industrialization, urbanization, and intensive agricultural practices.

Historically, soil pollution was primarily a localized issue, resulting from natural events such as volcanic eruptions and localized human activities like small-scale mining and agriculture and these caused minimal effects to the environment. The landscape of soil pollution changed dramatically with the onset of the Industrial Revolution in the 18th century. This period marked a profound transformation in manufacturing, agriculture, and urbanization.**[2]** Soil pollution has significantly increased since the Industrial Revolution due to factors such as extensive coal use, industrial waste discharge, and chemical-based agriculture. These activities have introduced heavy metals, pesticides, and industrial chemicals into the soil, reducing fertility, disrupting ecosystems, and posing severe health risks through direct exposure and the food chain.**[3,4]** Contaminated soil also affects water quality by leaching pollutants into groundwater and surface water, contributes to air pollution through airborne soil particles and volatile compounds, and threatens food security by lowering crop yields and contaminating food supplies.**[5]** Additionally, soil pollution is linked to various health issues, including acute poisoning, developmental and reproductive disorders, cancer, and other chronic diseases, with vulnerable populations such as children and agricultural workers facing the highest risks.**[6,7]**

While modern soil remediation techniques exist, many involve chemicals and advanced technologies that may cause secondary pollution or be too costly for large-scale use. This has led to growing interest in eco-friendly, traditional approaches to soil purification. *Anantadi Yoga*, an Ayurvedic formulation described in the *Sushruta Samhita (Kalpastana*), is traditionally believed to remove toxins from contaminated soil. However, despite its historical relevance, scientific studies validating its effectiveness in modern environmental contexts remain limited.

Aim and Objectives

Aim

To assess the potential of *Anantadi Yoga*, an *Ayurvedic* formulation, in purifying contaminated soil and enhancing its overall quality.

Objectives

The study aims to evaluate the impact of *Anantadi Yoga* on soil contamination by analyzing physical, chemical, and biological parameters. It seeks to determine its effectiveness in reducing pollutants from industrial and agricultural sources while improving soil structure, fertility, and microbial activity. Additionally, the research compares its efficiency with conventional remediation methods and explores its role in promoting sustainable and eco-friendly soil restoration practices.

Materials and Methods

Table 1: Shows brief description about the drugs of *Anantadi Yoga*.

SN	Name of Drug	Botanical Name	Family	Part Used	Proportion
1.	Ananta	Hemidesmus indicus R.Br	Apocynaceae	Root	200g
2.	Ela	Elettaria cardamomum Linn	Zingiberaceae	Fruits	200g
3.	Tagara	Valeriana wallichii D.C.	Valerianaceae	Root	200g
4.	Kushta	Saussurea lappa C.B. Clarke	Asteraceae	Root	200g
5.	Jatamamsi	Nardostachys jatamansi D.C.	Valerianaceae	Root	200g
6.	Tvak	Cinnamomum zelanicum Blume	Lauraceae	Bark	200g
7.	Tejapatra	Cinnamomum tamala (Buch.Ham)	Lauraceae	Leaf	200g
8.	Naga Keshara	Ochrocarpus longifolius	Calophyllaceae	Flower bud	200g
9.	Sarja Rasa	Shorea robusta	Dipterocarpaceae	Gum	200g
10.	Gugul	Commiphora mukul Engl	Burseraceae	Gum	200g
11.	Ushira	Vetiveria zizanioides Linn	Poaceae	Root	200g
12.	Devadaru	Cedrus deodara Roxb	Pinaceae	Heart wood	200g
13.	Krishna Mrittika (Black clay)				200g
14.	Sura				2L
15.	Cow's Milk				2L

A comprehensive review of classical texts, modern literature, and recent research sources was conducted to gather information on the formulation. The required ingredients were procured from reputable suppliers, authenticated through taxonomic confirmation, and stored properly. Soil samples were collected from ten agricultural and industrial areas of Himachal Pradesh. The formulation was prepared following standard methods at Charak Pharmacy, RGGPG Ayurvedic College and Hospital, Paprola. The analytical study was carried out in the Department of Soil Science, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. After the soil purification trial, the results were evaluated to assess the effectiveness of *Anantadi Yoga.*

