World Journal of Biology Pharmacy and Health Sciences

eISSN: 2582-5542

Cross Ref DOI: 10.30574/wjbphs

Journal homepage: https://wjbphs.com/

(Research Article)

A Study About Blood in Soil and Its Interactions

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World Journal of Biology Pharmacy and Health Sciences, 2025, 22(01), 477-481

Publication history: Received on 05 March 2025; revised on 16 April 2025; accepted on 19 April 2025

Article DOI: https://doi.org/10.30574/wjbphs.2025.22.1.0407

Abstract

This study investigates the interaction of blood with three soil types roadside soil, construction soil, and red soil under varying environmental conditions: cold, indoor (room temperature), and outdoor exposure. Using phenolphthalein reagent for blood decomposition and pH paper for chemical analysis, observations were made over ten days. Results show significant variations in pH levels and blood decomposition rates depending on soil type and environment. This research offers valuable insights for forensic science, particularly in crime scene reconstruction and estimation of bloodstain age.

Keywords: Blood-soil interaction; Phenolphthalein test; Soil pH; Forensic science; Decomposition; Environmental exposure

1. Introduction

Forensic biology serves as the bridge between biological sciences [3] and the justice system. Among the biological traces often encountered at crime scenes, blood is among the most critical due to its potential for DNA profiling, pattern analysis, and chronological interpretation.[2]. Simultaneously, soil often considered background evidence can preserve blood traces and provide environmental context.

This study focuses on understanding how blood decomposes and affects soil chemistry under different environmental exposures. It addresses a gap in forensic literature where limited attention has been given to blood-soil interactions as a tool for post-event analysis and crime scene reconstruction.

2. Materials and Methods

A controlled experimental setup was used to test three soil types: roadside soil, construction soil (M-sand), and red soil. Each type was exposed to three environmental conditions: cold storage, room temperature, and outdoor natural conditions. Fresh blood (source anonymized and ethically approved) was applied to each soil sample.[6]

Phenolphthalein reagent was used at intervals to test for blood decomposition,[1] while pH strips were used to monitor chemical changes over a 10-day period.[4] Samples were collected and tested every 2 days. Control samples without blood were also included for baseline comparison.

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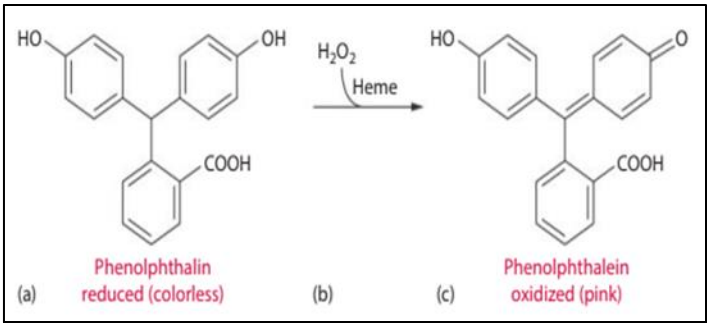

Figure 1 Chemical reaction of Phenolphthalein Assay [8]

3. Results

Table 1 pH Readings Under Cold Conditions

Soil types	Day 0	Day 1	Day 3	Day 5	Day 7	Day 9
Roadside Soil	7	14	7	7	1	5
Construction Soil (M-Sand)	7	7	7	12	3	1
Red Soil	7	7	9	3	3	3