Table 2: Showing acceptable limits of Soil

SN	Parameters	Desirable Limit	Harmful Limit
1.	Soil Texture	Balanced proportions of sand, silt, and clay (ideal is loam)	Extreme deviations can affect water retention, nutrient availability, and root penetration.[8]
2.	Bulk Density	1.0 to 1.6 g/cm³	Above 1.6 g/cm³ can restrict root growth and water infiltration.[9]
3.	Particle Density	2.60 to 2.75 g/cm³	Significantly lower or higher values may affect soil structure and plant growth.[10]

Particle Density

Particle density of soil, defined as the mass of soil particles per unit volume (g/cm³). It depends on the nature of soil constituents. Particle density provides insights into the density of soil particles, which helps guide soil preparation and improvement practices. This includes techniques to enhance soil structure and add materials that boost soil quality. Accurate measurement of particle density is crucial for effective soil management and enhancing agricultural outcomes.**[11]**

Bulk Density

Bulk density is the mass of soil (including both particles and pore spaces) per unit volume, typically measured in g/cm³. It is an indicator of soil compaction and porosity. Ideal bulk density values for agricultural soils range from 1.1 to 1.6 g/cm³. Higher bulk density values can reduce root growth, water infiltration, and soil aeration, leading to poor plant growth. Conversely, very low bulk density values can indicate excessive organic matter or soil disturbance.**[12]**

Soil Texture

The texture of soil is defined by the proportions of sand, silt, and clay particles present. This composition impacts how well the soil retains water, drains, and supplies nutrients. Soils are classified into textural classes such as sandy, loamy, and clayey based on their texture. Sandy soils drain quickly but may lack nutrients, while clayey soils retain water but may suffer from poor drainage and aeration. Loamy soils, with a balanced mix of sand, silt, and clay, are considered ideal for most agricultural purposes.**[13]**

Observations and Results

Objective parameters were used to assess the efficacy of *Anantadi Yoga* in purifying contaminated soil. Laboratory analysis was conducted to measure various soil parameters before and after treatment, and the findings were carefully interpreted. Soil samples collected from different agricultural and industrial sites in Himachal Pradesh were analyzed in four stages: Before Treatment (BT), 24 hours after treatment (ATI), 36 hours after treatment (ATII), and 72 hours after treatment (ATIII).

Effectiveness of *Anantadi Yoga* on soil texture

Table 3: Shows the effect of *Anantadi Yoga* on Soil Texture.

SN	Sample no.	Before Treatment	AT I	AT II	AT III
1.	01	Loam.	Loam.	Loam.	Loam.
2.	02	Sandy Loam.	Sandy Loam.	Sandy Loam.	Sandy Loam.
3.	03	Silt Loam	Silt Loam	Silt Loam	Silt Loam
4.	04	Silt Loam	Silt Loam	Silt Loam	Silt Loam
5.	05	Silt Loam	Silt Loam	Silt Loam	Silt Loam
6.	06	Sandy Loam.	Sandy Loam.	Sandy Loam.	Sandy Loam.
7.	07	Loam	Loam	Loam	Loam
8.	08	Sandy Loam.	Sandy Loam.	Sandy Loam.	Sandy Loam.
9.	09	Sandy Loam.	Sandy Loam.	Sandy Loam.	Sandy Loam.
10.	10	Silt Loam	Silt Loam	Silt Loam	Silt Loam

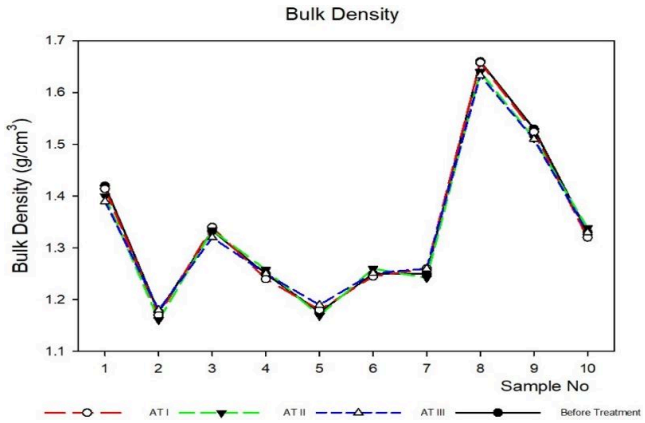
The soil texture remained unchanged across all samples and time intervals, indicating that the Ayurvedic remedy did not alter the soil's physical structure (Table No. 12).