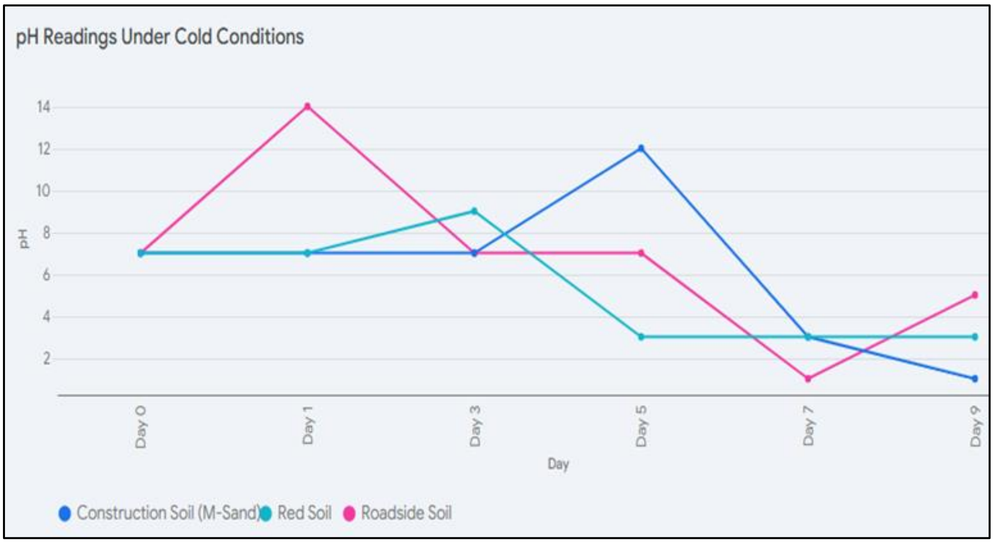

Figure 2 pH Readings Under Cold Conditions

- Cold Conditions: Roadside soil reached a peak pH of 14 on Day 1 before dropping to 1 by Day 7. Construction soil peaked at Day 5 with pH 12. Red soil showed milder changes, peaking at pH 9.

Table 2 pH Readings at Room Temperature

Soil types	Day 0	Day 1	Day 3	Day 5	Day 7	Day 9
Roadside Soil	7	9	8	5	3	3
Construction Soil (M-Sand)	7	12	9	3	1	6
Red Soil	7	8	12	3	1	3

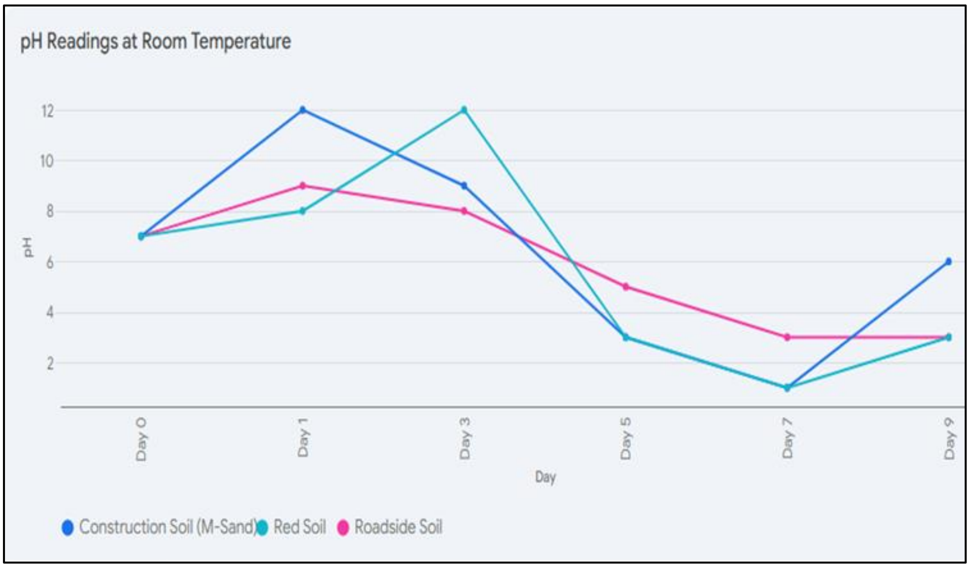

Figure 3 pH Readings at Room Temperature

-Room Temperature: pH generally increased early (Days 1–3) before dropping by Day 9

Table 3 pH Readings Under Outdoor Exposure

Soil types	Day 0	Day 1	Day 3	Day 5	Day 7	Day 9
Roadside Soil	7	12	12	1	1	1
Construction Soil (M-Sand)	7	10	8	1	1	1
Red Soil	7	7	9	9	1	1

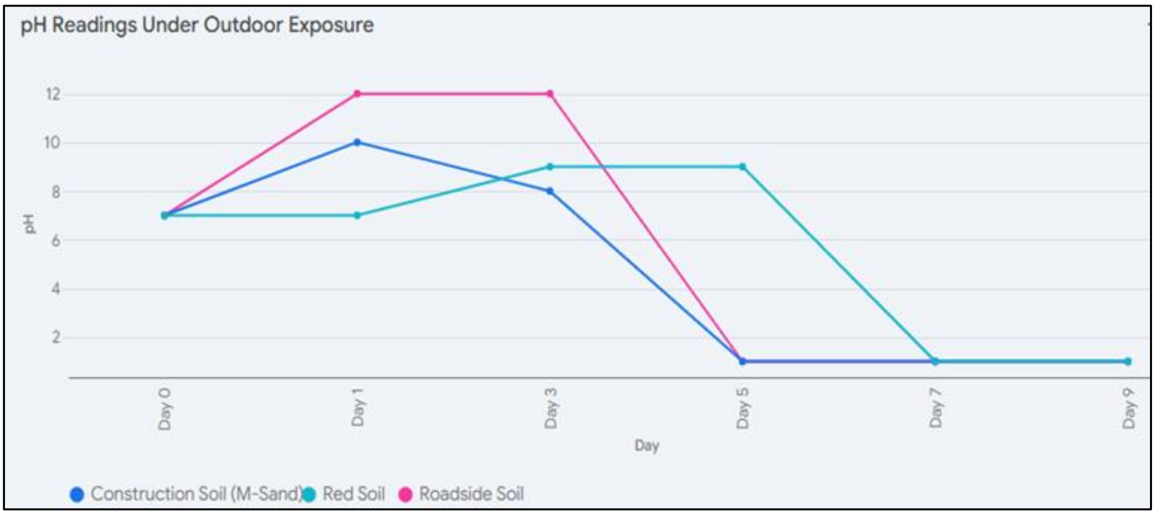

Figure 4 pH Readings Under Outdoor Exposure

- Outdoor Conditions: Exhibited rapid fluctuations in pH, likely due to environmental factors such as UV exposure and rainfall.

Table 4 Phenolphthalein Test Readings

Days	Cold Conditions	Room Temperature	Outdoor Exposure
0	Present	Present	Present
1	Present	Present	Present
3	Absence	Presence	Present
5	Absence	Absence	Absence
7	Absence	Absence	Absence
9	Absence	Absence	Absence

-Phenolphthalein tests showed positive results primarily on Days 1–3, indicating rapid early decomposition of Hemoglobin components.

4. Discussion

Environmental conditions significantly influence the rate of blood decomposition and soil pH changes. Cold environments delayed decomposition, while room temperature and outdoor exposure accelerated it.[7] Red soil exhibited the highest absorption and least visible staining, while construction soil showed prolonged visibility of blood stains.

Table 5 Blood Absorption in Different Soils

Soil Type	Absorption Rate	Surface Staining
Red Soil	High	Absorbs quickly, stains less
Roadside Soil	Moderate	Can alter blood colour
Construction Soil (M-Sand)	Low	Blood remains visible longer

High Absorption: Red soil (iron content affects binding); **Medium Absorption:** Roadside soil (due to organic matter and mixed particles).; **Low Absorption:** Construction soil (M-sand lacks organic matter).

Table 6 Blood Decomposition in Different Soils

Soil Type	Decomposition Speed	Colour Changes	Odour
Red Soil	Medium	Remains same	Absence
Roadside Soil	Fast	Dark Colour	Presence
Construction Soil (M-Sand)	Slow	Dark Colour	Presence

Fastest Decomposition: Roadside soil (high microbial activity); **Moderate Decomposition:** Red soil (due to iron and mineral interactions); **Slowest Decomposition:** M-sand (low bacterial growth).

Table 7 Physical Changes in Soils

Soil Type	Early Stage (0-3 Days)	Intermediate Stage (4-7 Days)	Late Stage (8-10 Days)
Red Soil	Stainless, no moist appearance.	Stainless, no moist appearance.	Stainless, no moist appearance.
Roadside Soil	Dark red stains, slightly moist.	Hardening due to protein coagulation	brittle or slightly crusty.
Construction Soil (M-Sand)	Dark red stains	Clumping	Dark red stains

0–3 Days: Blood is fresh; easy to detect; **4–7 Days:** Hemoglobin begins degrading; pH shifts in soil are noticed; **8-10 Days:** Decomposition by-products develop

These findings are critical for forensic investigations, as they suggest that blood's persistence and detectability can vary greatly based on soil type and climate. Understanding these dynamics aids forensic experts in determining time since deposition and potential movement of a suspect or victim.

5. Conclusion

The interaction between blood and soil is complex and highly sensitive to environmental variables.[5] Phenolphthalein tests are effective for early detection of blood, but their utility diminishes after a few days. pH analysis provides a promising supplementary tool for forensic timing and environmental profiling. The study confirms that soil-blood interaction analysis can support crime scene reconstruction and contribute meaningfully to forensic science.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Acknowledgement

I would like to express my sincere gratitude to all those who have supported and contributed to the successful completion of this research article.

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