This stability suggests that the treatment is non-invasive, preserving the soil's natural characteristics, which is crucial for agricultural applications. While aiding in detoxification, the remedy maintained the soil's fundamental properties, ensuring its continued suitability for cultivation.

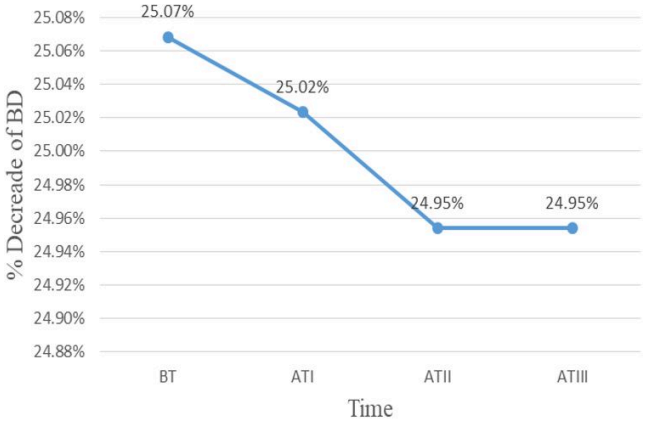
Effectiveness of *Anantadi Yoga* on Bulk Density

Table 4: Represent the data on bulk density (g/cm3) of the soil

SN	Sample no.	BT	AT I	AT II	AT III
1.	01	1.42	1.414	1.4	1.39
2.	02	1.176	1.17	1.161	1.18
3.	03	1.333	1.34	1.334	1.32
4.	04	1.25	1.24	1.258	1.25
5.	05	1.176	1.18	1.169	1.19
6.	06	1.25	1.245	1.26	1.251
7.	07	1.25	1.26	1.242	1.26
8.	08	1.66	1.658	1.64	1.633
9.	09	1.53	1.524	1.512	1.51
10.	10	1.33	1.32	1.338	1.33



Graph 1: Shows the variation of bulk density of soil samples before and after treatment



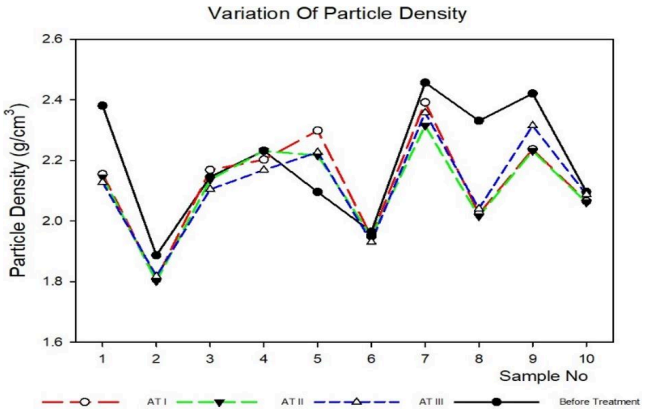
Graph 2: Shows the percentage decrease of Bulk density with time.

Bulk density, a key indicator of soil health influencing root growth, water infiltration, and overall soil structure, showed a slight reduction over 72 hours in most treated soil samples, while some remained stable or exhibited a minor increase (Table No. 13, Graph No. 01 and 02). Optimal bulk density values typically range between 1.66 to 1.72 g/cm³, and a decrease, particularly in samples with values above 1.6 g/cm³, suggests improved aeration and water retention, which are essential for plant growth and soil structure enhancement.

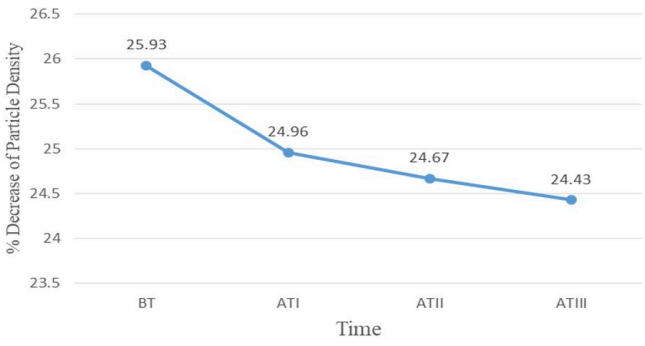
Particle Density

Table 5: Shows the data on particle density of the soil

SN	Sample no.	BT	AT I	AT II	AT III
1.	01	2.381	2.155	2.146	2.128
2.	02	1.887	1.808	1.802	1.818
3.	03	2.146	2.169	2.137	2.105
4.	04	2.232	2.203	2.232	2.169
5.	05	2.096	2.299	2.217	2.227
6.	06	1.965	1.949	1.949	1.931
7.	07	2.457	2.392	2.315	2.358
8.	08	2.331	2.024	2.016	2.041
9.	09	2.421	2.237	2.232	2.315
10.	10	2.096	2.066	2.062	2.088



Graph 3: Shows the variation of Particle density of soil samples before and after treatments.



Graph 4: Shows the percentage decrease of Particle density with time.

The particle density of soil, defined as the mass of soil particles per unit volume (g/cm³), showed mild variations before and after treatment with *Anantadi Yoga* (Table No. 5, Graph No. 03 and 04). Most soil samples exhibited a gradual reduction in particle density, indicating a loosening of soil particles. This suggests an improvement in soil properties, leading to better aeration and water infiltration. The application of *Anantadi Yoga* resulted in a noticeable reduction in particle density across most samples, making the soil less compact and more suitable for plant growth. This reduction highlights the formulation's effectiveness in improving soil structure, particularly in contaminated or compacted soils. The findings suggest that *Anantadi Yoga* has the potential to enhance soil health, contributing to better water retention and root penetration**.**

Discussion

The evaluation of physical parameters in this study demonstrated that *Anantadi Yoga* effectively influenced soil properties without altering its fundamental structure. Soil texture remained unchanged across all samples, indicating that the *Ayurvedic* remedy preserved the soil's natural composition, an essential factor for agricultural sustainability. This suggests that the treatment is non-invasive and does not compromise the physical integrity of the soil. Bulk density, a key determinant of soil aeration and water retention, showed a general trend of reduction over 72 hours. This decrease is particularly beneficial for compacted or contaminated soils, as lower bulk density enhances root penetration, improves water infiltration, and supports microbial activity. The reduction in bulk density can be attributed to the detoxifying and antimicrobial properties of *Anantadi Yoga*, which likely facilitated the loosening of compacted particles. Similarly, particle density exhibited mild variations, with most samples showing a slight reduction after treatment. This trend suggests that the *Ayurvedic* formulation contributed to a more porous soil structure, further supporting aeration and water movement. The presence of medicinal ingredients, known for their purifying effects, may have played a role in improving soil conditions, making the soil more conducive to plant growth. These findings highlight the potential of *Anantadi Yoga* as a natural and sustainable approach to enhancing soil health.

Conclusion

The study demonstrated that *Anantadi Yoga* effectively contributed to the purification and improvement of soil health while preserving its natural physical properties. The formulation-maintained soil texture, reduced bulk density, and slightly decreased particle density, leading to improved aeration and water retention. These changes indicate that *Anantadi Yoga* has the potential to revitalize contaminated or compacted soils without negatively impacting their fundamental structure. Overall, the results suggest that this *Ayurvedic* remedy can serve as an eco-friendly and sustainable solution for soil purification. However, further research with larger sample sizes and extended treatment durations is recommended to optimize its application and evaluate its long-term impact on soil properties. Integrating such traditional methods with modern agricultural practices could contribute to more sustainable land management and environmental conservation.

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